Govind Swarup

March 23, 1929 – September 7, 2020

Memories and Tributes

NCRA • TIFR

National Centre for Radio Astrophysics
Tata Institute of Fundamental Research

FOREWORD

With the passing of Prof. Govind Swarup on the evening of 7th September 2020, the world lost an icon in the field of astronomy and astrophysics; India lost a trailblazer in science and technology; and many of us lost a much valued, much loved friend and father figure. He pioneered the growth of the new field of radio astronomy in the country, and built facilities and institutions that have put India in the forefront on the global stage in this field. He has left behind a legacy that we can be truly proud of.

Govind Swarup was born in 1929 at Thakurdwara in the state of Uttar Pradesh, India. He received an M.Sc. in Physics from Allahabad University in 1950, after which he joined the National Physical Laboratories, New Delhi for a short while, before going to Australia where he worked with well known radio astronomers to get his initial exposure to this exciting new branch of astrophysics. He then moved to the USA, and obtained a Ph.D from Stanford University in 1961. A lot of his early research work was in the area of solar physics, as well as development of instrumentation techniques.

Swarup joined the Tata Institute of Fundamental Research (TIFR) in 1963, at the invitation Dr. Homi Jahangir Bhabha. The Radio Astronomy group he founded at TIFR was one of the first such groups in the country. His group quickly began building new facilities starting with a relatively modest radio telescope at Kalyan near Mumbai, but soon moving on to the the much more ambitious Ooty Radio Telescope (ORT). Built during 1965–70, the ORT was a truly remarkable achievement for its time, given the level of technology and expertise that was available in those days in India. It was possible mostly because of the innovative ideas of Swarup and the young, enthusiastic team that he assembled to execute these ideas. It is to their credit that the ORT is functional even today, having produced several important science results in a wide range of fields from such as the solar wind, pulsars, the diffuse interstellar medium of our galaxy, extra-galactic radio sources and cosmology.

During 1984 to 1996, Swarup conceived the design and directed the construction of the Giant Metrewave Radio Telescope (GMRT), which consists of 30 large (45 m in diameter) fully steerable antennas, spread out over a 25 km region, located about 80 km from Pune. A large number of the trained staff from Ooty moved with Swarup to set up base at Pune to execute this ambitious project. Once again, it was innovative ideas from Swarup that made this project feasible in the limited budget that was available. These include : the SMART design for the GMRT antennas that resulted in realising 45 metre sized antennas at very economical cost; the use of optical fibres for transport of signals from the antenans to the central processing facility -- a far sighted move that has paid off handsomely. From the time of its completion in 2002, the GMRT has remained one of the most sensitive radio observatories in the world in the frequency range of 120 – 1450 MHz, attracting users from all over the world who have produced a slew of cutting edge science results over the last two decades. It has the pride of place as one of the biggest basic science projects in the country.

In addition to building excellent facilities, Swarup played a key role in building up a strong group, guiding and training several individuals, many of whom now occupy key positions world wide. He also strived hard for improvement in the quality of science and technology education in the country, to make it an attractive prospect for the younger generations.

For his pioneering and tireless efforts, Swarup won several recognitions and awards (over 20 major accolades) over his lifetime, both at the national and international level. These include, amongst others, the Padma Shri (one of the highest civilian awards in India), the John Howard Dellinger Gold Medal of the International Union of Radio Science (URSI), the Herschel Medal of the Royal Astronomical Society, and the Grote Reber Medal. He was elected as a Fellow of the Royal Society of London and also of all the national science academies in India, as wall as of The World Academy of Sciences.

Through all of these achievements and accolades in life, Swarup remained very much down to earth, with a pleasant and approachable personality, always eager to communicate with scientists, engineers and students.

It is a measure of the stature and eminence of Govind Swarup that, when we organised a memorial function on the 7th of October 2020, there was an overwhelming response from all over the world. From young aspiring scientists to the older seasoned members of the community, we received more than 140 messages, wanting to convey their regards and condolences, recall his contributions and achievements as well as their own personal associations with him. Due to constraints of time, we could accommodate only about 60 contributions during the online event on 7th of October.

In this memorial book, we have attempted to include all the messages and responses received, from the Honourable Prime Minister of India, to some of the youngest student members of the astronomy community. We hope that this compilation will serve as a fitting tribute to the life and achievements of Govind Swarup, as well as to his warm and influential personality, as captured in the views and voices of several individuals who had the good fortune to interact with him for some part of the journey of life.

Compilation of this memorial book would not have been possible without the active help and support of several members of the NCRA family. In particular, Shilkumar Meshram and Divya Oberoi have put in a stellar effort, along with inputs from other colleagues : Jayaram Chengalur, Yogesh Wadadekar, Dharam Vir Lal, V. Venkata Subramani, Jayantilal Solanki and Hemant Lokhande. Our grateful thanks to all of them

Yashwant Gupta
Centre Director
NCRA -- TIFR

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Professor Govind Swarup was an exceptional scientist. His pioneering works in radio astronomy have attained global commendation. Anguished by his passing away. My thoughts are with his near and dear ones.

Narendra Modi
Honorable Prime Minister of India

With Professor Govind Swarup's demise, the world of astronomy has lost a great scientist, institution, and telescope builder. Ever-smiling, not one to take a no for anything he wanted to be done, he took on many impossible tasks, inspired colleagues to accomplish them. There is much to know about this life fully lived. In a tribute to Govind on his 90th birthday, last year, Wayne Orchiston and Sudhir Phakatkar recount his scientific journey. Excerpts from this in quotes below;

"Govind accepted an Assistant Professorship in Electrical Engineering at Stanford on 1 January 1961, soon after being awarded his doctorate, from time to time he had contemplated returning to India and launching a radio astronomy program there."

"In September 1961, Swarup et al wrote to the Council of Scientific and Industrial Research (CSIR), the National Physical Laboratory, and to the Department of Atomic Energy (Bhabha), with unsolicited letters of support. Bart Bok from Australia wrote: It seems to me that their offer to return to India as a group is a unique one, and that should, by all means, be accepted and acted upon promptly...comes only rarely in the history of scientific development of a nation, which scientifically, is obviously coming of age."

All replied and Swarup says: "We got replies from all the concerned authorities from India, but the most encouraging and highly supportive was from the great visionary scientist and a dynamic organizer, Dr Homi J. Bhabha"

"On 20 January 1962, three months after Swarup's letter, Homi Bhabha sent a cable to the four radio astronomers: —We have decided to form a radio astronomy group STOP letter follows with offer STOP"

"Over the next two months Homi Bhabha somehow was able to formalise the establishment of the new radio astronomy group at the Tata Institute of Fundamental Research, and on 3 April 1962 he wrote Govind:

"If your group fulfills the expectations we

have of it, this could lead to some very much bigger equipment and work in radio astronomy in India than we can foresee at present." A courageous promise made in difficult times and kept.

Govind resigned from Stanford and went to TIFR. He sent up India's first Radio telescope in Kalyan, near Mumbai, importing the parabolas from the Potts Telescope in Australia where he had worked as a visitor under the Colombo plan ten years earlier.

Govind embarked on building a radio telescope with Ooty as its site. This was a daring and audacious adventure for a 33-year-old starting investigator. This was when nothing could be imported, budgets minuscule and astronomers and engineers had to be trained from scratch.

Explaining what he wanted to do he says the plan was "to construct a large cylindrical radio telescope on a suitably-inclined hill in southern India so as to make its axis parallel to the Earth's axis, and thus taking advantage of India's close proximity to the Equator" The idea was 'sold' to Bhabha. The telescope was the source of important radio-astronomy findings. Govind says: "The design & construction of the ORT was a great challenge... as the development of technology in India was still in its infancy, and foreign exchange limited ..."

Govind embarked on a new mission to build a giant equatorial telescope, in Kenya or Indonesia. When those efforts did not materialize, he developed what was later to become the Giant Meterwave Radio Telescope (GMRT) and the

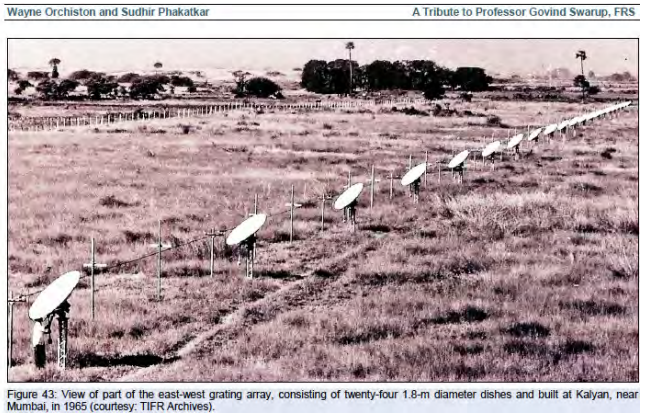

Figure 43: View of part of the east-west grating array, consisting of twenty-four 1.8-m diameter dishes and built at Kalyan, near Mumbai, in 1965 (courtesy: TIFR Archives).

National Centre for Radio Astrophysics (NCRA).

"The GMRT is the world's largest and most powerful low-frequency array and has been popular with Indian and overseas radio astronomers from the time it became operational."

"From Jan 2002- Sep 2015 there were 1769 successful research proposals submitted by astronomers from 31 different countries. Just under half of all proposals came from India."

From Kalyan to Ooty, and Narayangaon, led by Govind Swarup, India has built a great tradition in radio astronomy and populated the field with quality scientists and engineers. Radio astronomy has grown at the Raman Research Institute, Bengaluru and Indian Institute of Astrophysics, Bengaluru.

Govind was passionate about education combined with research. His writing and presentation to the Prime Minister's Science Advisory Council led to the establishment of the Indian Institutes of Science Education and Research, an idea pushed through by Professor C.N. Rao.

K. VijayRaghavan
Principal Scientific Advisor to the Government of India

We, the member of Department of Atomic Energy, are deeply saddened by the news of Prof. Govind Swarup's sad demise on 7th September 2020. Prof. Swarup was a beacon of inspiration, an innovator par excellence and a wonderfully inspiring leader. The scientific excellence of Prof Swarup and his group impressed Dr. Homi J. Bhabha who requested him to start the radio astronomy research in India. Prof. Swarup not only indigenously built the largest Radio Telescope of that time at Ooty, but built it to such a perfection that even after 50 years, the telescope is fully functional and producing useful results. He mentored a group which conceptualized, designed and constructed Giant

Meterewave Radio Telescope (GMRT) near Pune.

Regarded as the father of radio astronomy,Prof. Govind Swarup has left a big void and rich legacy of outstanding science and institution building. The absence of Prof. Swarup will be felt by the scientific fraternity in India in general and the members of DAE family in particular.

My the departed soul rest in peace. Our heartfelt condolences to the bereaved family

K. N. Vyas
Secretary, Department of Atomic Energy and Chairman, Atomic Energy Comission, Government of India

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Professor Govind Swarup was indeed a National Icon. It is rare for a scientist to command such widespread public appeal. That is because he was not only a brilliant scientist, but one among the prominent nation-builders after Independence. His efforts put India on the global research map in Radio Astronomy. He showed by way of real examples that it is not the resources that constrain the limits of scientific ambitions, but the limits of our imagination and creative abilities. He was a crusader for self-reliance in scientific instrumentation, of an Atmanirbhar Bharat.

He inspired scientists from across the institutions in the country to work for common scientific goals, including in DST institutions such as RRI, IIA and ARIES. RRI made important contributions to the GMRT and he guided IIA in building the 90 inch optical telescope indigenously. More recently, ARIES benefitted immensely from his guidance as the Chairman of its Governing Council.

With his passing away, India has truly lost an outstanding personality. The paradigms for practice of scientific research that he championed and followed will continue to guide us in the times to come.

All of us in this country will pray for the peace of his departed soul!

Ashutosh Sharma
Secretary, Department of Science and Technology, Government of India

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I first met Professor Govind Swarup sometime in mid 80s when he made a presentation to a largish group on the objectives, the concept and the details of GMRT project. What impressed and inspired a mechanical engineer like me was the fact that Professor Govind Swarup was not only a very eminent scientist, a recognised and very competent astronomer astro-scientist but also was a very competent engineer and project manager.

Later on I came across Professor Govind Swarup a number of times in different contexts and what has made a deep impact on me is his holistic approach to deal with scientific research, instrument and equipment building with a high degree of self-reliance, value addition within the country, and an overall approach to doing science in the country, which actually emulated the principles and ideals set forth before all of us by Dr. Bhabha. And I always felt that Professor Govind Swarup was next Dr. Bhabha for at least a person like me.

I use this occasion to pay my respects to his memory and wish that we continue his legacy for times to come.

Anil Kakodkar
Member, Atomic Energy Commission and former Secretary, Departmernt of Atomic Energy, Government of India

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I am deeply grieved to learn of the passing away of Dr. Govind Swarup. He was a pioneer in radio astronomy. And he built a group in the field which was sustained after his superannuation. When talking about Homi Bhabha, I also refer to his bringing in leading Indian scientists from abroad. In that context, one of the examples I give is that of Dr Govind Swarup.

I, and my wife, remember his smiling and warm personality, when we lived together in Kenilworth in the sixties, in fact in the same floor.

We pray that his soul may be in peace.

R. Chidambaram
former Principal Scientific Advisor to the Government of India

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I am deeply saddened by the news of the demise of Prof. Govind Swarup. With his passing away we lost an iconic figure of our atomic energy family. During my first visit to Ooty, I was awestruck by the sight of the half a kilometre- long and 30

metre- wide radio telescope aligned along the local latitude taking advantage of the slope of the terrain. Precise maneuvering of such a mammoth structure of parabolic cylindrical reflector and detecting feeble signals are no doubt engineering marvels. The team led by Prof. Swarup conceived, designed and built such a facility entirely with indigenous resources way back in mid nineteen sixties. I was told that the high sensitivity of the telescope makes it capable of detecting signals from a mere 1watt radio station located 10 million kilometer away.
The telescope has served half a century and continues to be one of the most sensitive radio telescope in the world. The high sensitivity and the collecting area of the Ooty radio telescope has been exploited for studies of astrophysical phenomena such as pulsars, solar wind and proto-galaxies. The exemplary ingenuity and courage shown by Prof. Swarup to take up such a project, when the country's industrial infrastructure was at its infancy, will leave an indelible mark in the Indian scientific history. I recall several occasions of meeting him and has always been impressed by his sincere and unassuming persona and his contagious enthusiasm. He will always remain an inspiring personality to scientists for generations to come.

Sreekumar Banerjee
former Secretary, Department of Atomic Energy, Government of India

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I met Govind for the first time after joining NCL in Pune four decades ago. The lovely smile on his face in the first meeting that I saw was the same that I saw when I met him for the last time during his 90th birthday celebrations.

I deeply admired Govind not just as a scientist, but also for simultaneously belonging to my tribe, namely engineering science and frugal innovation.

GMRT, with its ingenious SMART structural engineering, with its lowest cost but high sensitivity and accuracy, was an exemplar of frugal innovation with our Indian speciality of affordable excellence. Govind had 3 drivers in his life, purpose, perseverance and passion. But in addition, he had something extra, persuasion.

I was a personal witness to all these four attributes, when I saw him conceptualise and champion the building of, what were then to become Indian Institutions of Science Education and Research, with Science Advisory Council to the Prime Minister, of which I was then privileged to be a member.

This showed that Govind was not just 'telescope man' of India but he also had a grand 'telescopic vision' of Indian science. Today we talk about Atmanirbhar Bharat. Govind was an epitome of Atmanirbhar Bharat with Atmavishwas. Self reliant India with self confidence.

The leadership he provided in making India self reliant in 'antennas', by snatching away the turnkey project with rare self confidence from a foreign vendor, should serve as an Inspirator for us today.

To me, Govind was not an individual, but an institution himself, besides being an Institution builder. Individuals go but Institutions remain for ever. So Govind will live for ever.
I end by paying my humble tributes to this great legend and convey our deepest heartfelt condolences to his beloved family, Bina, Anju and Vipin.

Raghunath Mashelkar
former Director General of the Council of Scientific and Industrial Research, India

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Prof Govind Swarup was a visionary who applied his beautiful and creative mind to peep into the deepest and earliest part of the cosmos through an extraordinary feat of engineering and technology. His spirit of nationalism coupled with courage of conviction and self-confidence that India can do it made him venture into two world class telescopes successively, one in Ooty and the other in Pune, which today have been instrumental in producing some of the most fundamental and front ranking astrophysical outcomes contributing to the everlasting repository of human knowl-

edge. Simple in idea complex in execution; many who participated in this were of ordinary skills but with extraordinary commitment and abilities. These telescopes have stood the test of time as some of the foremost observatories anywhere in the world. My own personal contacts with Prof Govind Swarup were several at different points of my career, as a student, as a professional in space program, as Chairman of ISRO and more recently as my sounding board and mentor while seeking advice for Planning Commission and beyond. On each of these occasions, I saw him in different avatars, which he donned with ease, appropriate to the situations at hand. He strode like a colossus in the scientific firmament of this country and the world for several decades. The wonderful experience of knowing him and learning from him will always be etched in my mind as something special in my life.

K. Kasturirangan
Member, Atomic Energy Commission and former Chairman, Indian Space Research Organisation

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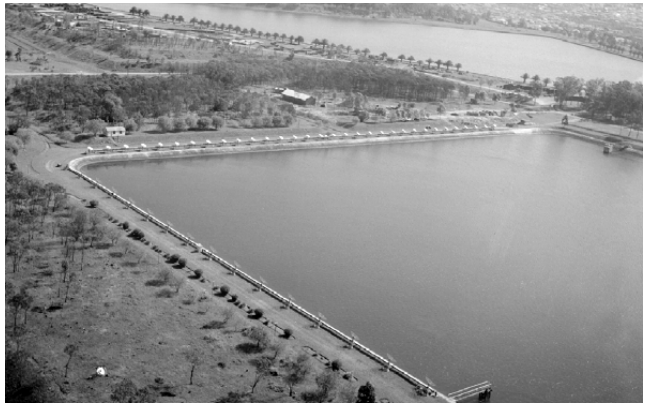
Govind Swarup joined Joe Pawsey's radio astronomy group at CSIRO in Australia and started working with Chris Christiansen using the Potts Hill radio telescope array. Govind Swarup calculated the Fourier Transforms by hand taking more than a month with an electronic calculator. The result was the first earth rotation aperture synthesis image. Thinking about better ways to make these calculations gave Govind an idea which he later discussed with Bracewell in Stanford. This was the genesis of the "Bracewell and Riddle" back-projection algorithm which had a major impact on medical imaging in the late 1960s. The dishes from the Potts Hill Array were given to India and used by Govind to start the first radio observatory at Kalyan.



As you will hear from Richard Schilizzi, Govind's impact on future radio astronomy developments extended well beyond India. At an ESA symposium in Leiden in 1993 Govind suggested a plan for an URSI Large Telescope Working Group and this plan was ratified at the URSI General Assembly in Kyoto later that year.

Govind was well known for his stream of innovative concepts and he also believed that through such International projects we could make the world a better place.

Thank you Govind

Ron Ekers
former Director, VLA, USA and former Director, ATNF, Australia

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Dear Bina and Friends,

As friends of the Swarup family since 1970, we send our deepest condolences on the loss of a dear friend. Govind and Bina became our close friends for the next 50 years. We would meet in many places. We first met in 1970 when we took the train from Bangalore (Indian Airlines strike!) to Coimbatore then by jeep to Ooty. Vijay Kapahi, who was to be our close friend for many years. We had a famous hike on a Sunday afternoon near the

telescope with Govind and his family.

Later a memorable highlight was our long visit in 1980. The GMRT was under construction and we witnessed the raising of one of the aerials with the multi-man crew. Back at NCRA we stayed for a few weeks. The world cup of soccer was occurring and we watched on tv at the Swarup home. We made many new friends.

Through the years, the Swarup family looked after us in many places. In addition to Ooty and Pune, we had wonderful visits in Groningen during his sabbatical there almost 30 years ago. We never forget the wonderful meals and hospitality we had at their nice home in Paterswolde.

In December 2013, I had a long visit to NCRA for the first Metrewave Sky Conference. Govind made his archive available as I prepared by article on "Origins of Radio Astronomy at the Tata Institute of Fundamental Research and the role of J.L. Pawsey". I spent a long weekend finding and copying many fascinating documents. This "Origins.." text was published in the 2014 volume in the Astronomical Society of India Conference series. Jayaram Chengalur was a major player in bringing my paper to completion.

This paper will now be included in the 2021 book (by WM Goss, Claire Hooker and Ron Ekers, Springer) From the Sun to the Cosmos, JL Pawsey, Founder of Australian Radio Astronomy. During this visit of 2013, I also saw and received a copy of the masterful interview done by Prof Indira Chowdhury whose book, Growing the Tree of Science: Homi Bhabhaand the Tata Institute of Fundamental Research (2016), contains an account of the founding of TIFR radio astronomy in the early 1960s. She has become a personal friend; we have met twice in Bangalore. The connection of Pawsey and Bhabha at the Cavendish Laboratory in Cambridge in the 1930s had been pointed out by Chowdhury in her earlier book from 2010, A Masterful Spirit: Homi J. Bhabha 1909-1966. I include a few photos from the past:

Room in Sydney University CSIRO radiophysics department where apparatus used in radio-astronomy experiments is built. Standing (from left): John Bolton, Gordon Stanley, Dr. Pawsey.

Fig 1. Sydney Australia , CSIRO (1953-1955), in back left to right John Bolton (FRS), Gordon Stanley, Joseph Pawsey (FRS) and in foreground Govind Swarup (FRS). Goss had worked for Stanley (Caltech 1971-1972) and Bolton (1967-1970 and 1974-1977, Parkes CSIRO).

Fig 2. shows Govind and Bina in West Texas (1956-1957), at Fort Davis, the Harvard Radio Astronomy Station. In the late 1980s, Goss met some old timers in Fort Davis, that had strong memories of Bina. She had made many friends and her (automobile) driving lessons left fond and humorous memories in the friends in Fort Davis. In addition, her infamous long cloths line with several saris blowing in the wind was a lasting subject of discussion and laughter. I assume this car in the photo is the car in which Bina learned to drive – on the right- hand side.

Fig 3. Stanford March 1958. Joe Pawsey puts his carved signature on pier East 1 of the Stanford Microwave Radioheliograph under construction. From the left Ron Bracewell, Govind Swarup and Pawsey. This pier is now part of the Bracewell Radio Sundial at the Very Large Array in New Mexico (Noon pier). Swarup's signature is on pier East-2 (10 am pier)

Fig 4. Staff present on 5 March 1958 at the Stanford site. From left C.C. Lee, mechanical engineer, Clark ?, Bracewell, Swarup and Chang (research student?) Photo by Pawsey with his Rolleicord camera.

W. M. Goss
Emeritus Scientist at National Radio Astronomy Observatory, USA

In the death of Dr. Govind Swarup on the 7th of September,2020, we and the world have indeed lost a brilliant scientist, a renowned astronomer, an accomplished engineer, and a great human being.

I first met Govind at Stanford in 1960, where I had gone from the Tata Institute of Fundamental Research (TIFR) on study leave to work for my Ph.D. degree in physics. He had just completed writing his Ph.D. thesis, and had been working as an Assistant Professor on the Stanford radio telescope, newly constructed on a hill towards the west side of the university campus. I still remember several dinners hosted by him and his gracious wife, Bina, at his home at Palo Alto, CA, where I was often invited along with several other students from India. During one of those informal dinner meetings, he told me that he was definitely planning to return to India, and that he had written to several persons in India to explore this possibility, including a letter to Dr. Homi Bhabha, the Director of TIFR at that time. Although, he already had some experience of working in India, at the National Physical Laboratory (NPL), New Delhi, before he left for Australia and Stanford, he was keen to know my views regarding the work culture at TIFR. Later, when he told me that he had received an encouraging response from Homi Bhabha to join TIFR to set up a radio astronomy group, I was obviously very excited and hopeful that he accepted the invitation! Indeed, he joined TIFR in 1963.

When I returned to TIFR in 1965 after my Ph.D., Govind was already building antennas for a small radio telescope at Kalyan in Mumbai. But he soon shifted his workplace to the TIFR Center in Bangalore, to be able to construct the Ooty Radio Telescope (ORT) at nearby Ooty. My interaction with him during that period became somewhat limited. Nevertheless, whenever he visited the TIFR main campus in Mumbai, he would often come to my office to tell me about his ideas on various topics, including the problem of improving science education at universities and colleges in India. I very much enjoyed those far reaching discussions. By the time I became the Dean of Physics Faculty, during 1983 to 1987, when Dr. B V Sreekantan was the Director of TIFR, our interaction increased considerably, as TIFR was putting up new proposals for the next national Five Year Plan, for setting up three new National Centres, including the National Centre for Radio Astrophysics (NCRA). Dr Swarup had also proposed to build a Giant Metrewave Radio Telescope (GMRT), under that Plan. The GMRT was indeed a very big and ambitious project. After the national approval for the project by 1987-88, he spent most of the time, along with his distinguished colleagues at NCRA in Pune, in designing and erecting the GMRT at Narayangaon, near Pune. He was very keen that his novel design for the required antennas should reduce the cost considerably, without sacrificing their efficiency. Throughout his scientific career, he always looked for perfection, and there was no exception to this rule in designing the GMRT. In fact, after I became the Director of TIFR in 1997, and the GMRT became fully operational soon after, I found Govind Swarup to be extremely happy and relaxed. An additional project to upgrade electronic control and data collection systems of the GMRT was also implemented during the next three to four years. With the completion of the initial project and its continuous upgradation, the GMRT has become a unique radio telescope which is being used by scientists from all over the world. It is a highly versatile instrument for new astronomical discoveries at the frontiers of knowledge. In addition to his several important scientific contributions, I think the GMRT is one of the greatest tributes to the memory of Govind Swarup.

S. S. Jha
former Director, Tata Institute of Fundamental Research, Mumbai, India

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Amongst scientists in India, Prof. Govind Swarup stands out in terms of vision and accomplishment. He was ever-passionate about both science and education. I remember he came to meet me at TIFR soon after I took over as Director in 2007. In his inimitable style, he strongly stressed the importance of educating and training young scientists, especially at the undergraduate level, in the milieu of a large research institute. Today, although we do not have a full-fledged undergraduate programme at the Institute, TIFR and its Centres do engage with undergrads in diverse, creative ways. It was indeed the good fortune of TIFR to have had him seed, and then lead, the radio astronomy programme at the Institute. As we know, this effort has paid rich scientific dividends over the years. One of Govind Swarup's most significant accomplishments was to gather a truly fine set of people at NCRA around the GMRT. I believe it is this single point which will ensure that his legacy will endure long --- beyond the decades to come ...

Mustansir Barma
former Director, Tata Institute of Fundamental Research, Mumbai, India

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The passing away of Govind Swarup removed from the scene the oldest active astronomer in India. Although 'oldest' indicates age, so far as Govind was concerned he was the youngest nonagenarian astronomer in India. Having observed him at work for nearly five decades I feel that he was ageless. There are several ways to look at this statement.

Firstly, whenever you met him he would have some idea to air. The idea may be to do with some new kind of radio telescope, or some new type of institution to attract young students. The trouble was that his imagination was fast changing and if you met him even after a week, he would have changed the ideas he last talked about.

Secondly, he was one of those rarities in India who are at home with instrumentation. His ideas fructified in Kalyan, Ooty, Khodad, ... and also in Brazil where Hanumant Sawant learning from Govind set up a telescope.

Thirdly, he had developed contacts with radio astronomers worldwide and it was through them that he kept Indian radio astronomy on active interaction with the international community of radio astronomers.

My interaction with Govind was closer when we both moved to Pune. He was setting up GMRT and its controlling institute NCRA and I was setting up IUCAA. Having Govind on our various committees was a mixed experience. But on the whole I would definitely rate it as positive. Certainly we are grateful to him for providing some office rooms in NCRA until IUCAA had its own buildings. This also included the shelter for IUCAA's growing library.

He will be greatly missed.

Jayant Narlikar
Emeritus Professor and former Director, IUCAA, Pune, India

I had like to begin by thanking the organisers of this event for giving me a few minutes to express these thoughts, which I am sure are going to hold a lot in common to the words said by many in this memorium and are perhaps essentially a repetition.

This is to express my deepest appreciation of the contributions that Dr. Govind Swarup made to the Indian Science and Education ecosystem. I do not work on Astronomy or Astrophysics, but because of the increasing importance of Astroparticle physics, I am able to appreciate the academic aspect of the impact of, for example GMRT, beyond the obvious pride of it being an important India based mega project. Being familiar with quite a few mega projects and the International mega projects community, I know the high regard in which GMRT (and of course prof. Swarup) are held at the International level. In the time period when India still very much carried the tag of being a 'developing country', Prof. Swarup built and raised a world class facility with the rather meager resources available then. This was brought home to me in full force, when I happened to be a member of some group which was being told of the plans of extending and strengthening GMRT program further.

I also had interaction and discussions with him in the context of his passionate interest in co-existence of science education and research in our Institutions, which I happened to share with him, since I had been involved with educational institutions in almost my entire life in science in India. In this interaction I experienced his innate humanity and kindness to a much younger and inexperi-

enced member of the science community. Indian science would forever grateful to him for his immense and essential contributions to guide its progress in Radio Astronomy.

Rohini Godbole
Honorary Professor, Indian Institute of Science, Bengaluru, India

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Let me make an extempore tribute to Govind whom I have known for many years. He was the first person I came across when I came on-board TIFR in 1967. He welcomed me, and Bina and Govind clearly made our family a part of their. When the Ooty Telescope was coming up, they invited us along with our little boy who was hardly 8 months old then, to come to Ooty. I could see what an enthusiastic support Govind was giving to his colleagues. His students then were really helping him and his passionate involvement in building up what is now known as Ooty telescope after the Kalyan radio telescope. There was like a radiation drag, which you felt.

Govind had always been a passionate scientist and an electrical engineer by training. At Standford, he did his PhD and then followed the example of Cavendish laboratory under the advice of Dr. Homi Bhabha. The Cavendish laboratory was well known for great work in nuclear physics and particle physics. But when Lawrence Bragg took over as the Cavendish Professor from Rutherford. He said you cannot afford to compete with United States and European nations, so let us now switch and he made the switch to Radio Astronomy by inviting Martin Ryle to set up Radio Astronomy and Max Perutz to set up Molecular Biology. The rest is history. And Dr. Bhabha, on that advice of John Cockcroft, exactly followed this advice. He invited Govind Swarup to set up the RA group and Obaid Siddiqi to set up the Molecular Biology group. All in all, if you look at the history, these two inspiring visionaries really set, if you like, basically the road map for the development of Indian Science. Swarup really made his phenomenal contribution... See many of conceive mega-Science, very few of us deliver and extract science at the end of it all. Govind dreamt of setting Ooty and then the GMRT. In fact, I was present at the DAE headquarters, Dr. Ramanna had invited some of us as kind of experts when Govind made the presentation for building up the GMRT. The only comment, Dr. Ramanna made was, "Govind don't be a bania. You are projecting the whole project in 30 crore. I will sanction 50 Crore for GMRT." And GMRT indeed needed that kind of budget. So, you need a good patron and DAE happened to be good patron. Swarup had the freedom and an enthusiastic batch of students, some of who spoke earlier. He delivered in about 15 years time, the GMRT.

But you know what Govind has always been very restless visionary, after Kalyan, he conceived the Ooty. After Ooty, he came to GMRT, I am sure, even in eternity Govind will be a restless creature, who will probably be planning a celestial network. So don't be surprised if one of these days we get signal from him.

I will remiss if I do not mention the contributions his wife, Bina, and the family made. Bina used to be alone in the TIFR quarters and Govind would spend months at Ooty, and later on at GMRT. With that I would like end my extempore tribute to Govind's memory who I will sorely miss as both my teacher and my mentor.

S. M. Chitre
former Professor, Dept. of Astronomy & Astrophysics, TIFR, Mumbai, India

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Govind will be sorely missed. He was an inspiration, for his contribution to world astronomy, for his huge role in building radio astronomy in India and for the help and friendship he gave in building radio astronomy in South Africa. Govind played an important role in advising us on the development of the MeerKAT and the SKA in South Africa. He was a warm and generous friend. Govind played an important role in the SKA as a global project and his continuing interest in the SKA was valuable and inspirational. We will miss him.

Bernard L. Fanaroff
former Director, South African Radio Astronomy Observatory, South Africa

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Professor Govind Swarup had a long and productive career, where he remained dynamic and energetic throughout. Professor Swarup's most significant contribution to radio astronomy will be remembered through the major and innovative radio telescopes whose design and construction he has spearheaded in India. Throughout his career he was also a strong supporter of international

relations, spending some of his early years working in a number of different countries, including CSIRO in Australia. He was such a good friend and colleague to many of us here today.

This combination of lifelong national and international collaboration, effort and enthusiasm is so well summed up in these last fifteen lines of Lord Tennyson's poem "Ulysses"

Come, my friends,
'Tis not too late to seek a newer world.
Push off, and sitting well in order smite
The sounding furrows; for my purpose holds
To sail beyond the sunset, and the baths
Of all the western stars, until I die.
It may be that the gulfs will wash us down;
It may be we shall touch the Happy Isles,
And see the great Achilles, whom we knew.
Though much is taken, much abides; and though
We are not now that strength which in old days
Moved earth and heaven, that which we are, we are, One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield.

Dave Jauncey
former Chief Research Scientist at CSIRO, Australia

On behalf of the staff of the National Radio Astronomy Observatory and all of Govind's friends and colleagues in the US astronomy community, please allow me to extend our deepest sympathies to his family, and express our sense of loss at his passing.

We will remember Govind for his decades of friendship, his commitment to international collaborations, and his innovative concepts for new radio telescopes starting with Ooty, then GERT, and finally GMRT with its SMART antennas. I remember many great discussions with him at conferences across the years, where his passion and intellect were apparent to everyone.

Sincerely

Tony Beasley
Director, National Radio Astronomy Observatory, USA

Namestey!

I am Atul Benke, MLA from Junnar, where the GMRT project is situated .
Honourable Govind ji Swarup, scientist who passed away, had done a very good job in our constituency.

First when the GMRT project was located there and the land was acquired from the farmers, it saw a huge agitation from the farmers. My father, MLA Vallabh Benke who was the leader over there, he spoke with Govind ji Swarup. The social part of his life, he did it very properly. The demand of Vallabh ji Benke and all the farmers was that to give some job to the farmers and to their children.

He said it is a very technical job which is a scientific oriented field and and so we can't just put the farmers over there. But for the non-technical persons you should do it for the farmers, Vallabh ji Benke insisted, and Govind ji Swarup accepted it. The central government was not ready to do all these things but with the immense pressure by Govind ji Swarup, the central government agreed and all the non-technical jobs were given for the local people.

GMRT is a very huge asset for our country, and due to GMRT, lots of jobs were created, and all the non-technical jobs were for the local people. GMRT is a huge asset for a country, the significance of a rural Maharashtra. So I thank Govind ji Swarup for the massive job.. He was very closely associated to my family. The social part of his contribution was too much that he made lots of friends in our area - the farmers, the politicians, the businessmen or the bureaucrats also.

So Govind ji Swarup was a humanly person for us. He was down to earth, friendly and we were very

fond of him. During my childhood, when I first saw Govind ji Swarup, I intended of becoming a good person like him. He passed away and it is a sad demise for his family, to the nation and obviously for the home-town Junnar also. Condolence to his family, scientists and may his soul rest in peace.

Atul Benke
Member, Legislative Assembly of Maharashtra from Junnar, India

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Renowned radio astronomer and scientist Dr. Govind Swarup died on 7 September 2020 due to old age. Dr. Swarup has contributed a lot in the field of astronomical research. He has played a major role in setting up the GMRT project at Khodad. This project is definitely of benefit to scientists from our country and abroad. His passing away has caused us a great loss. Khodad Grampanchayat, Khodad villagers as well as all service organisations from Khodad are with NCRA in this difficult time. We pray that Dr. Swarup's soul attains eternal peace.

Vishawas Kale
Sarpanch, Khodad village, Maharashtra, India

The famous astronomer Dr. Govind Swarup's passed away on 07/09/2020 due to old age and related illness. Dr. Swarup has done lot of research work in the field of Astronomy. He was instrumental in setting up the GMRT project at Khodad. Scientists from our own country as well as from abroad have benefited from this project. His sad demise is a big loss to all of us. I myself, the Grampanchayat Khodad, all village organisations and all the villagers of Khodad are with the NCRA in this painful time. We pray that the soul of Dr. Swarup attains eternal peace.

Shankar Eknath Thorat
former Sarpanch, Khodad village, Maharashtra, India

With the demise of Prof. Goving Swarup, we, not only India but the world has lost a great scientist and pioneer of astrophysics. I got the opportunity to meet him for the first time in Jehangir Hospital, Pune, when I was completing my postgraduate studies in medicine. After formal introduction, he requested me to serve for the staff and employees, and their families at GMRT, Khodad. Later on when three years later I started my Hospital at Narayanagaon, he came personally to our Hospital and asked me to join as a medical officer for the GMRT and their staff. Since that I am serving for the staff and employees and many International delegates of GMRT. The GMRT is just like family to us and our staff members . In 1997, after a fatal accident with a GMRT bus, he was instrumental for us in getting a modern ventilator in our hospital. With that we have started a Rural Critical Care Centre and saved thousands of lives of snake-bite poisoning and accidents, and many critically-ill patients in rural areas. In the inauguration speech of International Conference organised by International Critical Care Society of Pune at Bal-Gandharva in Pune, he emphasised the need of small Rural Critical Care Centres in India, which is very important. And his vision is also very important in health, as in Covid-19 situation there is a need for many oxygen and ventilator beds. So this is a very important point he has told this thing about 15 years back. And after that he has also given a speech at the age of 85 years in the IMA, Pune district Conference. His speech was really inspirational to all Doctors, so everybody appreciated his speech. Last incidence, we met about one year back at his birthday celebrated at Pune. He was very fresh, smiling and talked to us in a very good mood. We are fortunate to be associated with such a towering personality. We pay condolences to his family and may his soul rest in peace.

Dr. Raut
Medical Doctor, Narayangaon, India

With the passing of Prof. Govind Swarup on the evening of September 7, 2020, TIFR and India has lost an iconic figure. A true pioneer, he jump-started the country's efforts in the nascent field of radio astronomy, and built facilities and institutions that have put India on the global stage in the forefront in radio astronomy. He leaves behind a legacy that we can be truly proud of.

Govind Swarup was born in 1929 at Thakurdwara in the then United Provinces. He received an M.Sc. in Physics from the Allahabad University in 1950, where K.S. Krishnan was an important influence, and a Ph.D from the Stanford University in 1961. He joined the Tata Institute of Fundamental Research (TIFR) in 1963, at the invitation of Dr. Homi J. Bhabha. The Radio Astronomy group he founded

at TIFR was one of the first of such groups in the world. Swarup and his team quickly began building new facilities, starting with a relatively modest radio telescope at Kalyan near Mumbai, but soon moving on to the much more ambitious Ooty Radio Telescope (ORT) at Udhagamandalam in Tamil Nadu. Prof. Swarup's highly innovative design for the ORT (built during 1965-70) allowed for the construction of a fully steerable, large telescope at a modest cost. The ORT is functional even today, having produced several cutting-edge science results in a wide range of fields from the solar wind, pulsars, the diffuse interstellar medium, extra-galactic radio sources and cosmology.

During 1984-96, Swarup conceived and directed the design and construction of the Giant Metrewave Radio Telescope (GMRT), which consists of 30 large fully steerable antennas, each 45 m diameter, spread out over a 25 km region, near Khodad village, about 80 km from Pune. Once again his innovative design was crucial to allow the construction of a world class telescope at a very modest cost. The GMRT remains one of the most sensitive radio observatories in the world in the frequency range of 130 — 1450 MHz , attracting users from all over the world and producing a slew of cutting-edge science results. It has the pride of place as one of the biggest basic science projects in the country. Swarup became the project director of the GMRT in 1987, and when his group in TIFR became the National Centre for Radio Astrophysics of TIFR, he became its first Centre Director in 1993. He was a strong proponent of building up scientific capacity in the country, and played an important early role in the setting up of the IISERs. Swarup was a Fellow of the Royal Society (FRS) of London and of all the national science academies in India, and also of The World Academy of

Sciences. He had received over 20 national and international awards, including the S.S. Bhatnagar Prize (1972), the Padma Shri (1973), the Herschel Medal of the Royal Astronomical Society (2005) and the Grote Reber Medal (2007).

Despite his many achievements, Swarup remained a down-to-earth person, as happy to hold discussions with junior technical staff as with some of the greatest scientists of his time. He was always friendly and approachable, and he continued to share his infectious enthusiasm with young students till the very end. He is survived by his wife Bina, son Vipin, and daughter Anju.

Tata Institute of Fundamental Research, Mumbai, India

Dear Prof. Gupta,

We, at TATA Consulting Engineers, are deeply saddened to hear the passing away of Prof. Govind Swarup.

TCE had the privilege of working on the Optical Radio Telescope and GMRT projects. During the close interaction with Dr. Swarup, we were, as an engineering consultancy organisation, continuously amazed and inspired by his deep knowledge of various disciplines of engineering, apart from physics and astronomy.

At the same time, we were deeply impressed by his perennial quest for knowledge and innovation, his humility, affability and several qualities which we believe helped him to become one of India's top institution builders.

We believe that the role which he played in nation-building, consciously leaving behind an exciting career abroad, and striving to firmly place India in a respectable position in the global community of radio astronomers, will continue to inspire the future generations.

Kindly convey our condolences to his bereaved family, including the extended family at NCRA.

Very truly yours
For TATA Consulting Engineers Limited

Tata Consulting Engineers Limited, Mumbai, India

We in ARIES, Nainital are deeply saddened by the passing away of Prof. Govind Swarup. We express our heartfelt condolences to the grieved family members. Many members of ARIES have unforgettable memories of his association with ARIES when he was the chairperson of ARIES governing council and guided ARIES to the path of success and self-reliance.

Prof. Swarup accepted the charge of chairperson

Visit of Prof. Govind Swarup to the 3.6-m Devasthal Optical Telescope in November, 2016

Prof. Swarup in November 2016 at Devasthal, enquiring to the AD-FOSC team about the instrument, which was being built in India and now completed and commissioned on the 3.6-m DOT

of ARIES Governing council on 15th march 2016, when the installation of the 3.6-m Devasthal Optical Telescope near Nainital was just completed. He wholeheartedly supported the Devasthal optical telescope and ST-Radar projects of the institute. Prof. Swarup, as he has always been, remained inspiring for the ARIES members. He relentlessly enquired about the progress on the back-end instruments for the telescope and the images coming from the telescope. He was very supportive of building ARIES-Devasthal Faint Object Spectrograph & Camera (AD-FOSC) in India, which is now commissioned on the 3.6-m DOT. Four meetings of the governing council were held under his chairmanship between March, 2016 and November, 2017. Prof. Swarup visited Devasthal in November, 2016. ARIES is indebted for his invaluable contributions towards the progress of the institute.

Prof. Govind Swarup has left behind an ever-inspiring legacy in the forms of his works, vision and positive thoughts, which will keep guiding us for many years.

Amitesh Omar
Scientist, ARIES, Nainital, India

Dear Prof. Swarup

Today, I am not writing anything formal, but something which I truly feel by my heart. From my childhood, I had an interest in science, space and people who work in space. Later during the time of senior secondary, I get to know about a field which is known as Astronomy & Astrophysics. I did a very short research about both terms and saw the beautiful images of objects outside the tiny earth. I was fascinated and curious to know more about it. Then after getting enrolled in engineering, I searched, "How can an INDIAN Engineer contribute/work in the vast field of astronomy?, and it was the moment I first saw your name and then a pic of yours. Your name was there on the internet as the person who gave us the world-class facilities i.e. GMRT and ORT. That time I was not aware of the field deeply but in the second semester of my engineering, I got an opportunity to visit NCRA-TIFR. There was a workshop on "GRB: Prompt to Afterglow", which I attended after a lot of immature emails to Prof. A.R. Rao, asking

him that sir please give me a chance to attend the workshop. He was kind enough to allow me and It became my first occasion to visit any Research Institute. In the workshop, I met with Prof. Patrick Dasgupta and the way he attracted me towards astronomy and Astrophysics. It was awesome and I decided to pursue Astronomy as a career. Though I didn't meet you in person, I had in my mind that if a professor younger than you have done these many things in research and of awesome nature. I knew how great you would be?

After around 1 year of attending similar workshops and conferences, I thought to start a group of young astronomy aspirants to take them with me to the research institutes and have a feeling of the real research environment. I was fortunate enough to find a few colleagues who were already known to the field and had visited the institutes. Together we attended a lot many events across India and also get to know more about the pioneering work done by you, Prof. JV Narlikar, Prof. S. Anantkrishnan, and many others. At around the end of my fourth semester, I visited GMRT and our return from that event came up with an idea to start a small group of people to work on astronomical projects. And after a discussion with the team, We came up with 'Radio Space Physics Lab". We had no contact with you and hence I remembered you in my heart and opened it for the college students. The lab is present there in the college and I am happy that the management allotted us a full workshop loaded with various machines, tools, and with permission to work 24x7. This all happened because of the inspiration we got from GMRT, ORT, and the greatness of yours. In March 2019, we were the organizing committee volunteers in the URSI AP-RASC 2019. We, fortunately, got a chance to meet you in person but I was again not that lucky. I was selected for a training school in ARIES and hence I was there in Nainital but my other colleagues met you and got wonderful memories of you and Swarup ma'am. Though I didn't meet you you are alive in my heart and I thank you so much for inspiring millions of people to study this wonderful field of Nature.

Our deep condolences. Rest In Peace.

Individual Words:

Prof. Govind Swaroop, The eminent astrophysicist and a humble, kind human being.
Truly, I didn't work that deeply in Radio Astronomy but I had a keen interest in Solar Astronomy. I, Still remember, The conversation with you while going towards the conference venue from the airport during the AP-RASC conference last year in New Delhi. You asked me about my life and passion. After listening to me, You said one thing that I still remember, Your words were, " If you really want to succeed and carry your interest further, You need to work harder and excel your academics and that would be opening the gate of higher education and research." These words are a sharp tool for my mind and nothing can be achieved without hard work. And one who said it, was the man behind GMRT.
Good bye Govind Sir.
- Nishant Singh Rathore

My first meeting with him a few days before his 90th birthday reminds me of how young he was. All happy, energetic and ready to learn something new. He is going to live forever through his great contributions to Indian Radio Astronomy through his research work and the two of world's largest radio telescopes in India - Ooty Radio Telescope and Giant Metrewave Radio Telescope.He was an inspiration to me and many. His will to learn at such an age, his curiosity to know more inspired me to pursue Astronomy further. I can say I am lucky to have met a man of such stature. May his legacy continues to inspire more and more people around the world. His valuable contributions will live with our voyage through space-time.
- Harshit Tiwari

How lucky and proud we feel to have lived in an era in which we had a privilege to meet a legend and a pioneer. Late Padma Shri Prof. Govind swarup,

father of Radio Astronomy in India, such a humble scientist who always encouraged younger generations like ours to pursue fundamental sciences and come up with something for development of our nation's technology. It was just last year during celebration of his 90th Birth anniversary we got to meet him and his wife Mrs. Bina Swarup. We were hesitating in meeting a personality like him. But on going closer to him, we felt honored by the way he started inculcating basic learning through conversation. His dedication towards empowering the youth was truly spirit raising for us. In Spite of his adverse health condition at age of 90, he used to stand and give a continuous talk for an hour or two. To such a soul, who keeps inspiring us in one and many ways. We will greet you at your establishments at Khodad, Pune and Ooty. You're alive in our heart and through all the discoveries which have been made by GMRT and Ooty Radio Telescope (ORT).

Your demise has been an end of era which we use to proudly rejoice as the era of Prof. Swarup !!
-Yogeshkumar Joshi

At the end, We all say goodbye to you. You're still alive within all of us. Mother India gave birth to you and couldn't stay far from you for so long.

Thanks & Regards

Your Inspirations

- *Monica D.*
- *Yogeshkumar Joshi*
- *Harshit Tiwari*
- *Nishant Singh Rathore*
- *Krishna P.*

Regards
Krishna P.
Radio Space Physics Laboratory, India
http://www.radiospl.co.in/

On behalf of IISER Kolkata, our faculty, staff and students I extend our condolences on the passing away of Prof. Govind Swarup. Govind Swarup was a giant in Indian science who inspired generations of students, designed fantastic instruments to probe the farthest reaches of the Universe and catalyzed many national academic initiatives, including the Indian Institutes of Science Education and Research, one of which I have the privilege to lead today. He was one of the last of that pioneering generation which built the foundations of science in a newly independent India. In losing Govind, we have lost one of India's finest citizens.

Govind was a scientist and instrument developer par excellence, building spectacular astronomical

observatories, working with Indian talent on Indian soil. He achieved these feats by nurturing a synergy between scientists, engineers, software developers and

students of science, sustaining an interdisciplinary atmosphere which enabled these world-class observatories. It is precisely this kind of interdisciplinary and holistic approach to science that we wish to nurture in the IISERs today.

Govind was an early proponent of research institutions that would train undergraduate students, seamlessly combining teaching within an environment of research. He along with Prof. V.G. Bhide of Pune University conceptualized such Centres. These ideas were scaled up in later years by Prof. C.N.R. Rao and eventually led to the formation of the IISERs. Govind's contributions were fundamental to the conceptualization and eventual birth of the IISERs.

I am aware that Govind's loss is felt deeply by the community he had touched, including my colleagues here at the Department of Physical Sciences and the Center of Excellence in
Space Sciences India at IISER Kolkata. Govind's life is truly inspirational. Even in his physical absence from this world, I am sure that the legacy of his science and his achievements would continue to inspire and motivate generations of Indian scientists and students.

May his soul rest in peace.

Sourav Pal
Director, Indian Institute of Science Education & Research, Kolkata, India

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विषय: संस्मरण- प्रो गोविन्द स्वरूप

प्रोफेसर गोविन्द स्वरूप के संस्मरण विद्वत समाज के साथ साझा करना अत्यन्त सुखद अनुभव है। उनके चुम्बकीय- आकर्षक व्यक्तित्व के मनमोहक आमंत्रण को नजरअंदाज करना किसी के लिए भी असंभव था । उनके तीखे, स्पष्ट तथा सपाट कमेंट सोचनेकेवलए बाध्य कर देते थे। विषय की गहराई तथा उसके प्रवत उनका लगाव तो अप्रतिम था। इस महामना से मेरा प्रथम साक्षात्कार दो दशक पूर्व वर्ष 2000 मे हुआ था। विश्वविद्यालय मे Astronomical Society of India (ASI) की मीटिंग के उद्घाटन के संदर्भ मे मुझे उनसे भेंट करनी थी। यह एक आत्मीय स्नेवहल साक्षात्कार था। लगा ही नही कि मैं किसी FRS से मिल रहा हूँ। गजब की सौम्यता!

अपने उद्घाटन भाषण मे उन्होने Astrophysics मे research students की उपलब्धता की समस्या का प्रमुखता से उल्लेख किया । अनौपचाररक वार्तालाप मे उन्होने अपने slogan जय जवान जय किसान । जय विद्यार्थी जय विज्ञान ॥ का ज़िक्र किया था। उनकी चिंता अकारण न थी। उन्होने विश्व स्तरीय Observatory GMRT स्थपित किया था पूणत: Indigenous। उनकी सोच थी कि विश्वविद्यालय Radio Astronomy के रिसर्च सेंटर बने। गोरखपुर विश्वविद्यालय अगर रेड़ियो एस्टरोनामी सेन्टर के रुप मे अपना स्थान बना सका है तो इसके लिए प्रो. स्वरूप का तथा उनके सहयोवगयो का मार्गदर्शन और सहयोग मुख्य कारक रहे है। मेरे मार्ग निर्देशन मे श्वेता श्रीवास्तव तथा अल्का मिश्रा ने रेड़ियो ऐस्टरोनोमी मे पी एच डी प्राप्त कि।

प्रो. स्वरूप ने वर्ष 2002 मे विश्वविद्यालय मे Devendra Sharma Centre for Astrophysical Studies (DSCAS) की आधारशिला रखी थी। इस सेन्टर के Coordinator की हैसियत से उनसे घनिस्ठता बढती गई। अब वे हमारे पारिवारिक संरक्षक सरीखे हो चुके थे। उन्हे नजदीक से देखने और समझने का सुअवसर मिला । उनके समय प्रबंधन तथा लगाव से मेरा अभिभूत होना स्वाभाविक था। प्रो स्वरूप बहुआयामी व्यक्तित्व ही नही युग पुरुष थे। उनकी कमी तो हमेशा खलेगी। परन्तु, संतोष की बात है वक उनकी विरासत उनके सक्षम तथा मेधावी सहयोगीयो के हाथो मे सुरक्षित है। उनकी यादे हमारा मार्गदर्शन करती रहेंगी, इस शुभ कामना के साथ प्रो० स्वरूप की यादे सम्पर्पित।

प्रोफेसर ध्रुव चन्द्र श्रीवास्तव,
भूतपूर्व विभागाध्यक्ष, भौतिकी विभाग
गोरखपुर विश्वविद्यालय

It is with immense sadness that we have learned of the passing of Professor Govind Swarup, the world-renowned astrophysicist and radio astronomer, the originator and principal architect of the Ooty Radio Telescope and the Giant Metrewave Radio Telescope as well as the founder of the radio astronomy research team at the Tata Institute of Fundamental Research.

Professor Govind Swarup will forever remain in our memories as a great man of inspiration, eminent scholar, true visionary leader and the Master of unquestionable authority.

His departure is an irreparable loss to the radio astronomy research and in particular to the scientific community of the Astronomical Observatory of the Jagiellonian University. We owe him our heartfelt gratitude for all the years of fruitful cooperation and extremely profound influence that he had on the development of radio astronomy research in Poland.

We extend our most sincere words of sympathy and sorrow to the family members, friends and colleagues of the Deceased.

Directors and Faculty of the Astronomical Observatory of the Jagiellonian University in Krakow, Poland.

Prof. Marian Soida
Director of the Astronomical Observatory of the Jagiellonian University, Krakow, Poland

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One fine day in 1988, when I was busy with my Ph. D. work in the USA, I got a surprise phone call it was Prof. Govind Swarup from the Radio Astronomy Group of TIFR. After enquiring briefly about how my research work was progressing, he invited me to visit their group at Pune during my next trip to India, to hear about the exciting things they were embarking on there. I did make the visit to Pune in 1989, and the rest is history I was so impressed with the plans for the growth of radio astronomy in India and the enthusiasm with which Govind conveyed the same to me, that I decided to join the group immediately after my Ph.D.; a move that I have no regrets about at all.

The early interactions with Govind provided tremendous motivation, both scientific and otherwise; and over the 30 years or so that I worked or interacted with him, I kept learning new things from him (and also about him). His amazing mix of technical expertise and worldly wisdom on how to tackle any challenging task or situation, was hugely inspirational, and I benefited from it tremendously.

One of the traits that I admired the most about him was that he was always looking ahead, to the next challenge. He always dreamt big, with novel and sometimes audacious ideas. He also had the dedication and drive to convert these dreams to realities. Nothing brings this out better than the GMRT project that he conceived of and led, and I consider it my good fortunate that I was part of this en wdeavor with him, as a member of the team.

The other thing that stood out in my mind was his expertise in multiple fields : he excelled in all branches of engineering, was good at project management and man management, and had a strong hold on general administrative practices; and all of this without losing the driving focus on science.

One of my first memories with Govind Swarup, captured on film : from the historic occasion of the raising of the first GMRT antenna (top); even as we are absorbed with the antenna being winched slowly to the final position, Swarup is looking away into the distance, already thinking about the next challenge.

My last public appearance with Govind Swarup : we marked his 90th birthday in March 2019 with the inauguration, at his hands, of the upgraded GMRT.

Furthermore, he could handle many of these tasks simultaneously, much like a multi-core CPU. Several are the times that I was in group meetings with him where he was addressing different topics with different members, without losing the thread on any one of the matters !

Govind also had an amazing ability to identify and attract the best people and build teams, and the skill to interact with all kinds of people and get the best out of them. Finally, as a human being, Govind was an out and out optimist, for ever looking at the bright side. In spite of all his achievements, he was a very down to earth person ready to talk on all matters with everybody, and always with a smiling, cheerful and positive disposition. Over the years, I and my family got to know him, Bina, Vipin and Anju very well, and the lovely interactions will be missed very much.

Govind, having created major facilities in the country and built a strong group and institution, has left us of the next generation with a tremendous legacy something to cherish, as well as to nurture and grow to the next level. In that sense, it was most satisfying that we could have the privilege of his presence for the inauguration of the upgraded GMRT in 2019, coinciding with his 90th birthday celebrations a significant next step on the path that he set us on.

Yashwant Gupta
Centre Director, National Centre for Radio Astrophysics, Pune, India

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I first met Prof. Govind Swarup in the summer of 1986 when I spent a few months with the Radio Astronomy Group of TIFR as a visiting student. I was at that time doing a B. Tech. at IIT-Kanpur, and had developed an interest in radio astronomy. One of my teachers there, Prof. N. C. Mathur, (who himself had played a role in the early development of radio astronomy) suggested to me that I should try and do a summer project with Govind. At that time, the TIFR group, led by Govind, was working on the design for the Giant Metrewave Radio Telescope. That summer, Govind set me the task of computing the reflectivity of wire meshes, which involved both computations based on theoretical models, as well as attempting to make actual measurements using wire meshes inserted into a wave guide. It was my first exposure to experimental research, and it also awakened in me a life long interest in radio astronomy and radio astronomy instrumentation. This was in large part because of Govind's infectious enthusiasm.

Govind was not only responsible for cementing my interest in radio astronomy, but was also instrumental in getting me my first (and so far only!) permanent position. Govind met me at a conference, when I was a postdoctoral fellow, and suggested that I should apply for a position at the National Centre for Radio Astrophysics in Pune, from where he had just retired as the founder Director. I joined NCRA shortly afterwards, at a time when the GMRT was nearing completion; a few years after I joined the telescope was dedicated as a national facility.

Although Govind was, without doubt, one of the most influential persons in my radio astronomy career, what I remember most about him was his interest in everyone that he interacted with. He connected easily to people across a wide spectrum of backgrounds, and took a genuine interest in their concerns. Although he was one of the most accomplished and decorated scientists in the country, he remained down to earth, equally happy to talk to the junior most lab technician as to leading scientists from across the world. To the very end, he retained a keen interest in astronomy, checking on the progress of projects that he felt were promising, forwarding links to papers that he thought were interesting. His presence, and his warm, wide smile, will be much missed.

Jayaram N. Chengalur
Dean NCRA Faculty, NCRA, Pune, India

Remembering Govind Swarup-: An extraordinary and Passionate Scientist

In the passing away of Prof Govind Swarup India and the world has lost an outstanding and creative scientist who with his single minded dedication and pursuit, propelled India among the select nations at the forefront of research in Radio Astronomy. He will be remembered as the Father of Radio Astronomy in India.

My memories of Prof Govind Swarup stretch back to early sixties (I joined TIFR in 1962 from the then AEET Training School) when I heard about a giant Radio Telescope that he was setting up in the hills of Ooty based on a novel design that he had evolved. One of the objectives of this telescope was to use Lunar Occultation technique to measure the Position and Size of Radio sources identified with Quasars to check if they are at cosmological distances. It required great courage , deep knowledge and understanding of technical and engineering design issues, to embark on a complex project of this magnitude at that time . It is remarkable that he could translate his dream into reality with the help of young research students and engineers who had little training or background. Swarup was a versatile scientist possessing deep knowledge of not only physics but also engineering involved in the project. His extraordinary leadership qualities that motivated and inspired young persons, were established during the Ooty project. Successful erection and working of the Ooty telescope earned Swarup international recognition.
Swarup always dreamt big and the next ambitious project he conceived was setting up of a Giant Meter Wavelength Radio Telescope (GMRT) using 30 Parabolic dishes, each of 45 m diameter, arranged in a Y-shape array, operating as an Interferometer in 50-1400 MHz band. He developed a novel design that led to low weight and cost of the parabolic antennas which made it possible to erect the GMRT in a budget of only 50 Crores. GMRT operational since 2001 is used by astronomers world-wide to study radio sources and it has produced many notable results. I have first-hand knowledge about the complexities and challenges in the realization of the GMRT. It so happened that Prof Vijaya Kapahi , who succeeded Prof Swarup as the Center Director of NCRA, fell ill and sadly passed away in early 1999. This left a vacuum in the leadership of GMRT which was in a critical phase at that time. Although its erection was completed, it was undergoing tests and validation. It was facing several teething troubles which were coming in the way of its regular and continuous operation. One nagging problem was frequent failure of the azimuth and elevation drive motors. Front-end electronics at the focal plane also had component failures etc. There were managerial issues including a deep divide and distrust between 'Old' and 'Young' faculty. This in turn was demoralizing the engineering and technical staff. One by one these issues were resolved and by the end of 1999 most of the technical problems were licked. It must be said to the credit of Prof Swaup that he kept himself aloof from these and never offered unsolicited advice. However, whenever I went to discuss with him any problem, he frankly gave his opinion. I found that he was a treasure house of knowledge on technical matters. He was a cheerful person with optimism and was always smiling.
After spending a year as Center Director of NCRA, I returned to Mumbai campus to complete the Project proposal for the Astrosat Multiwavelength Satellite which I was keen to submit to ISRO. The Astrosat proposal was submitted to the Chairman ISRO and it received favorable response. The Astrosat payloads and satellite were estimated to cost about Rs 200 Crores. Therefore before taking a decision on a costly and complex Astrosat mission, a meeting of all the leading astronomers and astrophysicists was convened at TIFR by the ISRO Chairman where I presented details of the proposed mission and its scientific justification. Prof Swarup was present and he asked me several searching and critical questions about the scientific returns and what new science will emerge. He seemed satisfied with my response and at the end he voiced strong support for Astrosat satellite as he felt that it has potential to put India at the forefront in experimental High Energy Astronomy . In 2011 there was a meeting at IUCAA where I summarized the progress of Astrosat. He complimented me on the progress and expressed happiness that at last Astrosat is about to be realized.

My most recent and close interaction with him was during 2015-17 when the DST Secretary persuaded him to assume Chairmanship of the Governing Council (GC) of Aryabhatt Institute of Observational Sciences (ARIES). I was a member of the GC and Swarup and I were the only astronomers on GC. He asked me to brief him on the3.6 m Devasthal Optical Telescope (DOT). To our dismay, the azimuth drive motor for the DOT had failed at that time which severely affected the observations. It took 12 months to replace the motor as it was a custom designed motor. He took deep interest in the development of the focal plane instruments and their characterization. He would often talk to the concerned astronomer to know the progress of the work and their observation plans. One of the GC meeting in 2017 was held at Nainital and

he travelled to Nainital to personally interact with the astronomers and students. Next day he visited Devasthal site, a 50 km zig zag drive of more than 2 hours. He spent a few hours at the DOT, took keen interest in the activities at DOT and expressed happiness that this active optics telescope was performing as per the design specs. The azimuth motor was replaced and the DOT is working well and providing high quality observations. We travelled together to Devathal and back and during the entire trip of over 4 hours he talked passionately about science issues in general and astronomy in particular. In early 2017 he told me that he is nearing 90 years of age and wants to relinquish Chairmanship as he finds it stressful.

In March 2019 NCRA organized a meeting to facilitate Swarup on his 90 th Birth day as well as dedicate the Upgraded GMRT to him. I was also invited to this celebration. I found that though he appeared frail, he was still quite agile and greeted me and my wife warmly with a smile. It was a real pleasure to meet him and offer our greetings.

I feel privileged to have known and interacted closely with such an extraordinary scientist. My homage to him and condolences to Smt Bina Swarup and family.

His demise marks the end of a glorious chapter in the astronomical history of India.

P. C. Agrawal
former Senior Professor, Dept. of Astronomy and Astrophysics, TIFR, Mumbai, and former Centre Director, NCRA, Pune, India

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I am Durga Bagri. I joined Govind's group at Tata Institute in 1964 and was part of his group till 1983. Most of us were just out from college when we joined his group. He was always very caring, affectionate and inspirational. He was a great mentor.

Govind literally treated us as his own kids and allowed us freedom to grow in every possible way. He taught us not only engineering and science but also how to face adversities in life. One example that comes to mind is when Ooty telescope met with accident as it was just getting completed. He did not waste time moaning about the accident and immediately faced the challenge to make it work again. He was always very focused and able to switch with great ease from one topic to another almost instantaneously without losing focus

I was stationed in Ooty and Govind also spent a lot of time there during construction of the telescope and its initial operations. During this period, we used to spend a lot of time together during evenings and weekends. We used to go out for long walks and talk all sorts of things - Engineering, science, family, life, and what not. I learnt a lot from him during this period.

Those we love don't go away, they walk with us every day. Unseen, unheard but always near, still loved, still missed and still so dear.

Durga Bagri
former member, Radio Astronomy Group of TIFR, India

The ORT and GMRT are standing proof of Govind Swarup's inventive genius, innovative mind and audacity to face complex technical and engineering problems despite constraints of indigenous facilities and funding. His leadership qualities motivated young aspiring students to join him to make the dreams come true. When it came to crossing hurdles due to technical problems, no subject was out of bounds for Govind who gained expertise in several branches of engineering such as structural, civil and mechanical. I noted this trait as he went on building the ORT, the OSRT and finally the GMRT.

From ORT to GMRT I had worked closely with Govind. I had witnessed personally his boundless energy for work and discussions, and was of course impressed by his stamina. I was not astonished when he continued to work in his eighties on some astrophysical problems using data from GMRT. I had tended to believe that he would continue that way for several more years. That was not to be, and I was jolted. Well, everything ends, inevitably. But memories remain cherished by me, of a great personality.

V. Balu September 27, 2020. Coimbatore, Tamil Nadu, India.

V. Balasubramanian
former Head, Radio Astronomy Centre (TIFR), Ootacamund, India

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My association with Prof Govind Swarup began in 1976 when I joined TIFR as a doctoral student after a BTech in mechanical engineering from IIT Bombay. He was my PhD guide, and introduced me to

research in general and radio astronomy in particular. I found that every doctoral student of his had a special privileged status with him compared to his more senior colleagues and co-workers. He suggested many ideas that were emerging in the field, which he gathered on his visit to the IAU general assembly in Greece and from his interactions with other researchers in the Netherlands. I had the privilege to work a little on some of these ideas. In fact, my final PhD topic naturally arose out of the studies I did under his gentle guidance for the first few years.

After brief stints in Germany, Italy and Finland on post-doctoral research work, I joined as a junior faculty at Madurai Kamaraj University (MKU) in 1988 and later continued to work there as a research scientist funded by UGC from 1989. Swarup was interested in my teaching and other assignments at MKU, and always enthusiastic for discussions whenever we met, be it at annual meetings of Astronomical Society of India or when I visited him at National Centre for Radio Astrophysics (NCRA), Pune.

Swarup has made seminal contributions to electrical engineering, radio astronomy, astrophysics & cosmology and with zest he has built many radio telescopes: a radio interferometer near Kalyan (Mumbai) in 1960s, Ooty Radio Telescope (ORT) in 1970s, Ooty Synthesis Radio Telescope (OSRT) in 1980s, and finally GMRT in 1990s. Before he conceived and built GMRT, he had developed a grand idea of erecting a Giant Equatorial Radio Telescope (GERT) either in Indonesia or Nigeria or Kenya, along with a world-class research & teaching institute. GERT & INISSE (International Institute for Space Sciences & Electronics) didn´t see fruition due to political reasons in Kenya and Nigeria, and he visited Indonesia for site-selection. Unfortunately, Indonesia was found seismically too active to allow a robust structure like GERT. However, the experience he and his team members (scientists Vijay K. Kapahi, S. Ananthakrishnan, A. Pramesh Rao, D.S. Bagri, Ashok K. Singal and Vasant K. Kulkarni and engineers of TIFR Radio Astronomy Group) gained in planning GERT was useful for planning GMRT & constructing it. His ideas for INISSE inspired others in planning the first IISER (Indian Institute of Science Education & Research) in Pune offering integrated education & research programmes from BSc to PhD in all the sciences.

Swarup had a twinkle in his eyes when he talked to anyone, and his enthusiasm and energy were infectious. A remarkable trait of his was holding several conversations with different people in parallel, jumping from one thread to another. However, he spoke on equal terms with people. In working with anyone, he had a hands-on down-to-earth attitude. Despite an impressive legacy of long-term work, he was basically very humble, and interacted with all his students, co-workers & other colleagues on their levels with great friendliness. For me personally, he remained a somewhat distant but benevolent friend, who unstintingly offered advice & help when needed.

My wife Radha and I have various pleasant memories of interactions and meetings with him since 1984. As a VSRP (Visiting Students Research Programme) student Radha remembers his enthusiastic introduction and discussions with her on interplanetary scintillations for understanding the structure of radio sources. Radha also fondly recalls his visit to IIT Madras hostel one evening in 1989 to spend a couple of hours with Mridula

Joshi, daughter of M.N. Joshi and her. His visit to Radha's parents place at Chennai in 1992 when our daughter was a toddler and sharing a homely dinner with us is also a green memory in our hearts. He said then that his deep desire was to become a grandfather. Our last meeting with him was visiting him and Bina in their Pune residence about a decade back when he enthusiastically talked about his grandchildren. We are sad at his passing away, and convey our heartfelt condolences to his wife and others in his family.

We are also happy for the full life he led in nurturing generations of radio astronomers, engineers and others. Although Prof Govind Swarup is no more amongst us as a person his impact through the projects he inspired in radio astrophysics and astronomy will live on.

Dilip G. Banhatti
former staff member, Radio Astronomy Group (TIFR), India

Are you with me? – His words still reverberate in my mind ...

Prof. Govind Swarup passed away at Pune on Sept. 7, 2020 after a long and highly fulfilling life of 90 plus years. He was forever young and energetic.

I had the great privilege and an opportunity of working and interacting with Prof. Govind Swarup at the Radio Astronomy Centre (RAC-TIFR), Ooty and at TIFR-Mumbai during the 1970s when I was working towards my Ph. D.

A candid photo of Prof. Govind Swarup – 1976
Dr. Satyendra Bhandari

Prof. Swarup was a multi-dimensional personality. His sincerity, his hard work, his dedication, depth of his ideas and the scale of his imagination were matchless. He was a true genius who combined expertise in a variety of disciplines. In his research the ultimate goal was astrophysics and cosmology and he achieved it through his remarkable knowledge in a variety of scientific and engineering disciplines.

Having switched over from PRL, where I was involved in X-Ray Astronomy research, I reached Ooty to take up Radio Astronomy during the early 1970s. Within no time, discussions with Prof. Swarup made me realize that if I have to understand radio telescopes, beam formation, aperture synthesis, filter theory, and many other things, I must learn Fourier Transforms. Prior to that for me it was of limited application in time series analysis through FFT. In order to follow and understand Prof. Swarup's numerous ideas and discussions, the first thing I did was to buy the book – Fourier Transforms by Ron Bracewell written by Prof. Swarup's research professor at Stanford.
It served me well.

Prof. Swarup was always involved in endless discussions with all his colleagues... and he would constantly hammer his ideas and keep on asking "are you with me" at every step to make sure you are getting what he is saying. Engrossed in discussions, he would often forget his lunch or even going home in time in the evening. He would be left behind at RAC campus after most colleagues have left for their homes in town... without remembering to make arrangement for him to be dropped too!!!

After a while when it came to my first radio astronomy publication, a paper was prepared for Nature and as was natural, I thought of including my PRL guide's name. For this to happen it was logical that Prof. Swarup's name be added first. My coworkers jumped.. "what for!". It reflected TIFR culture – if anyone has not made a direct contribution, there was no need for it. So the paper in Nature was published with names of the three collaborating colleagues only.

As I carried along, I learnt about many wonderful qualities of Prof. Swarup. He was a down to earth man, and would participate in every situation and find a solution for every crisis...be it electrical, elec-

tronics, control systems, mechanical or structural aspects related to the giant Ooty Radio Telescope – that was built indigenously based on his conceptual design. Besides numerous responsibilities, he would even take part in regular maintenance the structure demanded. Being a huge moving structure placed on an inclined axis, there was a tendency for its parts to shift downwards. Those who know will realize the extreme difficulties involved. Each one of us had to climb the 10+m tall towers, with Swarup on one. We all would measure X-, Y-gaps between the drive sector and the pinion. If on any tower, the measurements were beyond permitted bounds, then we had to call Prof. Swarup for his judgment. He would climb down his tower, walk down the uneven hilly terrain, climb up to understand and sort out what is to be done. And all this often in inclement Ooty weather. For him it was a lifetime dedication to keep the ORT up and running. It was a great learning experience for each one of us. His informality and energetic participation was seen on numerous occasions.

In spite of his best efforts and ideas, he was aware of the possible lacunae in ORT design. He was always ready with simple workable solutions ahead of time. One such issue was related to the tremendous dynamic imbalance the structure had. An elegant solution was found and was ready to be implemented. But unfortunately days before its Implementation, the Telescope structure collapsed before our very eyes. The event and the gravity of the situation cannot be described in words. A decade of dedicated effort and hard work of Prof. Swarup and his team came to a naught within minutes.

All dreams crashed! It was here again Prof. Swarup's genius played its role. He absorbed all the pain and gave us strength to continue. And again it is his remarkable genius that he designed a simple solution, implemented it and even today, after 45 years, ORT is functioning smoothly. And this was when the country's foremost experts and consultants had written the project 'off' based on their analyses. Prof. Swarup's grit and determination saved the situation for us and for the nation to prove that it can rise like a phoenix and can stand on its feet. A number of Ph. D. students, including me, could complete their theses with many new exciting results and discoveries.

During the period when the 'reconstruction' of ORT was on, I had applied and was selected as an IAU Young Astronomer and attended the IAU School at Java, Indonesia. I returned with accolades from IAU and a copy of Comet Kohoutek's ephemeris with a novel innovative idea in my mind…..to see whether there is any chance of a radio source getting occulted by the Cometray plasma environment. The idea was to look for the 'scintillations' produced by irregular Cometary plasma in a manner similar to interplanetary scintillations I was investigating. To my utmost pleasant surprise, I found a known radio source in the sky being centrally occulted by Comet Kohoutek. I involved my colleagues in the unique and successful observations that resulted in the discovery of the phenomenon of Cometray Scintillations paving way for investigating cometary plasma from ground based radio astronomical observations --- perhaps one of the genuine 'discovery' from ORT. Of course publishing the results of these remarkable observations had to pass through rigorous scrutiny by Swarup. I remember umpteen after-lunch in-depth discussions with him to rule out possible artifacts due to antenna, ionosphere, solar activity etc. When the paper was communicated to an international journal by Prof. Swarup it received quick acceptance from the editor with "congratulations on such a fine piece of work" remark. Again, the author list did not include Prof. Swarup's name!!!

The same selfless nature of his working got reflected when I finished my Ph. D. thesis. It was signed by my official guide from PRL and not by Prof. Swarup in spite of the fact that my work involved numerous discussions with him and that entire work was carried out at RAC, Ooty. The entire ORT facility was thrown open to me without need for any formal MOU etc. Such was his greatness, welcoming all with openness.

Prof. Swarup never rested on his past accomplishments. He was always excited about his next level of ideas, next bigger scale of establishing something indigenously and proving to the world that India can do it even on shoestring budgets. Within the country, he was always trying hard to get small chunks of budget by making convincing pleas when others were enjoying large budgets without much accountability. He would make proposals, and give lectures to prove how much he can accomplish with the small budget he was asking for. Throughout his life, he was a man of small means, never allowing any wastage of any kind and making the best use of resources.

And while doing all these, conceptualizing, designing, building bigger and better telescopes, he never lost track of astrophysical problems he was hoping to solve…and solve he did in a remarkable manner… putting India firmly on the Radio Astronomy map of the World .. all within his lifetime. He was a living testimony of how a sincere dedicated

individual can achieve anything in any circumstances. And ORT and GMRT are examples of his single minded devotion to indigenous excellence.

He also played a tremendous role in development of antenna technology, electronics industry, science education & research and several other areas of national development.

He lived his life fully and accomplished more than most around him. His life needs to be Celebrated. He leaves behind a large family of his Radio Astronomy students and colleagues who will always remember the lessons learned while interacting with him and carry on his rich legacy forward.

The nation must rise now to pay a highly deserving tribute to the genius of Prof. Swarup – the great son of India – by bestowing the nation's highest honor on him.

ORT-from glory to gloom to glory again!

It was some fifty years ago The grand, glorious and famous ORT structure suddenly collapsed and fell Nothing was left for us but to pack our bags and go

Yes, I recall the ghastly event in all its vividness As I was among the unfortunate ones present to witness Beyond the physical collapse/ catastrophe It was crushing down of a million dreams and countless aspirations, no less.

It required immense courage to look at the frightening wreckage But for the genius of Swarup with his remarkable insight To absorb, analyse and convert The setback into a challenge

He brought it back to shape When every expert had written it off And it rose like a phoenix In reality, not just as in mythology's page.

The new ORT sprung back in better health than before To serve the upcoming generation of Radio Astronomers To realize their dreams And to accomplish and discover more and more.

Such is ORT's inspirational story From its birth to its reincarnation That it should grab much deserved attention And be brought to golden glory.

Satyendra M. Bhandari
former scientist, PRL and ISRO, India

Dear Colleagues,

I regret to inform you that Prof. Govind Swarup passed away in Pune, India after a brief illness (not COVID-19 related) and hospitalization. He was 91 years old. He was the founding director for the National Center for Radio Astrophysics (NCRA/TIFR), Pune which built and operates the Giant Metrewave Radio Telescope (GMRT). Govind did his PhD with Prof. R. Bracewell at Stanford University, USA before returning to India to join as a faculty member at the Tata Institute of Fundamental Research (TIFR). He started the Radio Astronomy group at TIFR which built a number of radio telescopes over time (Kalyan Solar Telescope, Ooty Radio Telescope (ORT), Ooty Synthesis Radio Telescope (OSRT)) culminating into the building of the GMRT at Khodad near Pune.

Govind was a Fellow of the Royal Society of London and all the national science academies in India, and also of The World Academy of Sciences. He had received a number of national and international awards, including the Bhatnagar Award (an Indian award for excellence in science), Padma Shri (a high civilian award in India), the Herschel Medal of the Royal Astronomical Society and the Grote Reber Medal.

To read more about him and his life please visit the following:
http://www.ncra.tifr.res.in/
https://en.wikipedia.org/wiki/Govind_Swarup#Personal_life

I was among the first young PhD students hired by him at the start of the GMRT project. Formany of us youngsters, he was a towering and inspiring personality who led by example. One of my first recollections of interaction with him is of after-dinner conversations ranging from Fourier optics to philosophy of life. He would spend hours working

with many of us who were building various GMRT subsystems. Those most enjoyable experiences, working as a young student along with an internationally recognized senior scientist were a life changing one, and which launched careers of many of us from India in radio astronomy. Even as we were just starting our careers in scientific research, he encouraged us to think big, look for new problems worth solving and work boldly with a combination of confidence and humility. He remained, till the end, a person with whom young people felt comfortable and inspired. My last personal interaction with him was similar to the first -- part encouraging ("....I have been working through your papers....very interesting...great progress since we talked about all this when building GMRT...") and part challenging ("....you still have this problem unsolved though...I expect that you will pay attention to this...it's important..."). He'll be missed.

The Meterwave Sky-II conference at Pune in March, 2019 was centered around his 90th birthday. During the conference he was actively discussing with the participants on a wide range of topics with his typical child-like curiosity and interest. Even in his last weeks, he remained mentally as active as ever. With colleagues at NCRA, he was working on an article for ARAA till just 10 days ago and discussing HI detections at high-z with the GMRT before his health took a sudden and rapid downturn. He passed away at 9PM (IST), Sept. 7th.

Sanjay Bhatnagar
Scientist, National Radio Astronomy Observatory, USA

Prof. Govind Swarup FRS, the doyen of Indian astrophysics, passed away on 7 August at 9 p.m. Accounts of how he established a thriving school of radio astronomy in India have been given in detail by various authors:

G. Srinivasan, 2015, Current Science 109, 618. W. Orchiston & S. Phakatkar, 2019, Journal of Astronomical History & Heritage 22, 3. Instead of again giving such an account, I shall write about my close association with Govind Swarup. An account of somebody's scientific achievements often does not make it clear how the next generation views him. Perhaps my personal account will bring out other aspects of Swarup's character and make readers who had not known Swarup intimately realize why he holds such a place of affection in the hearts of many of us. I am 27 years younger than Govind Swarup. Within the general field of astrophysics, our research specializations were as different as one could imagine. While Swarup was an extragalactic radio astronomer, I am a theoretical solar physicist. Our research styles were also totally different. After some very brief comments on Swarup's scientific achievements, I shall discuss how the unlikely personal bond between the two of us developed.

Govind Swarup's contributions to Indian science (note that I write 'Indian science' and not 'Indian astrophysics') are so vast that future generations will surely marvel that such a person even existed. Around 1960, when he was a budding assistant professor at Stanford University, four young Indian radio astronomers working in the USA sent a joint letter to the heads of several Indian organizations that they were willing to return to India and build a radio astronomy group if any place offered jobs to all of them. Only one head of an organization could give a positive reply to such an unusual request: Homi Bhabha, who had established TIFR a few years ago, but there was no astrophysicist at TIFR yet. Bhabha decided to offer jobs to these four youngsters. Only Govind Swarup among these four stayed on in TIFR. Others tested the waters and then returned back to their greener pastures – presumably because they felt that the conditions in India did not enable them to do competitive research of international standard in radio astronomy. But Govind would not give up. He went on to build two of the world's finest and most innovative radio telescopes - the Ooty Radio Telescope in the late 1960s and the Giant Metrewave Radio Telescope (GMRT) near Pune in the early 1990s - completely indigenously with the help of engineering skills available in India. He showed that India was capable of building such world-class state-of-the-art radio telescopes. I was quite close to him when he was planning GMRT and he excitedly told me a lot about it, although I understand nothing about telescopes. I remember that there was widespread scepticism about it in India at that time. Many pundits declared that India did not have the technological knowhow to pull through such a complex project and it would end up in a failure. Additionally, Govind had a very limited budget - a fraction of what everybody thought would cost to build such an ambitious radio telescope of such size. All the time, Govind had to continuously think of ingenious ways of cutting down the cost. After Roger Blandford heard of the total cost at which GMRT was built, he used to refer to it as "the Great Indian Rupee Trick." The other challenge for Govind was that he needed to hire good engineers for the project. He told me that at the time of building the Ooty Radio

telescope the salary that an engineer would get in a private company was about 1.3 times of what he could offer in a government organization, but by the time of GMRT this ratio had become more than 2. I guess that some gifted young engineers agreed to work with Govind at this hugely reduced pay only because of his charisma and personality.

Apart from TIFR, the second Indian organization with which Govind Swarup had a very close link is my workplace IISc. He spent several years on the IISc campus in the 1980s when the TIFR radio astronomy group was housed in a building not far from the present-day Physics Dept. It was at this time that he took the initiative (with Prof. V. Radhakrishnan of RRI and Prof. Vainu Bappu of IIA) of establishing India's first graduate school in astrophysics: the Joint Astronomy Programme (JAP). When Chanda Jog and I joined IISc in the late 1980s, we received tremendous support and encouragement from Govind. A disproportionately large number of today's senior and middle-aged Indian astrophysicists (much more than 50%) were trained though this Prograaame. Before writing a little bit about this Programme and how my association with Govind began, let me make a few remarks about the second mission of Govind's life besides building radio telescopes. He always said that, if good Indian scientists only did their research in their isolated ivory towers, then Indian science had no future. We have to attract bright young students to basic science and then train them properly. It was in this second mission of his life that Govind interacted with me perhaps more closely than with any other Indian astrophysicist.

Before the starting of JAP, no place in India offered courses in astrophysics. Any Indian student wanting to do PhD in astrophysics had to learn the subject on his/her own. As graduate programmes in astrophysics became the norm around the world, Govind and his colleagues felt that India also must start her graduate programme. The model they came up with was that students would be taught by astrophysics faculty members of different institutes and, after course-work, these students could work with any faculty member in a participating institute. Since IISc had an atmosphere closer to a university than other institutes with astrophysics groups, Govind was particularly keen to have IISc as the nodal point of JAP, although there were no astrophysicists at IISc at that time. When I joined IISc at the age of 30, I found quite a lot of work for JAP dumped on my shoulders. Since I joined IISc five years after the start of JAP, I have not been a witness to its beginnings. However, various reforms were urgently needed in JAP when I joined IISc – from re-structuring of the course curriculum to formalizing inter-institutional arrangements. I do not know what Govind saw in me, but he gave me almost unstinting support to implement various reforms in JAP. In many meetings to discuss JAP, Govind would come to my rescue when I would be attacked from all the sides and made sure that I could get my way. I am not suggesting that what Govind used to do was the best way for a senior person to manage such a complex situation. But it shows what kind of person Govind was and, in this process, I developed a strong bonding with him. I used to spend a lot of time in the building of the TIFR Radio Astronomy group – especially in their cozy library. I felt like an orphan when the group shifted base to Pune to build GMRT.

Govind was very worried in the 1990s that many of the famous Indian universities had declined (he always fondly recalled how he had been taught by giants of Indian physics like KS Krishnan when he was an MSc student at Allahabad University). Govind felt concerned that young Indian students did not have too many choices in those days for a good undergraduate training in basic science. He (along with Prof. VG Bhide of Pune University) gave a detailed proposal to the Govt of India for starting institutes of science exactly like the IITs. There was considerable progress with the proposal. But then it got shelved. A few years later, this idea was revived and the IISERs were established following the model given in the Swarup-Bhide proposal. They should be regarded as the spiritual fathers of the IISERs. I know that Govind used to feel somewhat hurt that he was not given enough credit for this, because this project was very close to his heart.

I was closely associated with Govind for what he once described to me as the biggest failure of his career. He had a soft corner for Bengal. He was very concerned in the 1990s that, even though some of the best physics students were coming from Bengal, there was no centre of astrophysics there (this was before the astrophysics group started in IIT Kharagpur). He was very eager that an astrophysics centre should be set up in the campus of a university there, and Prof. Chanchal Majumdar was one person who was giving him strong support from the Kolkata side. Although I was about 40 at that time with no standing in the Indian academic community, Govind sent me as his emissary to hold meetings with Vice-Chancellors and senior professors of Jadavpur and Visva Bharati universities. There was quite a lot of enthusiasm and Govind also managed to raise initial funds to start such a centre. After coming very close to being realized, this project shamefully got

derailed due to the political intrigues of some Bengali academics (I do not want to describe these things in detail), who suspected that Govind must be having some hidden ulterior motives! It was unbelievable to them that somebody could selflessly devote so much time for a project without any self-interest. Govind told me ruefully that it was the only time in his career that he had to abandon a project after it came so close to realization. When I was in Kolkata with Govind for a 2-day meeting to discuss this centre, the second day was declared a bandh by the Left Front at a very short notice. We had to squeeze the whole meeting in one day. Since it was not possible those days to change flight bookings at such a short notice, Govind had to spend the second day in the SN Bose Centre guest house. As I knew that Govind had come to Kolkata solely for the sake of Kolkata, I did not want him to be left alone on a day of bandh. I asked the SN Bose Centre to give me also a room in their guest house. When Govind came to know of it, he protested repeatedly: "You have your parents and in-laws in Kolkata. You should go and spend time with them. Why do you want to waste a day with an old man? I shall be fine. Do not worry about me." But he obviously felt relieved that I decided to stay with him. Luckily, the cooks in the guest house showed up and we had good food. Since there was nothing else to do in that day of bandh, Govind talked to me for several hours - about his childhood and youth, the dreams he had as a young man, his deep patriotism, his concerns about common people of India, his achievements, the difficulties he faced in his career. That day remains etched in my memory as one of the most memorable days of my life.

I now describe a rather personally humbling encounter that I had with Govind Swarup in Thiruvanthapuram about 3-4 years ago. T Padmanabhan and I had been invited to give two prestigious invited lectures on astrophysics at the National Space Science Symposium held at the Vikram Sarabhai Space Centre. On arriving at the guest house, I found Govind there. He told me that he had come to give a regular talk in a regular session. I felt really awkward that, while I was giving a prestigious invited talk, such a legend of Indian science had come to give only an ordinary talk. Govind sensed my discomfort and seemed to be quite amused by it. He gave his disarming and childlike – but also somewhat naughty and mischievous – smile and said: "You will surely describe the many important results which had come out of your research group in the last few years. But I have not come here to talk about my past achievements. I told the organizers that I wanted to give a regular talk on the new research I have started a year ago. I am very excited about it and want to tell others. The organizers wanted to fix an invited talk but I did not agree, because that would not be correct. I have not done anything important in this new field yet." The man close to 90 did not want any special arrangements. He had come from Pune alone, ate the regular food at the guest house with us and walked to the conference venue (about half a kilometre from the guest house). Apart from giving his talk on radio observations of Venus in a session where all the other speakers were less than half his age, he listened to the other talks attentively to find out what younger people were doing.

I end by mentioning one other incident. Once when I was at the GMRT site (probably about 15 years ago), a British journalist had come to see GMRT on that very hot summer day. Although Govind was in his mid-70s, he himself was showing around. When we were walking towards the cafeteria for lunch, Govind saw that the journalist's car was parked under the shade of a tree at the farthest corner of the parking lot. Without telling anybody anything, he himself suddenly sprinted for 50 metres in the scorching sun to the driver and told him: "aap thoda khana ke liye idhar aiye". That was Govind Swarup. When he would head a group or a project, there would be no hierarchy of any kind. He would regularly sit down for lunch or tea with the juniormost engineer or the youngest PhD student. Everybody who worked with him felt that they had to give their best for him.

Those of us who had the opportunity of being close to this gem of a human being will always remember him for his passion for science, for his deep humanism, for his compassion for fellow human beings and for his towering intellect. There has not been another person like him in Indian astrophysics and probably will never be.

Arnab Rai Choudhuri
Professor, Dept. of Physics, IISc, Bengaluru, India

Dear Divya,

I am very sorry to hear of this loss. A great builder of astronomy has passed away and the his exceptional achievements and highly accomplished students he mentored stand in testimony of his contributions. I have known him and his family from the time they arrived in India in the early 1960's. I

would appreciate it very much if you could please convey my deepest condolences to Bina behn and rest of his family.

Ramanath Cowsik
former Director, Indian Institute of Astrophysics, Bengaluru, India and currently Professor of Physics, Washington University in St. Louis, USA

Farewell, Professor Calculus!

It was an honour to interview Professor Govind Swarup in 2005 for the TIFR Archives that I was setting up. Professor Swarup was 76 years old at the time, but whenever I think back of that interview, I don't see a 76 year old, I see a young man inspired by science and one who wanted to do something for his country. He was clear that he wanted to return to India – "the idea was always to return to India...Being from a family of farmers I knew I could build a radio telescope in a innovative way." But he did not want to return by himself. "I wanted a world-class team to come back. We were like kings there in the US." Ronald Bracewell, the radio astronomer who Professor Swarup had first met in Sydney was in Stanford when Professor Swarup completed his Ph.D. Swarup recounted how Bracewell had said, " Govind, you can be second rate in somebody else's field or first rate in your own field." Swarup never forgot that phrase and often used it in his inspirational and motivational talks to young people. His return to India and setting up a Radio Astronomy Group at TIFR in 1963 and in the course of setting that up training a number of young men is the stuff of legend. He went on to build the Kalyan interferometer, the Ooty Radio Telescope and later the GMRT. Through his six long sessions with me, Professor Swarup would explain the technicalities of his work to me with an enthusiasm that was infectious. Perhaps this is what made him so endearing and made him sound so youthful.
His beaming smile was something that lit up the room. And he recounted with great amusement how Vikram Sarabhai had laughed and reported that his daughter, "Mallika always says that you are like Professor Calculus." In the interview, Professor Swarup paused after he told me this and then added, "The other day one of my neighbours told me that her daughter also calls me Professor Calculus." He laughed, "Thirty years later I am still called Professor Calculus!"
Farewell, Professor Calculus, here is a haiku especially for you:

The lamp once out
Cool stars enter
The window frame.
Natsume Soseki (1867-1916)
I know the stars are smiling.

Indira Choudhury
Director, Centre for Public History
Srishti-Manipal Institute of Art, Design and Technology, Bengaluru

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Govind Swarup: an indelible mark on Indian science

Govind Swarup has left behind an indelible mark on the modern science of big experiments and instruments. He was not a path follower but was instead a path maker. It is only these kind of people who leave behind legacy and monuments on

which rests the edifice of science. They also serve as lighthouse for shining the way ahead.

After the first steps of initiation into setting up radio antenna on Kalyan hill near Mumbai, he thought of a really ingenious instrument in Ooty Radio Telescope on a hill having the North-South slop that matched with the latitude of the location. ORT did brilliant and imaginative work on measuring the angular size of distant objects for addressing the burning question of the day -- Bing-Bang or Steady State cosmology?

He was not the one to sit happily on one's laurels. In mid 1980s, he thought and conceived real big in Giant Metrewave Radio Telescope – GMRT. When

he was scouting for a suitable site for it, I chipped in arranging some bit of logistics -- accommodation and vehicles for field visits around Pune.

By all reckoning GMRT is the greatest instrument of modern science in the country which has not only advanced the frontiers of science but also of technology. Technology that was used to accuracy of one foot had to cope up with the challenge of a millimeter.
GMRT was also a trigger for creation of another institute, IUCAA. The challenge of bringing that into existence was taken up by Jayant Narlikar and I had good fortune of working with him right from the conception of the project.

Govind was a true torch bearer of the legacy of J C Bose and C V Raman, and has taken that legacy not only to greater height but has given it a new dimension.

He had the uncanny knack of not letting the curious child in him ever leave him. Finally he has left so much of value and grandeur behind that it would be impossible to forget him.

Naresh Dadhich
Emeritus Professor and former Director, IUCAA, Pune, India

I had the opportunity of meeting Prof. Govind Swarup several times after I started Persistent in the last 25-30 years.

We first met him when Prof. Ramesh Sinha introduced us to him. He was the Director at GMRT, and I had just started a new business in Pune. And I was looking at data in other related areas. So we had some very interesting discussions, and we actually started working with GMRT in early 90s around the AIPS++ project. My interactions with Prof. were always enregising. It was amazing, how curious he was, how he would come up with new ideas? And would challenge everyone. He loved really working with younger people and it was quiet exciting to work with him. His son is my age, as we were in same class. Vipin and I are from the same batch. So, he was like a father figure to me and I really miss him. His contributions to astronomy has been amazing.

I want to mention another story, where, I had an opportunity to work with him. He was aprt of a small group of scientists, led by Prof. V. G. Bhide, who were responsible for setting up the IISERs.
I attended several of their meetings, as some outsider whom they would use for bouncing their ideas. And one of their main challenges was how do me make science attaractive to new students. They always felt that everyone wanted to go to the IIT and become an Engineer and we were not getting enough top students, who would become Scientists. I am so delighted to see the progresses made by IISERs in Pune, and other parts of the country; that his dream of getting bright studengts to come to Science has been fulfilled We would miss Prof. Govind Swarup. But I want to express my sincere condolences, we will remember him all our lives. The work that he has done will live for ever. I want to express my condolences to Vipin and rest of the family and I wish and hope that God will give you all the strength to deal with this great loss.

Anand Deshpande
Founder & Chairman, Persistent Systems Ltd, India.

Association with Prof. Swarup began immediately after I joined TIFR in 1976 and moved CRL, Ooty.
He was in the midst of upgrading the dipole array in the Ooty Radio Telescope (ORT), planning of Giant Equatorial Radio Telescope (GERT) to be sited on equator as well as countless other projects along side round-the-clock observations with ORT. One day in 1978 when I shared the news of successfully running the barycentric correction program obtained from Jodrell Bank a few years back, he was thrilled beyond belief which was a real morale booster. In 1979 when I wanted to observe some radio pulsars to determine their periods and higher derivatives for TeV Gamma-ray observations, Prof. Swarup generously provided time on ORT. Only two decades later I indirectly learned that his generosity was my involvement in building an atmospheric Cerenkov telescope and his innate desire to support a fledgling experimentalist!

After his move to Pune, occasionally he would visit Ooty and would stay in our guest house and I took those opportunities to invite him to Cosmic Ray Laboratory in Raj Bhavan and show him around. Most of our exchanges were usually oneway with I being the listener and he would articulate a large number of ideas and at least one or two of them would be enormously beneficial for us. On one occasion I was staying in Ooty with my family when Prof. Swarup and Binaji arrived. Earlier that day I had shown the ORT to my 9 year old son and I introduced Prof. Swarup and the builder of the ORT. My son immediately asked him how one can have a telescope with so many gaps? Prof. Swarup sat with him for next one hour and drew diagrams to

explain the working of ORT. At the end of explanation my son innocently commented, "uncle you know a lot about radio astronomy". All of us burst out laughing but for Prof. Swarup that comment was the reward he needed. Such has been his impact that 26 years have passed since that episode yet my son remembers every detail of that exchange.

Some years back after his bypass surgery in the Asian Heart Institute in Mumbai he was recuperating in his daughter's home in Colaba. One evening we received an urgent call from Binaji and my wife and I rushed to see Prof. Swarup. When we reached there Binaji told me that as soon as he was in a position to sit, Prof. Swarup has been sharing with the family his ideas for building better radio telescopes and she wanted me to spend some time. I stayed with Prof. Swarup for the next two hours and whenever he got really excited I had to threaten him with a walkout unless he calmed down. For once my threat worked!

When we wanted to set up the GRAPES-3 experiment in 1991 in the premises of Radio Astronomy Centre, Prof. Swarup welcomed us with open arms and actually came and identified the present site. We owe a large debt to Prof. Swarup in the success of GRAPES-3 experiment. Scientist like him are probably born once in a century and leave behind a multi-faceted legacy that may last another century.

Sunil Gupta
former Senior Professor, TIFR, Mumbai, India

वज्रादपि कठोरापि, मृदूनि सुमादपि|
लोकोत्तराना चेंतसि कोइ पवज्ञातुमर्हसी ||

Harder than a diamond, softer than a flower;
Who can fathom the minds of great persons?

- A Sanskrit Bard

Me and Vijay were the first to join Dr Govind Swarup in August 1963. Having finished the Atomic Energy Training School Course, we were to select our future! My choice was TIFR. What impressed me immensely when I met Govind was his simplicity, zeal and enthusiasm. He talked about starting a new group in radio astronomy.
"Mind you, it is going to be hard work physically and mentally" he said, after giving a brief introduction to the subject and his plans.
"We have to start from the very scratch, are you ready?", he said. After a pause, I told. "Yes, I am".
"Take some time, think over, meet me tomorrow."
Looking back, I feel very happy and proud having joined my hands with him. I had the privilege of working with him on all the 3 telescope projects!
"Call me 'Govind' and not 'Dr Swaroop'", once he told me, when we were going by jeep in search of a suitable site for the Kalyan Telescope. I was a bit puzzled, being a student, looking at his simplicity and warmth.
For me 'GOVIND' is
G: Genius
O: Outspoken
V: Visionary
I: Intellectual
N: Nationalist (to the core)
D: Doyen of Radio Astronomy in India
That is 'GOVIND' Swarup for all of us at the Radio Astronomy Group and NCRA!

J. D. Isloor
former member, Radio Astronomy Group of TIFR, India

I was very saddened to hear of Prof. Govind Swarup passing away. His contributions to Indian science, and Radio Astronomy in particular, are immense. In fact it is hard to believe that one person could do all this, and in the process he touched so many lives.

He was a pioneer, a visionary and was driven by excellence in science. He designed telescopes with innovative designs (Ooty Radio Telescope and GMRT), with the aim of extracting high quality science out of them. He motivated people to join and work on these projects. Like Homi Bhabha and Vikram Sarabhai, he dreamt big and built institutions and projects which have shaped Indian science.

I feel a great sense of personal loss too, as Prof. Swarup was one of the first astronomy teachers I had, this was at the first summer school in astronomy held in Bangalore in 1976. This was just before I was to leave for a PhD programme at Stony Brook in the US. The lectures by and the interaction with Prof. Swarup and others at the summer school left a very strong impression on me and indeed on most of us. After that I was sure I wanted to return back. Prof. Swarup was largely responsible for my joining as a faculty at IISc, Bangalore in 1987. At that time, the TIFR Radio Astronomy group was based on IISc campus. The group was very active

and had a charged atmosphere as the GMRT was in the planning stage at that time. Prof. Swarup was extremely supportive to us in the running of JAP (Joint Astronomy Programme) which was in its early years then. In fact, he had played a major role in the establishment of JAP.
Over the years, whenever I visited NCRA or IUCAA, I would look forward to meeting Prof. Swarup. He was an inspiring person, full of ideas and enthusiasm. He was equally interested in listening to others' ideas and hearing about their new work. I remember his taking notes at the seminars at NCRA! After one seminar that I gave at NCRA, he was intrigued by the shape of the dark matter halo, a topic I was working on at that time, and he asked me several questions about that. He was genuinely curious about all fields in astronomy. He was warm and supportive of younger people. I was touched that Prof. Swarup attended the last talk I gave at NCRA in October 2015, he was in his mid-80's then.

I feel privileged to have known Prof. Swarup all these years. We will all miss him. He is no longer with us, but his memories and his teachings will always inspire us.

Chanda Jog
Honorary Professor, Indian Institute of Science, Bengaluru, India

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Dreams of the days with Prof Govind Swarup passed on just like that. Interaction with Prof.GS for the past 40 years cannot be summarised in a single page of word document. A few memories being shared through photoshoots to remember

the association with Prof. GS at the beginning of my carrier and before going in production of GMRT. Many people memories will be flooded in after the GMRT. Still some seniors like to share their memories for pre GMRT activities.

My dreams to work in OOTY RADIO TELESCOPE Project was born in the year 1965-66 during my Intermediate Studies, when I heard the all India Radio News (English version in Night 9-00 PM) about the world largest Radio Telescope being fabricated in India at Ooty. The dream became a reality when I visited ORT for the Interview in the year 1977.

FIRST PHOTO ADMIRED ON SEEING ORT
On seeing the Telescope thought was getting penetrated in my mind how India can build this large beautiful Mechanical challenge Telescope, where those days Angular contact bearing need to be get Imported and Erection of this huge dynamic structure was a challenge especially on a slope surface.

I just walked to the Second floor of the ORT office, where people restricted me not to pass through because it was where the Director seated in his office. This does not bother me much and I started walking across the corridor crossing his room. My bad luck was Prof G Swarup, was away to Mumbai and PA to Prof. GS Mr. P. Bhaskaran informed me.

After working few months, I could meet Prof. Swarup, at TIFR centre, IIsc campus, Bangalore. At that time Prof. Swarup's visit to Bangalore for the Development of GERT(GIANT EQUATRIAL RADIO TELESCOPE) project and studies. Somehow the Project does not take shape. However Prof.GS was really working for a new telescope for the country where by that time ORT and OSRT got installed about 20 years back.

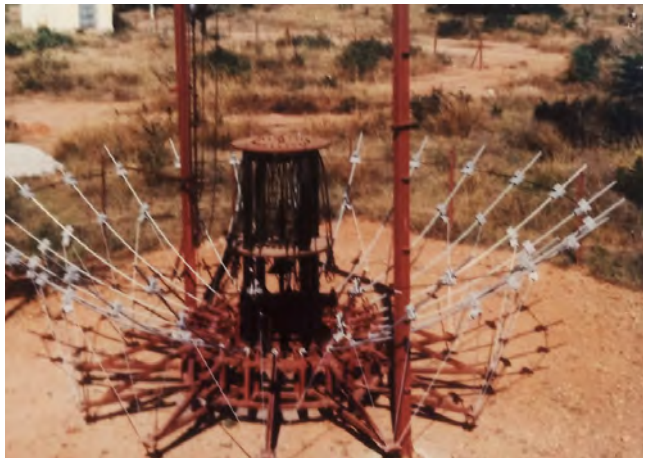
The Brain Storming session of Development of New telescope was under discussion whether to be a Dish or Parabolic Cylinder. When Ideas were concluded for Dish, Prof. GS Started telling everyone the cost of the dish should be minimum. Those days any parabolic surface creation was very difficult and cost oriented. Also Millimetre wave length Telescope was being built by RRI at NAL (National Aeronautics Limited) Bangalore, where Honey comb structure were used to reduce the mass and surface was being machined.

Prof.GS has brilliant Idea of making wire rope structure connecting the parabolic frame and on to the Structure thin mesh got to be attached. A few Development photo as guided by Prof GS was installed and tried out at the back Yard of TIFR Centre, Bangalore Campus.

In the meantime, ideas were flowing in from Prof. GS, and development of Umbralla type dish was developed. Several phases of development and interaction with Prof G.Swaroop is quite large to put in words. Explained by photos on Birth of GMRT and Developments.

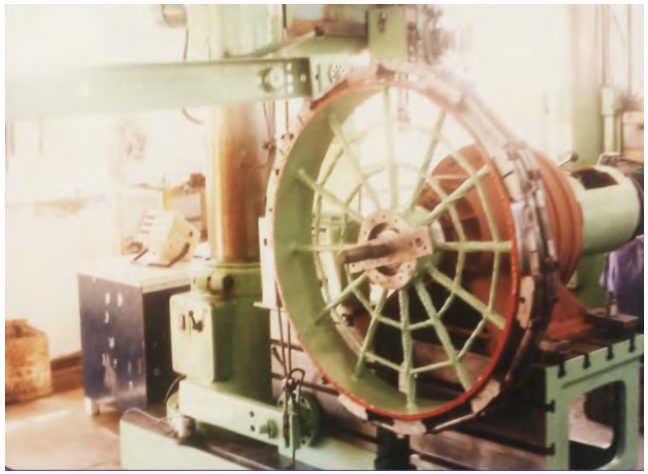
Initial photo the development of rope truss with mesh attached.

One layer of lower segment was developed.



Umbrella type dish development

Wind tunnel testing of GMRT antenna at IISC aero-space engineering department.



Umbrella type dish development

GMRT gear boxes being tested at vendor place

In association with Prof G.Swarup, Gained a Great knowledge of how to apply theoretical studies in to useful mankind practical applications.

Prof Govind Swarup is professor in Astronomy, Mechanical Engineering, Electronic Engineering and total Indian Scientist work for the Nation leaving his carrier from USA and working in the fields of Muthorai hills at Ooty with family, proves his interest in building our Nation.

WITH BEST REGARDS AND PRAYING HIS SOUL REST IN PEACE.

KARTHIKEYAN.
STUDENT OF A GREAT INDIAN SCIENTIST.

M. N. Karthikeyan
former staff member at NCRA, Pune, India

Like everyone else, I have known Professor Govind Swarup as a great astrophysicist, radio telescope builder and a towering figure in Indian and world astronomy. But after his passing away, my thoughts about Govind have been focused mainly on my personal interactions with him over the years. I used to visit TIFR, Mumbai as an undergraduate for four years before I joined the institute as a graduate student in the early seventies. Over that early period, I had never heard about Govind, possibly because in those days my friends and I were so enamoured with nuclear physics. When I joined the graduate school, Govind asked me to work with him, but by then I was enamoured with theoretical astrophysics and wanted to work with Jayant Narlikar, which I did. Once again, some years later, I had the chance to work with Govind when he asked me to shift from TIFR to the Indian Institute of Science in Bengaluru to head the JAP programme there, which I did not do. If I had accepted either of these offers, my phase space trajectory would have been quite different, except that in configuration space it would have ended in Pune anyway, as it has now done. But I am sure that working with Govind Swarup would have been quite a different experience from working with Jayant Narlikar. Their ethos, aspirations and achievements have been very similar, but the outwards manifestation of these great qualities in the two gentlemen could not have been more different. My regular interactions with Govind, in person or on the phone, were limited to his talking and my listening and trying to get in a word or two occasionally. What surprised me very much was that the few words I managed to utter were recorded, processed and remembered, without any interruption in his own streams of words and ideas, and were brought up in future conversations. In this manner Govind took me from his early ideas for a great new radio telescope to the GMRT. Perhaps what I naively said occasionally did make a difference to the outcome. An important set of conversations I had with Govind was about the Thirty Meter Telescope (TMT). Govind was not comfortable with India joining the project, he wanted us to build an optical telescope in India. But this would necessarily have been a significantly smaller telescope, leaving us a factor 10 behind in aperture for the foreseeable future.

My friends and I tried very hard to convince him that we should join the project. He finally relented to say that we could join at the 5 percent level. That would have deprived us of a seat on the TMT Board. After many discussions and arguments Govind finally agreed to our joining at the 10 percent level. Perhaps he always had that in mind, and was simply getting us to sharpen our arguments and focus our attention on the important issues which we were missing in our enthusiasm. I last met Govind at a dinner party just before the pandemic. He had gone frail but his spirits were undiminished and he did speak to me as in the old times. I am sure he continues to be the same wherever he is now, though he can speak to us only in our imagination.
Prof. Govind Swarup who left us a month ago is universally regarded as a father of Indian RA.

Ajit Kembhavi
Emeritus Professor and former Director of IUCAA, Pune, India

I joined his group at TIFR in 1967 as a 19 yr old research associate. And so I not only had the privilege of his academic mentorship but also his inside view of his visionary leadership for over five

decades. In 1963 Swarup opted to move from USA to India, his decision was truly remarkable for two reasons: Firstly in 1960s India was experiencing a wave of brain-drain to US, but Swarup chose to swim against the tide and doing so he proved that the kite flies highest against the wind. Secondly, 1960s was also the golden age of RA, which saw ground breaking discoveries like quasars, CMB, pulsars, does being in the 1960s really mean being in the right place at the right time yet Swaroop Took the bold step of returning to India and start radio astronomy hear from scratch. Basically his mantra was to aschew fashionable science And promote that signs that exploits India's natural advantages. For instance his antenna design for the Ooty telescope exploited the natural Hill-slope at Ooty.

Likewise he constructed the smart design concept for GMRT antennas to exploit the fact that this season doesn't get snow. Today dozens of engineers And scientist nurtured in Swaroop ecosystem are making important contributions
across the globe, and many of them were trained at the Ooty telescope and at the Ooty synthesis radio telescope, which was really the seed for GMRT. And GMRT paved the way for the Square kilometre array, the telescope of the future. The iconic voyage professor Govind Swarup makes him a Navratna of science in independent India.

In my humble opinion, it would be fitting tribute to his memory that GMRT Observatory at Khodad is named after him.

Gopal Krishna
former Senior Professor, NCRA, Pune, India

Dear Yashwant:

At your request for a contribution to the forthcoming memorial meeting (October 7, 2020) to remember and celebrate Govind Swarup's contribution to radio astronomy I am contributing this somewhat long reminiscence. This letter documents my first encounter with Govind, the professional support that I received from him and concludes with my views of his pioneering role in Indian and global radio astronomy.

In 1976, V. Radhakrishnan, then Director of Raman Research Institute (RRI) and Swarup (then Director of the Ooty Radio Telescope, ORT) decided to hold a summer school centered around Astronomy & Astrophysics [1] on RRI campus, Bengaluru. It is important to remember that in the '70s astronomy was not a part of the Indian school nor the college syllabi. The summer school was aimed at MSc students presumably to entice them to the burgeoning astronomy PhD programs at RRI, the Tata Institute for Fundamental Research (TIFR) and the Indian Institute of Astrophysics (IIA).

In 1976, I was in my third year of the "Integrated 5-year" MS "Engineering/Applied Physics" program at the Indian Institute of Technology, Delhi (IITD). The department was unusually strong in optics (the celebrated A. Ghatak) and quantum optics (the famed C. L. Mehta). I started a small project with Dr. S. Chopra who had recently joined the department as an Assistant Professor. He had obtained his PhD at University of Rochester working with the famous experimental and theoretical physicist, L. Mandel, one of the founders of quantum optics. Dr. Chopra was keen to start a program of designing and building digital processors to measure various statistics of photon arrival times.

My knowledge of astronomy was limited to what I had read in Scientific American in the libraries of Dharwad University and IITD. I certainly had no knowledge of astronomical research that was being undertaken in India. Nonetheless, when I saw the posting of the RRI summer school on the bulletin board I was intrigued and immediately applied. The application was rejected because I was in my third year which was the equivalent of BSc III.

However, I had my own scholarship – a National Science Talent scholarship from National Council of Educational Research and Training (NCERT) – which generously provided stipend through the academic year, admission to summer schools (with funding) and purchase of textbooks. Summer schools for NST scholars were held at various laboratories around the country to expose the scholars to various areas of their chosen majors. One of my professors informed me that Swarup was visiting IITD and suggested that I persuade him to admit me to the school. I duly met him at the Guest House of IITD and made my case.

He was supportive and in due course I was admitted[1]. Govind was fond of reminding me of this first encounter at IITD. In fact, he gleefully recounted this meeting during my last (and final) meeting I had with him (April 2019, Pune). Govind told me that he thought anyone who is enthusiastic and determined should be a given chance and that is why he permitted me to attend the summer school. In some ways – enthusiasm, energy and determi-

nation – provide the most compact description of Govind. The 1976 summer school proved to be a hit. We had lectures not only from Swarup and Radhakrishnan but many young people, some who had obtained their PhD in India (e.g. R. Nityananda) and some who had returned from abroad (e.g. G. Srinivasan, C. Shukre, D. Mallik). As a part of the summer school we visited the Kavalur Observatory[2]. There was a sense that Indian astronomy – with ORT, Kavalur, Aryabhata X-ray satellite and theory groups with global standing at TIFR and RRI – was about to takeoff. The summer school met its objective with many participants enrolling into an astronomy PhD program the next year (C. Jog, A. Pati, G. Saikya, R. Nandkumar, S. Sukumar and others; see photograph at the end of the letter). Govind took interest in me and issued a carte blanche invitation to visit ORT. I spent the winter vacation at ORT. With support from ORT technical staff I finished my first experimental project, a variable lag photon-counting digital "clipped" (1-bit) auto-correlator. The successful completion of this project led me to design and build a 64-channel photon clipped correlator for my undergraduate thesis [2]. The winter trip convinced me that my future was in radio astronomy and not in physics. Having concluded thus I returned to Ooty again in 1977.

The main programs at ORT, commissioned in 1971, were (1) using the method of interplanetary scintillations (IPS) to crudely determine angular sizes of radio sources, (2) lunar occultation for even finer angular studies and determination of position and (3) search for the deuterium hyperfine line. In Ooty, I undertook a ground-up study of interferometry, both amplitude and intensity, and IPS theory. During a lunar occultation, the chart recorder pen provided a thrilling and dramatic demonstration of Fresnel integrals. During my stay, Govind tried to interest me in pursuing IPS research. However, as he recounted to me during the 2019 April meeting, I apparently declined, saying that the program was (1) already populated by many astronomers and (2) it had a limited future scope! It is to Govind's credit that such a frank reply did not make him lose in interest in me. During my stay at Ooty I still recall some of the wild ideas that I would propose to Govind, almost every day, to "improve" ORT (e.g., mercury filled tubes with valves to change the center frequency of reception).Govind listened to these ideas and worked with me through the details (and in almost all cases the scheme would turn out to have a fatal flaw). I was a guest for dinner on more than one occasion at his Ooty house and that is when I first met Bina. Upon return I decided that I wanted to pursue a thesis ground in radio astronomy but with an eye towards optical intensity interferometry.

At the summer school I also befriended Rajaram Nityananda who had recently joined RRI after finishing his PhD at the National Aeronautical Laboratory. Rajaram had a deep understanding of waves and optics. I spent subsequent the summer vacation at RRI[3]. I had planned on enrolling for a PhD program at RRI with Rajaram as my advisor. However, at some point, Rajaram thought that my desire for an experimental thesis in Radio Astronomy was best pursued by going to the US. I applied to Berkeley, Caltech and MIT. Caltech rejected me and MIT admitted me with no financial aid. By August of 1978 I found myself with a graduate research assistantship from the Radio Astronomy Laboratory (RAL; C. Heiles, J. Welch, D. Backer), University of California, Berkeley (UCB). Thanks to my stay at Ooty and interactions with Rajaram I had developed a deep understanding of interferometry. This investment paid off with the invention and implementation of an innovative mode for the newly commissioned Very Large Array (1981) and an air-linked interferometer at Arecibo for HI absorption spectroscopy (1982). I graduated from UCB with a PhD in 1983. After a brief post-doctoral period, I joined Caltech in 1985 where I have remained ever since.

In subsequent years Govind and I kept in touch with each other but we had little professional interaction mainly because my interests switched to other areas of astronomy (optical-, X-ray- and g-ray-astronomy). Govind was keen to see me return to India and made a major effort every time the Directorship of IIA opened up. I was too deep rooted in the US to return to India. Furthermore, my heart was not in optical astronomy and so returning to India to push optical astronomy was simply not in the cards. Incidentally, I became Director of the Caltech Optical Observatories[4] out of a sense of duty. In 2018, after over twelve years of service, I stepped down and promptly returned to my roots: radio astronomy and the diffuse interstellar medium. Every now and then my wife and I wonder whether we made the right decision to continue to stay in the US.

The words that come to me when I think of Govind are: energy, enthusiasm, hard work, persistence but most importantly execution. Govind was a true pioneer of radio astronomy. He built two world-class facilities in a relatively poor developing country. He showed that with sufficient grit and determination world-class experimental research can be undertaken in India. However, to achieve this you have to be dedicated. As a student of the

ultimate clinical analysis of life – the Bhagvad Gita -- on this day I would like to celebrate Govind's spectacular life by saluting the numero uno karma yogi of our era.

I would like to take this occasion to suggest re-purposing[5] TIFR's investment at Ooty: ORT and the Cosmic Ray Laboratory (CRL). The two facilities taken together can undertake research in lightning [3,4] and space physics (mapping the solar wind via IPS [5] and sensing interplanetary magnetic fields via muon intensities). In fact, given that our eco-system is increasingly fragile (floods, fires, pandemics, drought) it would be prudent to monitor space weather and build early-warning systems to safe-guard our satellites and electrical grid. The traditional interests of both cosmic ray research and radio astronomy can continue with the merged facility: cosmic rays at the knee can be studied by combining radio and particle physics techniques [6] and ORT with its upgraded wide field-of-view [7] can commensally monitor and explore the meter-wave sky for transients on timescales starting at milliseconds [8]. I am sure Govind would have pleased with this ambitious suggestion.

Sincerely

S. R. Kulkarni
George Ellory Hale Professor, Dept. of Astronomy, Caltech, USA

Group photo of the 1976 summer school

[1] A domino effect was that my two class mates, Milind Purohit (now Dean, Okinawa Institute of Science & Technology and Sudhakar Prasad, University of New Mexico & University of Minnesota) also sought and were admitted to the summer school!

[2] Now renamed to Vainu Bappu Observatory. It is located about 170 km South and East of Bengaluru.

[3] Staying at Rajaram's RRI apartment – gurukul style -- and going through Cambridge physics problem set.

[4] Consisting of the Palomar Observatory, California and the W. M. Keck Observatory, Hawaii.

[5] This proposal comes directly from discussions I had with my long-standing friend Dr. Sunil Gupta (Director of CRL, emeritus) during my visit to TIFR as a part of my JRD Tata Chair Professorship.

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After joining TIFR I was asked to join Radio Astronomy Group and go to Ooty. I landed at Radio Astronomy Centre Ooty on 2nd August 1971. In the evening on the same day Swarup gave me a short introduction to Radio Astronomy. Those were exciting days. The average age of the group was about 27 years. We were all motivated by his boundless energy, never-say-die spirit and his stress on hard work. We were all fired up to take various exciting research activities but soon we suffered a setback when a major accident caused Ooty Radio telescope go out of action. Swarup again motivated all of us to roll up our sleeves and work hard to get the telescope operational within two years.

Once the Ooty Radio telescope started functioning again , Swarup started working on Ooty Synthesis Radio Telescope (OSRT) and dreaming about Giant Equatorial Radio Telescope (GERT). All of us gained valuable experience in building and operating a Synthesis Radio Telescope when OSRT was being built and operated. The expertise gained in this was, later turned out to be cruicial while building GMRT. The other project (GERT) never materialized.

Building GMRT was a gigantic task and I am sure it would not have been possible without the inspiring leadership and single minded devotion of Swarup. He was a tough task master and expected full committeemen from all of us. He dominated the Radio Astronomy Scene in India for about 5 decades. He can be rightly called the Father of Radio Astronomy in India. With his passing away an exciting era of radio astronomy in India has come to an end. May his soul rest in peace.

Vasant Kulkarni
former Professor, NCRA, Pune, India

From your mail and messages from Facebook, I came to know the passing away of Prof. Govind Swarup. It was indeed a great shock. His ever cheerful smiling face flashed my mind. I pray that his soul rest in peace and my heartfelt condolences to his family.

As you know I had known prof Govind Swarup since I joined TIFR in 1965 in the High Altitude studies group and was well aware of the activities of his radio Astronomy Group since Balu, who was my training school batchmate joined him and only 4 of us who came to TIFR. My interaction with him increased later, as a member of the group committee II and further in connection with the GMRT development and as Chair of the DAA. As you are aware that Govind was always bubbling with grand ideas and he had no hesitation of discussing these with anyone, even much juniors to him. At times he did take very strong positions but it was possible to persuade him with efforts. I can also vividly recall our endless tea table discussion in setting up a centre which was his latest passion and how various astronomy centres help provide the manpower, which later germinated into IISERs. He was a treasure trove of new ideas and a builder par excellence who just could not sit idle. In his passing away, radio astronomy has lost a giant and astronomy in general, a strong supporter.

R. K. Manchanda
Honorary Professor, USQ, Australia and former Senior Professor, TIFR, India

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I was saddened to learn the passing away of Prof. Swarup. I was part of the team from BARC that designed the Servo System for GMRT in the late 80's and early 90's. I fondly remember my numerous interactions with him during those exciting days and nights as we surmounted one problem after another with Professor egging us on and leading from the front. Be it an issue related to gear-box or motor, pointing error or locked rotor frequency, Professor Swarup would surprise us with his insights. Not the one to be satisfied easily, not the one to take no for an answer, he relentlessly pushed us towards optimum solutions.

I recall our heated arguments over the cause of current ripple in AZ drive. We apportioned the blame on the construction of the bull gear itself. Professor wasn't convinced. He suspected the servo system. We had to drive the motors directly from a battery and demonstrate that current ripple persisted.

In Jan 93, in the immediate aftermath of Mumbai riots, I happened to travel with him from NCRA Pune campus to GMRT site. Professor was deeply disturbed. He spoke at length and said he was writing to PM expressing his anguish.

On another occasion, I happened to meet him at site, immediately after the visit of Prof. Chandrashekhar to GMRT site.

"You know what he told me after visiting the site?" he asked me with a twinkle in his eye and that disarming smile of his. "'You must be liking doing this, isn't it?', That is all he said" he quoted Chandrashekhar with a childlike glee.

Working with Professor Swarup has been truly inspiring. Rare are men of his caliber, commitment and humanism.

Y. S. Mayya
Raja Ramanna Fellow, DAE and former Distinguished Scientist, Bhabha Atomic Research Centre (BARC), Mumbai, India

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We were very saddened to learn that Professor Govind Swarup has passed away. He was a highly respected astrophysicist who made contributions to a remarkable variety of areas of radio astronomy. His vision led to the creation of the powerful and unique Giant Metrewave Radio Telescope, building on other facilities that he also started, namely the pioneering Ooty Radio Telescope. With these and through his wide range of other activities, he raised Indian radio astronomy to the highest international level.

On behalf of Michael Kramer, Anton Zensus and myself, I would like to convey our condolences to his family and to the National Centre for Radio Astrophysics.

Karl Menten
Executive Director, Max Planck Institute for Radio Astronomy, Bonn, Germany

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Govind Swarup's passing brings back many memories.. I would like to share my own, from the early 1970's to the early 1980's –a period which the younger readers may not know that well.
For me and others doing astronomy at the Raman Research Institute, this was a period of initiation into astronomy, with a strong radio flavor. Radharkrishnan, who founded the group, was a strong influence of course, but the Radio Astronomy Centre at Ooty was very much part of our lives. Govind had a major role in many academic programmes in Bangalore and Ooty, from which all of us benefited. But I would like to focus on the unique relationship which developed between the group at RRI and that at Ooty. We felt welcome not as guests but as close relatives. Govind's own broad vision and strong working relationship with Radhakrishnan made this possible. We had N.V.G Sarma bringing the Ooty experience and culture in setting up the RRI electronics lab, which was later to contribute to the GMRT first generation receivers. My colleague Anantharamaiah was practically a dual citizen, observing recombination lines at Ooty for years. and bringing back vivid tales of the Ooty group. For me, personally, learning about deconvolution from C.R.Subrahmanya was a major concrete influence. All this was overlaid with a sense of the grand adventure which Govind had launched, and the talented group he had assembled, trained, and inspired.

I could not have dreamt, then, that this was just a prelude to a grander , harder, longer venture - the Giant Metrewave Radio Telescope - and for me, later, a whole decade in Pune. When the history of experimental science in India is written, the GMRT will stand out as a rare example which measured up to and even set a global standard. It was my privilege to be touched by Govind and to be entrusted with a part in sustaining his legacy.

Rajaram Nityananda
Professor, Azim Premji University, Bengaluru and former Centre Director, NCRA, Pune.

As a graduate student of TIFR, I admired Professor Govind Swarup a lot for his vision and his ability to fulfil the vision. Later, as an independent researcher, I found that none can match his successful effort to do cutting edge science by building a world-class facility with a shoe-string budget. By being an unassuming trailblazer, he inspired all researchers working in natural science. India has lost a true icon who made extraordinary contributions to science as well as education.

S. Ramakrishnan
Director, Tata Institute of Fundamental Research
Mumbai, India

Though I had no formal link with NCRA/GMRT from Sept 1990 [I moved to Bangalore to join the nascent NCBS], my contacts with Prof Swarup and his family continued till recently. The last message he sent me was in April 2020, when I sent him some pictures of flowering trees from Bangalore, when he said "we miss Bangalore".... . We were in regular touch till then on phone, whatsapp, in person, etc.

I started meeting Prof Swarup after the TIFR Centre building in IISc was built as a joint facility for Mathematics and Radio Astronomy in 1977. From then onwards he kept saying he will transfer some people from Ooty who will help me in Admn and organizing things for the Radio Astronomy part of the TIFR Centre. [TIFR Centre was first occupied by the Mathematics group]. For astronomy, first to be transferred was MN Karthikeyan [in 1979?] who retired in 2008 as a Sr Mechanical Engr from NCRA, followed by A.P. Praveen Kumar, who retired as a sr Electronics Engineer from NCRA in 2012. Both continue to be active in their professional pursuits even now – Praveen teaches electronics to the Physics/Electronics Masters students at the Pune Univ. My first surprise with Prof Swarup that he had sent Karthikeyan and Praveen Kumar, to set up a Mechanical Workshop and Electronics Lab respectively, when I thought he will send either an academic staff or an administrative staff to work with the scientific and/or management of IISc.

Looking back, Prof Vijay Kapahi and Shri Nagarathinam are two people Prof Swarup would have missed – though both had lived to see the GMRT come alive and kicking. .NV Nagarathnam, I miss now the most – Prof Swarup could motivate him [as indeed almost everyone who worked with him] to give his dedication and commitment to anything he was asked to; Nagarathnam, though basically an elecl engineer, not only did all electrical work with dedication and in a fail-safe manner, trained a host of people in whatever he was doing, more importantly, he was Prof Swarup's Man Friday. I saw this first –in 1988 when RAC was celebrating its Silver Jubilee with Shri R.Venkataraman, the then President of India, as the Chief Guest. On the previous evening, work on building a 'pandal' where the function was to be held the next day was not being done fast or properly. Prof Swarup sought out Nagarathnam, told him that he should take up the Pandal work from now on. When next morning Prof Swarup came back he saw the 'Pandal' completed in all its glory. Similarly, the first person who was transferred to Pune in 1986 [though most others moved in 1989 only] for all work related to land acquisition at Narayangaon, coordinating with the Govt of Maharashtra, Poona University, and working tirelessly with the Revenue Dept for acquiring the large tract of land in Khodad/ Narayangaon and nearby areas, obtaining all the required approvals, creating an administrative set up in Gole's Bungalow inside the Pune University [which the University graciously gave to GMRT to initiate all GMRT related activities] etc was not any admn person, or an academician but Nagarathnam; such was Prof Swarup's faith and trust in people. To him it didn't matter who the person was, what was his background or expertise; because once he developed trust in a colleague, he knew they will deliver in any area that they were asked to.

Few more comments
I would like to make a minor modification to your statement that Professor Swarup trained generations of astronomers, engineers; he also trained a host of administrators: all of us from MNS Nair, P. Bhaskaran, M. Mathews, T.S. Viswanathan, K.V.Rama Iyer, ... J.K. Solanki including me - all of us grew to the highest position possible – though only TSV and I were the ones who moved out of NCRA/GMRT; TSV went to NCBS and later CAM [as their Admn & Finance head]. After retirement Viswanathan moved to Professor H. Sharat Chandra's Centre for Genetics in the Govt of Karnataka's IT campus called Bangalore-Helix. I moved to NCBS and in between also to IISER TVM [a new autonomous Institute of MHRD], back to NCBS, inStem [a new autonomous Institute of DBT] and later to C-CAMP [NCBS, inStem and C-CAMP constitute the Bangalore Life Sciences Cluster – BliSC]. Rama Iyer continues to work for ICTS-TIFR, as an indispensable member of their management. All of us mentioned above had very close and long professional and personal association

with Prof Govind Swarup. We all started our career at the lowest level, or middle level with Professor Swarup; he motivated all of us to give our best to the Institute , its Centres or Projects and Science. I can quote several examples where he has brought out the best in me [and I am sure others as well]. In my case as indeed in the case of all of us, such exposure and training we received enabled us to take on bigger responsibilities both in the Institute or wherever we went. He was also very keen to discuss/inform the technical advances or glitches GMRT was facing at different stages, and if we said we didn't understand - he comes down to the level where we can understand. I had often wondered how does he find time to do not only such things, have very close links with so many people – both scientists and non-scientists - and work with everyone at all levels whether it was in setting up NCRA at Pune University, GMRT at Narayangaon, his giving vision and direction to his thought that good students are being spoiled by poor teachers or poor colleges when they go for B.Sc that we must have a national programme for teaching under-graduate courses by the finest teachers/researchers in a University setting where the students spend with industry, research, govt etc - much like what IITs are doing - but for basic sciences. Fortunately, when repeatedly HRD Ministry didn't take this forward, he saw this being supported initially by the Tatas [this, if I recall correctly, Tata's support came about after the TIFR Council meeting at GMRT Khodad in 2001], and soon after by the Govt of India as what are now called IISERs.

I remember going with Prof Swarup and Prof Vijay Kapahi to the Vidhana Soudha for the first time – must be in 1983 or 84 – seeking 2000 acres of land in Gauribidinur [about 100 km from Bangalore, not far for from the Seismic Array Station of BARC] to set up GMRT, meeting the then Chief Secretary Shri Tumkur R. Satishchandra. He was very courteous and supportive and said land will not be a problem and offered all help from the Karnataka Govt. It was much later that we learnt that Satishchandra had done Physics Masters in Central College along with Prof BV Sreekantan – was an admirer of science and scientists, knew TIFR and Prof Swarup's work very well. He was a pillar of strength all through, and it was when he was in the Planning Commission that the three National Centres – NCRA, NCBS and HBCSE – were proposed and approved. Later, in 1990 when land was allotted for setting up NCBS in UAS-GKVK campus, he had to intervene to ensure that the land was quickly transferred..

In the initial days of GMRT, one of the things [by which time Prof Swarup had moved to Bangalore] he asked me is to see if we can start maintaining separate rosters at Bangalore for reservation of jobs for SC/STs - so that we have a fair representation of them as well as unreserved staff. He asked me to fully understand the rules and procedures, explain to him [which I did on 2-3 days in the evenings; my time with him was generally after 6pm in the office]. Once he was convinced, he asked me to take it up with the Registrar, and that is how we started maintaining separate rosters for reservation for all GMRT/NCRA posts. I had to repeat this in 3 more places; NCBS, IISER TVM and inStem.

He was affable and courteous to everyone. When he moved to the TIFR Centre in the IISc campus, he had sought accommodation in the IISc Quarters [large no of residential quarters were just then getting completed inside IISc campus for the first time in its history. He was allotted a Type III [Type C] quarters which was 550-600 sft and built badly. I went and saw it first, and told him not to take it but ask for a bigger house. Though I went and asked the IISc Registrar, he said let Prof Swarup ask Prof [CNR] Rao - the then IISc Director. I remember the amount of persuasion I had to indulge in order to make him request Prof CNR Rao for a bigger house, and most apologetically he broached the topic to Prof CNR Rao. Finally, he was allotted a new larger house in 2 minutes walking distance from his office - almost opposite the TIFR centre.

He had excellent rapport with successive TIFR Directors and Registrars. During Prof Sreekantan's time – which is when the GMRT was proposed, approved and major work initiated at Ooty, later Bangalore and last at Pune and later Narayangaon – there were issues which I thought Prof Swarup should not decide but should be done by the TIFR Director. When I pointed this out on a few occasions, he said you don't understand the Institute. There can only be one Director in the institute – and unless the Director can tell me convincingly why a certain thing cannot be done, I will insist that he must do it. And almost always he was right. This and perhaps more were done by the TIFR Management when the TIFR Governing Council delegated considerable powers to NCRA and NCBS in 1990s. [This was taken forward further in NCBS by both Professor Obaid Siddiqi and Professor K.VijayRaghavan.] But there were also things Prof Swarup looked upto Prof Sreekantan for advice and guidance; one such thing that I saw was building the first prototype of 45 meter GMRT antenna at Ooty – which was Prof Sreekantan's

suggestion.

Those were days when there was no email, whatsapp or mobile. One of the first things he asked me when I started working for Radio Astronomy group [these were the days before GMRT when discussions and proposal for GERT were ongoing] from early 1980s was till what time in the night he can call me; and if there was a call after 9pm, all of us at my house knew it was Prof. Swarup.Those days he used to leave office after 7pm, and he is busy from 9 pm onwards on his research or office related work.

The sacrifices that Professor Swarup made for the pursuit of his passion in science and building the world class facilities in Ooty and Pune, as indeed the sacrifices that Bina Swarup made due to Prof Swarup's deep dedication to science and long absence from Mumbai, and to a lesser extent even after the family moved from Mumbai to Ooty and Bangalore must have been mammoth. His passion, dedication and enthusiasm for science and technology will live on through the hundreds of people whom he encouraged and nurtured who are now spread across the world, and the institutions that they all live/lived and worked.

T. M. Sahadevan
former Head of Administration, NCBS-TIFR, Bengaluru

It has been a very special privilege to be a part of Govind's journey, a very enriching one full of fond memories of our long association with both him and his wife Bina. Although I first met him during the summer school on astronomy and astrophysics which he initiated and was held at the Raman Research Institute, Bangalore during the summer of 1976, our close association started from the summer of 1977 when I joined the Radio Astronomy Centre at Ooty to work with him. It was the 15th of August 1977 when I landed at Ooty, and Govind welcomed me warmly with that absolutely infectious smile, which has been etched in my memory ever since. Our conversation the following morning on what we could work on seems to have happened just the other day; I can almost see the sheet of paper with his notes and words that keep echoing from about 43 years ago.

Simplicity, humility and modesty were the hallmarks that characterised him while building the state of the art telescopes to answer the big questions of the day with unbounded enthusiasm and energy. He was always eager to learn new tools and technology. All these were infectious. We were like one big family working together to achieve the goals amidst numerous challenges. A strong believer in developing indigenous technology and expertise, Govind has left behind a legacy that generations will remember. His legacy is not merely in the telescopes he built, the numerous individuals he mentored but also in his passion for science education which led to the establishment of the IISERs, and the institutional cultures of egalitarianism and passion for hard work which are crucial. He was thrilled when I took up the post of Vice-Chancellor of Cotton University in 2012, and came late evening to listen to my experiences in December 2017 at what seemed like Govind's young age of 88, running on 89. I cannot recall a single instance when a letter or message has not been replied to during our long association when technology has changed from snail mail to telexes, faxes, email and WhatsApp, the last reply being a couple of months ago. It is difficult to find such persons today. He returned to India at a time when Homi Bhabha and others, strongly supported by Nehru, were laying the foundations of science and technology growth in the country, and left an indelible mark and a legacy for us to cherish, celebrate and carry forward.

D. J. Saikia
former Professor at National Centre for Radio Astrophysics, Pune, India

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My interaction with Govind mainly started in the mid '80s when he used to visit Pune in connection with the GMRT. As a student in TIFR in the latter half of 70's, I knew about him and had seen him but not had much direct interaction with him. In the mid-80's, when I was on the faculty of the physics department of Pune University (now SPPU), for an year or more, he gave me an opportunity to work with him and radio engineers from his group on antenna theory, computing the response of an antenna to an electromagnetic wave. This was with GMRT in mind. It was in fact a novel experience for me, since my training and previous experience had been in general relativity. He was ready to take the chance. I am grateful to him for this. Accordingly, I visited Ooty for a month or two in 1986, and I fondly recall many experiences of close interaction. I found that not only was he a great inspirer, he was also full of new ideas and always excited on some aspect or the other about a

physics problem and, in general, science. This excitement was highly infectious to people around him and bore generous fruits. This enthusiasm and excitement never deserted him throughout his life as I gathered. In my future work, the experience of working with him on radio antennas was very useful to me and partly motivated me to take on gravitational waves and their detection, because here too one is dealing with an antenna - the gravitational wave antenna - some of the concepts can be directly translated from electromagnetic waves to gravitational waves.

He was a great visionary and thought big. He built institutions - he in fact was an institution himself! He was passionately interested in science education in India. As a person, he was very helpful. With his demise, India has lost a priceless jewel.

Sanjeev Dhurandhar
Professor Emeritus, Inter University Centre for Astroomy & Astrophysics, Pune, India

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I deem it my fortune to have been associated with Prof.G.Swarup for over 50 years. When I appeared for the interview for the ORT in the year 1969, Govind interacted with the interviewees freely and spoke about Radio Astronomy as an exploratory tool with immense potential for R & D and about the upcoming instrument ORT. He emphasized on indigenous R & D and self-reliance by establishing such projects in the country. This made me decide to join the group. I started looking at him as a doer with a mission. His insatiable enthusiasm to establish the ORT within 5 years and later the GMRT within a decade, by wetting everyone's brain and hand was a great motif because of which, I feel, the group has been able to establish the GMRT successfully and keep evolving well. His high degree of motivation and dynamism to upgrade telescope systems in stages and keep pace with the state of art in another significant character of Govind. His insistence that the group members should make use of their experience and expand to multiple disciplines made an impression in me on many occasions. Govind lives in everyone's memory by his achievements and leadership.

M. R. Sankararaman
former senior Engineer at NCRA, Pune, India

First time I met Govind (he liked me to call him "Govind") in Ooty, in the Southern part of India where the biggest Ooty Radio Telescope is located. The Ooty Radio Telescope was built by Govind in the hilly slope to facilitate the equatorial mount for the telescope. I visited him at Ooty, after a visit to Indian Institute of Astrophysics (IIA) in Bangalore. During one of my visits to Ooty, he enthusiastically updated me that the final site of Giant Meterwave Radio Telescope (GMRT) would be near Pune, south of Bombay. When the GMRT was initiated, the National Centre for Radio Astrophysics (NCRA) was set by Govind at Pune, inside the Pune University Campus. The development of GMRT took place in Pune. During my visit to NCRA, I had opportunity to visit the picturesque site of GMRT with Govind. The trip with Govid was a memorable one. The trip between Pune and GMRT site took about 2 hours and for the whole trip Govind talked and talked. Even now Govind's discussion about the development of GMRT is green in my memory. That trip gave me opportunity to get familiar with GMRT development.

Around 1994 , I initiated intense efforts to develop an interferometer to image the Sun in the decimeter wavelength band; it was desperately needed to compliment around the clock solar observing in decimeter band. We selected sites for possible development for the antenna construction. I invited Govind to visit INPE for about 3 weeks in the month of September 1997, to discuss our project with him.

Govind expressed his desire to visit the possible all sites of the project with the topographer. He was always the person at work. We visited several sites. Finally, when we came to the last site in a valley, he viewed all aspects and suggested it to be suitable site for the telescope construction. But our topographer said that the site would be a difficult site to get developed. But Govind told that that was Hanumant's problem. The most important, Govind said, "name this valley, as Govind valley". We will do it.

On the day of departure, Govind handed over to me a set handwritten manuscript on the details of the project and named it as "Brazilian Decametric Array" (BDA) project. Eventually the MOU between TIFR and INPE was signed. All hardware and software required for the first phase of 5-antenna system were developed at NCRA, Pune and IIA, Bangalore. Presently we are in 2nd phase the BDA development.
Authorities at INPE, Director of INPE (Darcton

Policarpo Damiao and Joaquim E.R. Costa, Chief of the Space weather program are supporting the BDA presently developed , under responsibility of Dr. Jose Cecatto) to play an important in space weather science and prediction. On functioning the telescope site will be named "Govind's Valley" as per his wish.

The BDA gives the perpetual memories of Govind to international community, but a toy project for him. It will satisfy his wish to probe sciences in southern sky.

Selection of BDA site in Chchoeira Paulista on 13th September 1997. Right most is Dr. Hari Om Vats, PRL, in hat India Prof. G. Swarup, F.R.S., Director GMRT with Dr. H.S. Sawant, INPE (white shirt).

Hanumant Sawant
former scientist at National Institute of Space Research (INPE), Brazil

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The Square Kilometre Array owes much to Govind. His interest in large telescopes began in 1962 when Ron Bracewell and he wrote a Nature paper on "Future large telescopes" based on an array of parabolic cylinders arranged like a square venetian blind, one km by one km. By the time SKA construction starts next year, it will have taken quite a while for the original large telescope idea to come to fruition, although not with cylinders.
Not long after Ooty was completed in the early 1970s, Govind began thinking about the next big project, the Giant Equatorial Radio Telescope, or GERT. To be designed and developed as an international telescope with ten times the collecting area of Ooty.
When it became clear at the end of 1983 that GERT wasn't going to be funded, Govind then radically changed the concept into what became the GMRT. He told me he came up with the idea while seeing in the 1983-84 New Year with a glass of whisky. The picture shows a 2019 re-enactment of that moment.
One aspect of the GERT science case came up again, independently, for the SKA. This was the possibility of detecting neutral hydrogen in emission in the distant universe. At a key moment in SKA history, in 1990, Peter Wilkinson from Jodrell Bank gave a conference talk about a one square kilometre array concept to follow the VLA and the

GMRT. The main justification was to detect neutral hydrogen in the early universe, an idea he'd arrived at independently. Govind made the only comment on the talk, not, as you might expect, to point out he'd already proposed that science case in the past, but on additional points to strengthen the case.
Thinking about how to realise such a telescope led Govind and Ron Ekers to propose an URSI global working group in 1993 to take up the challenge of creating this very large radio telescope. This is now recognised as the formal start of the SKA.

As I said at the beginning, the SKA owes much to Govind. It was a great privilege to have known and worked with him.

Richard Schilizzi
former Director, Square Kilometre Array project, UK

Govind Swarup was an outstanding scientist. He mentored his students and younger colleagues and helped them to become successful scientists, engineers, technicians, and project managers.

Right from the outset at TIFR, he had total freedom in choosing his projects to put India in the forefront of radio astronomy. He knew on his return to India in 1963 that he would have to work and innovate with local resources. He taught himself and his team the engineering, electronics, and construction skills that would be the foundation for all future projects.

He was easily approachable and dealt well with students, colleagues and coworkers of all ages. He always made time for school-age children despite the heavy burden of his responsibilities.

Govind trained a number of us in skills far beyond science and engineering—he taught us how to work with industry, government, and international organizations in planning, coordinating, and funding our projects. With his guidance we were able to start with Ooty, build GMRT, and support a number of international endeavours including VLBI and SKA.

My friend Govind was always ready for a discussion and debate on the latest issues in science, Engineering, or even government funding—especially when they had to do with increasing the outreach of science education. I hope that we can continue to follow his lead and advance his dreams and aspirations.

Ramesh Sinha
former Professor, NCRA, Pune, India

A tribute to my mentor and guide, Prof. Govind Swarup

I joined the team of Govind Swarup in TIFR in Sept 1966. Thus, began a long association with Govind and everyone else in the team. The excellent teamwork under his guidance paved the way for solving many hurdles and achieving extraordinary dreams like building the Ooty Radio Telescope (or GMRT later). We saw the first light from Ooty Telescope on the night of Feb. 18, 1970. Govind had boundless energy, and embarked on the Ooty Synthesis Telescope, Giant Equatorial Radio Telescope and finally on the GMRT! He put us all to hard work to excel in instrumentation as well as in science. He motivated everyone that he came across and wasted no time in formalities. He was highly focused on what he wanted to achieve in the time available. He was also very persistent and created a very large school and facilities that are likely to remain strong for a very long time.

After his formal retirement, he tried to set up an Indian Institute for Science and Technology Education (IISTE) with Prof.V.G. Bhide; they almost succeeded but the Govt changed and it became the IISERs of today.

Govind became a legend in his lifetime, was a true scientist and remained simple throughout his life until the last day. May his soul rest in peace. My heart-felt condolences to his family.

Subramanian Ananthakrishnan
former Senior Professor, NCRA, Pune, India

The Govind I remember was a visionary, with an infectious enthusiasm for doing science, an optimist to the core, parallelly processing many ideas and people. He even wondered once jokingly if it is possible to have a chip implanted in his head which will help in this parallel processing; everyone around strongly opposed this! He of course played a crucial role in my own life as he gave me my first permanent faculty position; his reason for hiring me was to also have a theorist among faculty who were building the GMRT; a pigeon among the cats so to speak! We wrote several papers together, driven by his power of positive thinking! I remember him enthusiastically wanting us to predict signals from comet Shoemaker Levy collision with earths atmosphere and observe this; observations were in fact done, but prediction was an impossible task! Govind had no sense of hierarchy, as long as the person/issue was interesting scientifically. As a young person, it was so easy to get fascinated by what he talked about at any time and one felt compelled to contribute to what he asked one to think about. I had got Govind to give an IUCAA colloquium some years back and he was equally enthusiastic at the age of 86 and talked about GMRT observations of Venus, a planet which has come in to prominence recently! I last saw Govind on his 90th birthday celebrations and will miss his always smiling and very humane face greatly.

Kandaswamy Subramanian
Distinguished Professor, Inter University Centre for Astronomy and Astrophysics, Pune, India

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When I met Dr Govind Swaroop for the first time in August 1964, I immediately noticed his pleasant smile and bright twinkle in his eyes. He explained to me the planned structure of the series-feed subarrays and asked me to discuss further with Kapahi who had already started working on this.

Over a period of time, I took over this task from Kapahi. Several other colleagues also joined Dr

Swaroop to work on other parts of the Ooty telescope. All of us soon realized that behind that pleasant smile there was a hard taskmaster driving us all to work as a cohesive team dedicated to a common goal. We saw in him a perfect group leader, in fact a father figure for all of us. And he was certainly the father of radio astronomy in India.

After the Ooty telescope was commissioned, I returned to Mumbai, and with Dr Swaroop's support and guidance, started working on sponsored projects with Dr Sitaram for the MONEX program of IMD. Through all this subsequent work, Dr Swaroop always remained my guiding spirit.

Even a decade later, when I started working in SAMEER on building the MST radar in Tirupati, it was Dr Swaroop's support and guidance which proved crucial. In this sense, he remained a father figure all through my career.

Suresh Damle
former staff member, Radio Astronomy Centre (TIFR), Ootacumnd, India

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I have watched Govind Swarup, mostly from a distance, since 1963 when he joined TIFR in Mumbai. I had joined TIFR in August 1963 as Research Associate after my training at what was then called Atomic Energy Establishment Training School. Two of my colleagues from the school, Vijay Kapahi and Isloor, joined him soon. While he was working on his dream project of a cylindrical radio telescope for lunar occultation, to make decisive observations to answer questions about distances of the radio sources, he was also providing hands-on training to the young group through installing a telescope near Mumbai for solar astronomy.
He was a very proud Indian whose dreams found full support from Homi Bhabha and M G K Menon , both very proud Indians too, at TIFR. Through his untiring energy and enthusiasm he gave us the Ooty Telescope and the GMRT. His enthusiasm and commitment to GMRT had let to the joke that the full expansion of GMRT was "Govind's Masala Radio Telescope".

He was a great son of our country who laid the foundation of radio astronomy in the country and grew it to the level of global leadership.

S. N. Tandon
Professor Emeritus, Inter University Centre for Astronomy and Astrophysics, Pune, India

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I am indeed very sad to hear of the death of Govind, whom I have known for many, many years. In fact, I think that it was on my very first visit to NCRA in Pune when I visited the GMRT site that Govind, himself, sho ed me the telescopes. Somewhere I have a photo of him on that occasion part way up one of the telescopes.

He was indeed a person of great intellectual and practical ability, and it was no small feat to bring into being the NCRA facilities. There is no doubt that his cheerful smile and his great insight will be very much missed. That said, he will surely always be remembered by his tremendous legacy.

It is quite some time since I have seen him, which I think was on the occasion of his last visit to Jodrell Bank. In the evening, I took him to see John Ponsonby and we spent an enjoyable evening together. I have informed John of the sad news.

With much sadness & best wishes

Peter Thomasson
Jodrell Bank Observatory, University of Manchester, UK

Prof. Swarup was one of the key scientists who built the scientific base of post-Independent India. He grew up in Allahabad steeped in the ideals of the freedom movement and responded to Dr Bhabha's call, returning to start Radio Astronomy in the country. The programme in Astronomy he pioneered is one of the highlights of scientific research done in TIFR and across the country today and the GMRT telescope, with its recent impressive upgrade, a living testament to his contributions. Prof. Swarup will forever remain an inspiration for us all in TIFR.

Sandeep Trivedi
Distinguished Professor and former Director, Tata Institute of Fundamental Research, Mumbai, India

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Dear Bina,

Writing on behalf of the Raman Research Institute, the Director of the Institute, my colleagues and I, we would like to convey to you, Anju and Vipin our condolences and share our deep sense of loss at the passing away of Govind.

Reminiscing, the personal friendship and mutual respect between Govind and Rad has been good for RRI, good for the development of Radio Astronomy in the country. Professor Govind Swarup gave a prescient vision for Radio Astronomy for India, which was inclusive in a manner that was the hallmark of his generation, and had the goal of making significant science advancements and discoveries by efforts in the country. His vision was inclusive and opened the doors for scientists and engineers from RRI working together cooperatively with friends in the Radio Astronomy Centre, Ooty, the TIFR Centre at Bangalore, and more recently at NCRA, Pune, towards building world class facilities and doing key science with the facilities.

When he built the Ooty Radio Telescope, the friendship between the two institutions saw RRI building the spectral line receivers and taking on radio recombination and Deuterium line studies of the Galaxy. When Govind built GMRT, he welcomed RRI building the 21-cm receivers and engaging in studies of the gas phase in galaxies and galaxy clusters. More recently, as the country prepared the ground for meaningful participating in the futuristic International Square Kilometre Array radio telescope, Govind shared his ideas on developing novel prototype antennas and Govind worked with our astronomers and engineers to trial a pre-formed parabolic dish at the Gauribidanur Field Station.

It was the distant dream of Professor Swarup that Radio Astronomy one day discovers the distant and early universe during its transition from gas to galaxies. Encouraged by Professor Swarup, TIFR and RRI have collaborated in this quest since the '80s, and thanks to the open- minded and far-sightedness of Govind, the open borders between the radio astronomy groups are paying off towards the future as they jointly propose to build in India critical components of the Square Kilometre Array, and realise the vision of India participating in this key science with Radio Astronomy.

While we are saddened that Govind is no more with us, we look back at his life as an inspiring phenomenon that we are fortunate to have experienced. It has been a privilege for so many of us to have been mentored by Govind and to have been touched by his infectious enthusiasm for living life to its fullest, in a cheerful smiling demeanour, come what may. I would like to also take this opportunity to personally thank you for your kindness, welcome and concern for my family and me, and do hope we will continue to keep in touch in the years to come.

With warm regards and best wishes,

Yours sincerely,

Ravi Subrahmanyan

Ravi Subrahmanyan
Director, Raman Research Institute, Bengaluru, India

Prof Govind Swarup, father of radio astronomy in India, was a great inspiration for all of us. My "Sat Sat Naman" to this great personality. I would like to narrate two incidents related to him : first about GMRT site selection, and the second one about the BDA formative stage.

In Feb 1985, Prof Swarup and his team had surveyed 3 possible sites for GMRT : one near Bangalore, one near Pune and one near Indore. A meeting was called specifically to consider the ionosphere's inmpact. Three very senior scientists of ionospheric physics were invited there. Since I had done my Phd using 140 and 360 MHz radio beacon from ATS-6 satellite recorded at Ooty, I also was invited to speak at this meeting. All three senior scientists gave very long talks, 1 hr each, and I spoke at the end for about 15 mins. In my talk based on my study of ionospheric scintillations and my knowledge of scintillation theory, I categorically stated at the end of the presentation that the Bangalore site will be the worst from the ionospheric scintillations point of view, and the sites near Indore and Pune will be all right; and in fact, as Pune is slightly south of the equatorial anomaly region, it may be sligthly better than Indore. After my presentation, Prof Swarup came to the stage and made the statement that three senior scientists spoke a lot about ionospheric physics and ionospheric scintillations, but did not make any mention about the impact on the sites we have in mind; but Vats very categorically stated the impact of ionospheric scintillations on all the 3 sites, and I thank him for that. From that I learnt that any meeting that you go to, you should talk precisely to the point for which the meeting was called.

Another experience that I had with Prof Swarup was in Brazil in 1999. At that time, I was on sabbatical leave there to work with Prof Sawant for about 2 yrs. Prof Swarup visited there for a week and discussed all aspects of the BDA. I am very confident in saying that it is because of Prof Swarup

that the BDA could be created in Brazil.

Prof Swarup will be remembered for ever, and may his soul rest in peace.

Hari Om Vats
former Professor, Physical Research Laboratory
Ahmedabad, India.

Govind Swarup was a preeminent astronomer-engineer who created world class radio astronomy facilities in India. The great success of the Ooty telescope and the GMRT in Pune, and the scientists and engineers he nurtured, stands testimony to his monumental contribution. He is one of those who carried forward the vison and legacy of Dr Homi Bhabha who founded the Tata Institute of Fundamental Research, and whom he very greatly admired. You can see him recall his experience and conversations with Bhabha in the film on Homi Bhabha made by TIFR.

He was deeply committed to education and its role in the ascension of India to become a great scientific power. Simply put he said, "Unless we combine undergraduate education with research and experiments in all disciplines (e.g. in social sciences with field surveys) we cannot expect our universities to become world class".

In his passing away India has lost a great visionary and inspirational scientist- engineer and a committed educationist.

In 2008 I was in IUCAA Pune during the first ICTS Cosmology Program. At that time, we were actively searching for a place to establish the ICTS. Govind spoke to me and emphasized that Pune and its neighborhood would be the best place to start the new Centre. He talked about the future growth of the Bombay-Pune economic corridor and the presence of good institutions in Pune. We did look seriously for land in Pune, as it is close to Mumbai, but all our efforts failed.

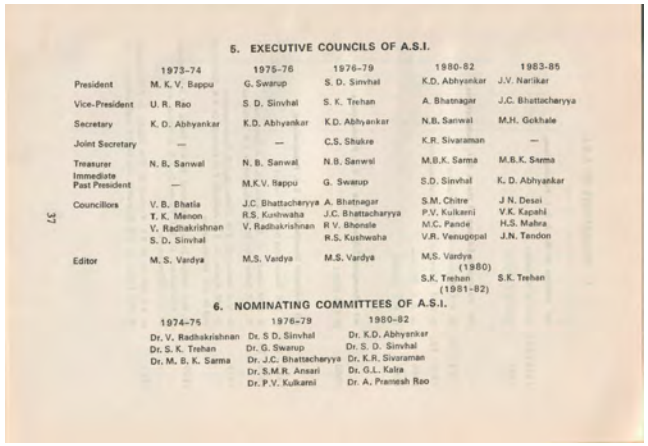
The ICTS finally came up in Bangalore and Govind did visit us in 2015 during the program on "Extra Galactic Relativistic Jets: Cause and Effect". He introduced Bernard Fanaroff who delivered a public lecture. After the talk as we were all leaving the lecture hall, he came up to me and in his informal and direct style said, "You had a vision, like Bhabha you had a vision". I will always cherish his words.

He will be greatly missed but his legacy will live on.

Spenta Wadia
former Centre Director, ICTS-TIFR, Bengaluru, India

The Astronomical Society of India is deeply saddened by the demise of Professor Govind Swarup, one of the early members of the Society. Professor Swarup was the second (1975-76) President of the ASI, soon after it was formed, and guided its destiny during the formative years. He was a regular figure in ASI meetings, participating enthusiastically in the scientific deliberations as well as in the matters of the Society.

Professor Swarup returned to India in 1963, with a PhD from Stanford, and a strong motivation, desire and aspiration to develop radio astronomy in the country. Today, the Ooty radio telescope, the



5. EXECUTIVE COUNCILS OF A.S.I.

	1973–74	1975–76	1976–79	1980–82	1983–85
President	M. K. V. Bappu	G. Swarup	S. D. Sinvhal	K.D. Abhyankar	J.V. Narlikar
Vice-President	U. R. Rao	S. D. Sinvhal	S. K. Trehan	A. Bhatnagar	J.C. Bhattacharyya
Secretary	K. D. Abhyankar	K.D. Abhyankar	K.D. Abhyankar	N.B. Sanwal	M.H. Gokhale
Joint Secretary	—	—	C.S. Shukre	K.R. Sivaraman	—
Treasurer	N. B. Sanwal	N. B. Sanwal	N.B. Sanwal	M.B.K. Sarma	M.B.K. Sarma
Immediate Past President	—	M.K.V. Bappu	G. Swarup	S.D. Sinvhal	K. D. Abhyankar
Councillors	V. B. Bhatia T. K. Menon V. Radhakrishnan S. D. Sinvhal	J.C. Bhattacharyya R.S. Kushwaha V. Radhakrishnan	A. Bhatnagar J.C. Bhattacharyya R.V. Bhonsle R.S. Kushwaha	S.M. Chitre P.V. Kulkarni M.C. Pandé V.R. Venugopal	J.N. Desai V.K. Kapahi H.S. Mehra J.N. Tandon
Editor	M. S. Vardya	M.S. Vardya	M.S. Vardya	M.S. Vardya (1980) S.K. Trehan (1981–82)	S.K. Trehan

6. NOMINATING COMMITTEES OF A.S.I.

1974–75	1976–79	1980–82
Dr. V. Radhakrishnan	Dr. S D. Sinvhal	Dr. K.D. Abhyankar
Dr. S. K. Trehan	Dr. G. Swarup	Dr. S. D. Sinvhal
Dr. M. B. K. Sarma	Dr. J.C. Bhattacharyya	Dr. K.R. Sivaraman
	Dr. S.M.R. Ansari	Dr. G.L. Kalra
	Dr. P.V. Kulkarni	Dr. A. Pramesh Rao

Giant Meterwave Radio Telescope and the National Centre for Radio Astrophysics are testimonies of this desire and aspiration. He leaves behind a team of astronomers and engineers groomed to rise above their normal selves and meet challenges.

Professor Swarup's passion for development of cost effective and innovative technology went beyond radio astronomy. Always effervescent, with

an unabated enthusiasm for science and technology, he attracted and inspired a large number of scientists and engineers of all ages. The story of his work and life will continue to inspire future generations of astronomers and engineers.

A pioneer, and an icon of Indian Astronomy, Professor Swarup will be greatly missed.

On behalf of the Executive Council and the members of the Astronomical Society of India, I convey my condolences to his family and the National Centre for Radio Astrophysics.

G. C. Anupama
President, Astronomical Society of India

We are extremely sad to learn that our dear Govind is no more. A personal irreparable loss for me. What ever I could learn and achieve was due to his personal guidance and goodwill from day one. He created a galaxy of outstanding students and inspired thousands of beginners aspiring to explore the Universe.

He was ever ready to help you with his infectious smile and his phenomenal talent and depth of knowledge was awe inspiring. He taught us how do dream big, have faith in your own abilities and not lose hope even in the darkest hours and always was sure that the Sun will rise soon. His contributions to Indian as well as International science will be remembered for generations, and his legacy will live on in the next generation facilities in science and higher education he helped create.

Thanks Govind for everything you did in this world. Please convey our deepest and heartfelt condolences to the whole NCRA, RAC family and to specially to Govind's own family (Beena ji and children).

Joydeep Bagchi
former Professor, Inter University Centre for Astronomy and Astrophysics, Pune, India

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Prof. Swarup is an inspiration - when we think about how he built the Ooty Radio Telescope! I remember once when I was visiting NCRA and sitting at the canteen, he just came and sat there (I never met him before) and just started to talk, "Hi I am Govind, I used to work here. What do you work on?". So down to earth! We talked for quite some time. That day he encouraged me to take up risky problems where publication might not come immediately. I wish I had more opportunities to interact with him.

Manjari Bagchi
Professor, IMSc, Chennai, India

I do not recall any meeting with him in the last thirty years that I knew him when he was not excited about some novel idea.

My first meeting with him was during the IUCAA-NCRA introductory summer school in 1990. He had undergone a surgery and was not supposed to speak. But he started coming for sessions as soon as he could move around. Our sessions were held in SPICER college but the final project presentations were in the NCRA lecture hall. After one presentation where I had asked a question about CMBR, he dragged me to the notice board to show me the first FIRAS spectrum from COBE, explained it to me and said, isn't it wonderful? That enthusiasm never ebbed. He insisted on speaking to participants of the school for a brief while, which somehow stretched to 90 minutes until Kapahi and others forced him to stop speaking on account of his health. Discussions continued outside over tea. Here is a slightly grainy picture from that discussion, and a group photo of the school.

During my stint at IUCAA as a graduate student, visitors to NCRA were distinctly different from a typical visitor to IUCAA. I recall listening to Joe Taylor, who came across as someone who not only knew his astrophysics but was familiar with engineering details of radio telescopes at the deepest level. I also recall the kind of respect they gave to Govind. I saw this again when I played host for his visit to CfA. Given his easy going nature and his emphasis on trying to understand new things, he sometimes left an impression that was not commensurate with his level of understanding or his contributions.

Towards the end of my stay at IUCAA, Govind started proposing academic institutes of a new type. This proposal will finally lead to formation of IISERs about a decade later. In my meetings with him in the last ten years, he always wanted to know how IISER Mohali was progressing, and gave suggestions on how we can improve the program further. His own dream had been of institutes where students can move freely between basic sciences and engineering. That is something for the future.

Govind's enthusiasm, and sharp insight will be missed.

Jasjeet Singh Bagla
Professor, Indian Institute of Science Education and Research, Mohali, India

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I, R. Balasubramaniam, joined as Scientific Assistant in Radio Astronomy Centre (RAC), Ooty in Jan 1974 and retired as Group Co-ordinator, GMRT Operations in June 2012. I was fortunate to work under Prof. Swarup in ORT and OSRT projects in RAC, Ooty and in GMRT project of NCRA, TIFR.

I was involved in many projects during my career. And I would like to share few of the great moments we had with him. He used to sit with our Telemetry group many times during project development phase in RAC, Ooty and in GMRT/NCRA campuses either during office hours or after office hours for very interesting and brainstorming sessions to understand the progress of our systems. And we would be nervous during the meeting but he guided and encouraged us in many ways to develop and install reliable systems. He had indeed inspired us and rekindled our thoughts with many new ideas.

He was knowing many formulas in fingertips and use them to derive and calculate anything just like that with a pen and paper. We also used to wonder during our all group meetings about his fast mind switching capability to discuss at length with any group either electrical or electronics or mechanical or civil or even general administration and could guide all the groups. We were fortunate to work under his leadership. He was also a GREAT human being and I would like to thank him for helping me personally many times.

We cannot forget Prof. Swarup's technological and scientific contribution to Radio Astronomy in India. RIP Prof Swarup. Our deepest and heartfelt condolences to Mrs. Bina Swarup and family. Thanks.

R. Balasubramaniam
former senior Engineer at NCRA, Pune, India

My first interaction with Prof. Govind Swarup happened during a conference at TIFR in 2004. We invited him to deliver the 53 Saha Memorial Lecture in 2018 (https://indico.cern.ch/event/683407/page/13100-saha-memorial-lecture). As I was coordinating his visit and the lecture, this gave me an opportunity to discuss a lot with him. He told me an interesting story. He had a great plan to build a radio telescope in Kalyani which is about 50 away from Kolkata and where one of first two IISERs is located. In this connection, he made several trips to Calcutta during 90s. Radio physics department of Calcutta University and Kalyani University were part of this project. His first radio telescope was located in Kalyan and the last one could be in Kalyani. However, it did not materialise. We lost a golden opportunity to have one of his creations in the eastern part of India.
Prof. Swarup was a visionary, great scientist and above all, he was a great human being. I saw how much he was loved by common people during his 90th birthday celebration. I pay my tribute to Prof. Swarup.

Debades Bandyopadhyay
Senior Professor, SINP, Kolkata, India

Govind has been nothing short of a phenomenon in radio astronomy.

It was my privilege to have had him as one of my mentors in the early days of my career. In fact, Govind was still the Director @ NCRA when I started as a student, and naturally, in my formative years, he had a great influence on me.

A characteristic of Govind was that he used to take personal interest in everyone's research (including a beginner like me back then!), and that is something that always motivated us to work harder.

I take great pride in saying that my PhD research work made extensive use of the Ooty Radio Telescope that he built. In fact, several hundreds of hours of pulsar observations from that telescope

have gone into my PhD thesis, and all the publications that came out of it. Interestingly, many years later, my career path has brought me back to low frequency radio astronomy taking me back to the roots, and prompting me to recollect those good old days, and all the wisdom he imparted.

Here at Curtin, radio astronomy is indeed a major focus area, with SKA-Low coming to Western Australia. In preparation for that, we have been doing a lot of pulsar work at low frequencies, and we get to use the GMRT, another telescope that Govind built as his contribution to global astronomy.

Govind has left a deep void in astronomy, but he has also left a great legacy for us to take forward.

Ramesh Bhat
Research astronomer, Swinburne University, Australia

It is hard to believe that Govind is no more. We received the devastating news last night, but it has taken me time to find words. His simplicity, dedication, innovative skills, leadership and above all dedication to the joy of science has been a lesson for us all. How he remained an active, guiding spirit till the end is beyond remarkable and a testimony to his uniqueness. The nation will miss him deeply. My sincere condolences to the NCRA family which has so successfully followed the path led by him and is all set to grow and flourish further in the years to come. I hope the family is OK and Bina has the support she needs at this hour. We deeply and solemnly share the grief of all of you.

Dipankar Bhattacharya
Distinguished Professor, Inter University Centre for Astronomy and Astrophysics, Pune, India

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I am deeply saddened after listening to the news of the sad demise of Prof. Swarup. I consider myself extremely lucky to get introduced to him around April 2008 in the GMRT canteen when I joined there to carry out my Masters thesis. He himself approached me and asked my details. Then, he started to share his journey. The very next day, he called me into the library and asked me to solve a problem on the transmission line. When I had attempted it, I can still recall that he had appreciated my effort in front of the audience in the conference hall at GMRT, which really boosted me a lot. Later, he was very happy when I joined IIT Kanpur for my PhD. He was delighted when he came to know that I had joined IIIT Allahabad as he had done his earlier days education in Allahabad. I can recall that he organized a lecture for me at DIAT Pune when I was still pursuing my PhD. While I was in Kanpur, he visited once and came to the campus of IIT just to meet me following an important meeting. I have never seen a person with such a high stature can maintain a down to earth image with an ever gentle smile in his face. It is my privilege to come across such a great person who was full of enthusiasm and inspired many young minds. I take this opportunity to share some moments with him. May his departed soul rest in peace. My sincere condolences to the bereaved family !

Somak Bhattacharyya
Assistant Professor, IIT BHU, Varanasi, India

Prof. Swarup is an icon! The positivity and enthusiasm with which he talked about any new idea is itself a learning lesson for all of us. I am in no position to comment on his extraordinary contributions to radio astronomy, but his life and his work stands out as an inspiration for generations of Indian scientists to take challenges and live a life for the joy of science. His passing away is a great loss for me personally, since he advised me to make a career in ways where I can lead and not follow. It changed my life forever. Goodbye Prof. Swarup. I feel extremely blessed to have shared your company.

Suchetana Chatterjee
Assistant Professor, Presidency University, Kolkata, India

I was extremely saddened to hear of the demise of Prof. Goving Swarup. He was truly a visionary scientist, always looking ahead, designing and building radio telescope and thinking up exciting science projects. He was also such a great motivator -- always so enthusiastic about science and able to communicate it to students and faculty alike. I remember first meeting him in 1990 in NCRA, when he spent a couple of hours explaining the GMRT to me and another Ph.D student. He was so excited and we felt it too! Years later every time I met him, he always seemed just as excited. Another very humane aspect about Prof. Swarup was that he never spoke down to you (student, faculty --- whatever), and so you never felt intimidated by him. I found that he was one of the most approachable scientists I had ever met. I will miss him I always tried to look him up in NCRA every time I visited.

Mousumi Das
Professor, Indian Institute of Astrophysics, Bengaluru, India

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I should say at the outset that I never had the privilege of interacting with Prof. Govind Swarup. The only possibility arose when I came to NCRA to give a Colloquium in NCRA in May 2019. He was unwell and could not attend the talk. I have always admired Prof. Swarup's building an institution, based on a unique radio-telescope, from scratch from afar. After my visit to GMRT this was further reinforced. While I could not meet Prof. Swarup, I did visit the labs and met several scientists and engineers, many of whom were groomed by him. I was overwhelmed by what I saw and heard.

I remember seeing Prof. Swarup around 2002 (when I came with my son for a KVPY interview to Pune and stayed for a day at the NCRA Guest house) at an adjoining table in the Canteen surrounded by a few students and engaging in a lively scientific discussion.

Vivek Datar
Senior Professor, TIFR, Mumbai, India

During my M.Sc. project at NCRA (2003-2004) I had chances to interact with Prof. Swarup at NCRA and GMRT. I was working on my M.Sc. project on Radio Holography. We had several discussions on various things related or unrelated to my project. Regardless of how long or short those interactions were, I always got out something to learn from them. His enthusiasm and passion about science and astrophysics always encouraged young students and motivated them in their career path. My deepest condolences to Prof. Swarup's family and friends.

Abhairup Datta
Professor, Indian Institute of Technology, Indore, India

A world-renowned scientist, and researcher in astronomy Dr. Govind Swarup is not with us today. He passed away due to old age on 07 September 2020. We have lost a great scientist. He was the father of the world's largest radio telescope project. His extraordinary deeds and his significant con-

tribution have added to the country's reputation. He also worked extensively in the Khodad village for science education and outreach. While setting up the GMRT, he was of the view that something should be done for the village of Khodad. He set up the "Khodad Rural Science Centre" in the village where ordinary school children are learning science in a fun and interesting way.

His departure is a huge loss for us. Dr. Swarup Sir's passing away has caused sudden grief even personally to me, my family and the villagers of Khodad. While paying homage, we pray for the GYANSURYA who was obsessed with science, till the very end. I offer my heartfelt homage to his holy soul and pray that it may attain eternal peace.

Jalinder Dongre
former Sarpanch, Khodad village, Maharashtra, India

The passing away of Prof. Govind Swarup brought many memories to me. However, keeping the time limit in mind, I mention just a couple of my thoughts.

As a young student of Radio Astronomy at RRI during the early eighties, I came to know of the motivation and history behind the construction of ORT and all the good work being carried out by the Ooty group under the inspirational leadership of Govind. Both the ORT and the Ooty group were an inspiration to all of us.

While I thought ORT was already big enough, little did I realise that this was only a precursor for bigger things to come. Govind was talking about GMRT with 30 dishes spread over 25 km. I thought to myself 'this is surely a crazy thing to attempt in India.' During the mid-90's GMRT was becoming a reality. I remember a meeting at RRI when we tried to convince Govind that we must have 21 cm-line feeds on GMRT. In his characteristic style, Govind said 'If you want 21 cm-line feeds, you build it' and RRI did.

Starting with the mid-90's I made innumerable visits to NCRA/GMRT. No visit was complete without meeting Govind (quite often in the corridor or in the canteen) who would be concerned about some problem or the other related to the telescopes, to RFI, to power lines, etc. He would be posing these problems to youngsters, goading them to solve them and keeping track of them for weeks and months to come even when he was pushing 80 !

Even today, when I visit the GMRT site, I cant suppress a sense of disbelief in me that 30000 square meters of miracle is working in our backyard; a miracle made possible by Govind's inspirational leadership and his group's dedication.

I feel privileged to have worked in radio astronomy at a time when a legend like Govind was around. There is no doubt in my mind that
Govind will continue to inspire generations of astronomers to come.

K. S. Dwarkanath
Emeritus Professor, Raman Research Institute, Bengaluru, India

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There are very few individuals like Govind, who is capable of inspiring and influencing the lives of so many people across six decades. Words can not describe how all of us felt when we faced with this void Govind left after his sad demise. I, Vishal Gajjar, one among those many countless individuals whose professional life has been heavily influenced by Govind's guidance, here to pay my respect to this great human being.

By building two of the world-class radio telescopes, Govind planted and nourished the field of radio astronomy for several generations in India. In the spirit of being a true Bharat Ratna! Govind was enthusiastic about many questions in the field of astronomy. One of these topics on which I sensed a particular connection with him was on the question of life in the Universe. Govind was an avid proponent of Search for Extra-Terrestrial Intelligence (SETI) and yearned for GMRT's participation right from the early days of telescope coming online. I recall numerous conversations we had in the NCRA canteen and in his office on this topic while I was doing my PhD. I am currently working as a researcher with the Breakthrough Listen project at the University of California, Berkeley which is one of the largest projects to search for evidence of intelligent life in the Universe. For which, I give full acknowledgment to Govind. He cultivated and supported me to pursue this career which has given me so much joy and prosperity for which I am ever indebted. My deepest condolences to Govind's family and close friends. I am sure by seeking answers to nature's most profound questions with the GMRT, we will find a way to remember him forever.

Vishal Gajjar
Project Scientist, University of California, Berkeley, USA

I am sad to know the departure of Professor Govind Swarup, the founder of radio astronomy in India. He was an inspiration to all of us. Govind was such a great person and scientist, he will live on in our memories forever. My heartfelt condolences.

R. T. Gangadhara
Professor, Indian Institute of Astrophysics, Bengaluru, India

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I would also like to convey my condolences to the entire NCRA family as well as Prof. Swarup's near and dear ones. Unfortunately, I did not get the chance to meet Prof. Swarup until about five years ago. He had come to the new ICTS campus for the very first program we had held there which was on active galactic nuclei. Thus a very memorable occasion for me and all of us at ICTS.

https://www.icts.res.in/program/ERG2015
I had the opportunity to share a car ride with him to and fro the conference dinner. I was struck by how passionate he was about science. He told me about the process of conceptualization of the IISERs - an enormous contribution, in addition to NCRA and radio astronomy in India. He was very positive about the ICTS and the programs we were organising as a means to enthuse young researchers, catalyse path breaking work and bring about national and international collaborations across institutions. It was very heartening to feel the support and encouragement of someone like him who had demonstrated that it is possible to set up a global institution in India, fostering cutting edge science here. I am sure his vision and legacy will last in our country and continue to inspire.

Rajesh Gopakumar
Centre Director, ICTS-TIFR, Bengaluru, India

It is with great sadness that I learnt that Prof Govind Swarup, the father of Radio Astronomy in India is no more. With his passing away, we come to the end of an era in Radio Astronomy, especially in India. Prof Swarup was a giant of a personality, who conceived of and developed the Ooty radio telescope and the Giant Meterwave Radio Telescopes, which are still operating as two of the most productive facilities in Radio Astronomy internationally.

My interactions with Prof Swarup started in 1983 at the Ooty Radio Telescope, when I and my NPL colleagues helped his group, especially, Prof S Ananthakrishnan by providing accurately traceable time standards for their VLBI experiments. I still remember, we had flown two atomic clocks from NPL, New Delhi to Bangalore in running condition by Indian airlines. In fact two seats were booked in the aircraft for these two clocks in the name of Mr and Mrs Clock. I have vivid recollections of meeting Prof Swarup for the first time- his broad smile and childlike enthusiasm in explain to us the Ooty radio telescope. The VLBI experiments done at Ooty for the first time in India were a great success.

Our interactions continued over the years and there were occasions when we provided timing support to experiments at GMRT and it was a great experience to see the GMRT facility slowly come up and become operational. In the later years Prof Swarup had formally retired. However, he was always available for sharing with me the latest exciting developments in radio astronomy – and always with that childlike enthusiasm.

Prof Swarup had a special relationship with NPL, my Alma Mater. It is here that he had started his career in 1950. He was deputed to CSIRO, Australia in 1953 for his first training in Radio Astronomy. He returned to NPL in 1955 and, after spending a year in trying to initiate activity in Radio Astronomy without success, left for the USA to do his PhD at Stanford. The rest, as they say, is history. He always had his special love for NPL. When in 2014 we had invited him to deliver the first "A P Mitra Memorial Lecture" at the NPL auditorium, he readily agreed and delivered a brilliant lecture that also included anecdotes from his years at NPL. It was during this function, that he expressed his keen desire to join the NPL former Scientists' Forum, since he said that he qualified to be a "former NPL Scientist". Of course, we were very glad to have him.

Recently the prestigious URSI Asia Pacific Radio Science Conference (URSI AP-RASC 2019) was held in New Delhi during 12-16 March, 2019. This was mainly organised by the Indian Radio Science Society (InRaSS) and Prof S Ananthakrishnan and I, as its President and General Secretary respectively, had to shoulder the bulk of the organisational responsibilities. We decided to felicitate Prof Swarup on his 90th birthday, which was

around the same time. We were really delighted when he accepted our invitation and travelled to Delhi despite his extremely frail health condition. He also gave a fantastic keynote address in a special Commission - J (Radio Astronomy) session that we had organised in his honour. This was the last time that I got to meet him. Despite being extremely weak he was his enthusiastic self with his trademark broad smile – an image that will be forever etched in my memory.

I would like to take this opportunity to pay my most sincere tributes to his memory. May we continue his legacy for all times to come.

Amitava Sen Gupta
former Director, National Physical Laboratory, New Delhi, India

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I am deeply saddened to hear of the sudden passing away of Professor Govind Swarup. As a Ph.D. student at NCRA during 2001 - 2007, I had the opportunity to interact with him quite regularly. He would generally join students' table in the cafeteria for lunch which would then go on for a couple of hours. I can still recall many of those discussions. He was genuinely curious about astronomy and learning whatever that is needed to get things done ! I feel fortunate to have met him. He was a wonderful human being, warm and friendly....shall always cherish the memories of our interactions. My deepest condolences to his family.

Neeraj Gupta
Associate Professor, Inter University Centre for Astronomy and Astrophysics, Pune, India

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We have lost Govind. He was not only the leader of building innovative world-class radio telescopes but also a never-ending source of inspiration to do new things to do big things and that too with a smiling face always. Talking to him, wherever you meet, is a discussion on science that has taught us his approach to science and life in general. His appreciation on making discoveries using GMRT and push with an idea to do more will be missed. The commitment he had for inspiring and educating students of RAD@home citizen science research will always be kept in mind. Our real tribute will be following his words and working for science and society. He is a true Bharat ratna.

Ananda Hota
Scientist at Centre for Excellence in Basic Sciences, Mumbai, India

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My condolences to all that are close to Prof. Govind Swarup. I am thankful for the opportunity to have met him and interact with him. As the main driver behind planning and constructing the Giant Metrewave Radio Telescope, he is indirectly responsible for much of my scientific achievements, for which I am very grateful. I had the opportunity to visit and use the GMRT, and in the process made many Indian friends. The times that I met Prof. Swarup he has always treated me very kindly, and I continue to treasure these memories.

Huib Intema
IT Support Scientist and Radio Astronomer, Leiden University, The Netherlands

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I am saddened to hear the sad demise of Prof. Govind Swarup.Kindly convey our heartfelt condolences to the bereaved family.

Prof. Swarup was a genius and a very good human being. I was fortunate enough to be associated with him for more than 30 years. Our interactions started from the year 1986 consequent upon his relocation to TIFR Centre, Bangalore from RAC,Ooty. As soon as he moved to Bangalore, there was a spurt in the project related activities. Those days were very hectic and I could face the challenges/daunting tasks related to this Mega project successfully.

As a person in-charge of Finance,Accounts and budget of this prestigious GMRT project, right from its infancy stage,I have closely interacted with him.Our interactions were always pleasant.
Professor Swarup was a genius,a towering personality,a multidimensional /versatile person with an eye for every detail. He was a good listener, used to motivate/encourage us and played a significant role in shaping us as "Administrators".He was always helpful and was interested in our well being. He helped in getting a transfer for my wife from Bangalore to Pune.

I continued my interaction with him even after my retirement. Unfortunately, I couldn't attend his 90 th birthday function due to some reasons. I did meet him in February 2020 when I visited Pune. Though, looking fragile,we exchanged pleasantries.

With his passing away,the world has lost an ex-

ceptionally outstanding Scientist!

May his Soul rest in peace!

K. V. Rama Iyer
former Head Administration & Finance, NCRA, Pune, India

This is a great loss to the scientific community. Also for those who know him closely. I have met him many times and talked to him. His witty conversation and the mesmerising smile will always linger in our minds ! I join with his family, friends and the whole astronomy community in mourning the loss of a great man in Science !
with regards

Joe Jacob
Newman College, Thodupuzha, India

I was deeply saddened when I received an e-mail from a senior colleague about the sad demise of Prof. Govind Swarup on 7th September in Pune after a brief illness. Although I never had a chance to meet the doyen of Indian Radio Astronomy, the fragrance of original work has no boundaries and is felt everywhere. His legacy will live on in the form of the telescopes that he built, and the generations of scientists and engineers he trained. Prof. Swarup's vision and foresight has led in creating a strong base of Radio Astronomy in the country. UM-DAE CEBS community offers its deepest condolences and pray to the almighty that may his soul rest in peace.

V. K. Jain
Director, UM-DAE Centre for Excellence in Basic Sciences, University of Mumbai, India

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As I recall my very 1st memory of Prof Swarup, it was rather full of questions. He wanted me to answer, "Why an electric bulb emits light which are inherently Electromagnetic Waves?". I mumbled and I think my answer was not satisfactory to Prof Swarup. Nonetheless I tried answering and he correctly explained the phenomenon to me. If he had not done this, I would not have entered the field of Radio Astronomy Instrumentation and eventually received a PhD associated with it.

That was his greatness that he gave time and motivated others to excel along with numerous challenges which he overcame in creating ORT and GMRT. I am truly saddened by the fact that such a great mentor, scientist has taken a final rest. My heartfelt condolence to his immediately family and the family of professionals in numerous disciplines and countries.

Yogesh Karandikar
Founder, Tantrayut Telecommunications Ltd., Mumbai, India

Govind Swarup's remarkable life and career were paralleled by those of my own mentor and inaugural Grote Reber medal winner, Professor Bill Erickson. Govind and Bill were especially close friends throughout their careers, and there was undoubtedly a great cross-fertilization of imagination between them. Their earlier instruments, Govind's Ooty telescope and Bill's Clark Lake TPT played major roles in my early career. While their later instruments, Bill's low frequency systems on the VLA and Govind's major achievement with the GMRT, dominate the research of my group until today. Govind was a very good friend of my mother who also only recently passed away. He was a loyal friend at a challenging time in her professional career, as I will always remember. Govind treated me almost like a son, and I will remember him as I do Bill, like professional fathers across my career. My deepest condolences to Govind's family, and my thoughts go out to the many friends and professional colleagues over whom he was so influential.

Namir Kassim
Scientist, Naval Research Laboratory, Annandale, Virginia, United States

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JAI SHIVARAY
As a Member of Parliament of Shirur Loksabha I pay tribute to Padmshri Late Dr. Govind Swarup. His immense contribution and work in the field of radio astronomy has not only made the country proud but also will be remembered for generations to come. Be it Ooty Radio Telescope or be it GMRT, all the projects which took place under the able leadership of Dr. Govind Swarup have help to our country make its strong present on global platforms in the field of Radio Astronomy. His passion for science and his love for engineering

has inspired me. Despite being a pinnacle success and achievement, his humbleness and his down-to-earth nature must have touch every man's heart he came across. Walking the path shown by late Dr. Govind Swarup ji and making our country proud and powerful in the field of Radio Astronomy is the true tribute to this National Hero.

Amol Kolhe
Member of Lok Sabha from Shirur, Maharashtra, India

I am extremely saddened by the news of Prof. Govind Swarup. May his soul rest in peace. My condolences to his family members. Here I share some of my memories related to Govind. I moved from TIFR-Mumbai to NCRA-Pune in July, 2001 as a graduate student and I met Govind then in NCRA for the first time. He was by then retired, but used to come to NCRA everyday till he had by-pass surgery in 2005 (Post surgery he used to come a few days a week). When I met him, I was overwhelmed by the simplicity and down-to-earth attitude of Govind in spite of his great stature. During my entire NCRA days and my two years of IUCAA postdoctoral days, I met him almost on a regular basis and interacted with him. He was a fountain of inspiration for me and I still can hear his words of inspiration. He himself used to tell me his family related stories, his careers, his feelings. To me as if he was The Pitamah (grandpa). As a young graduate student, getting a Pitamah like figure to talk to on a regular basis is like a heavenly experience. He encouraged me a lot almost every time I spoke to him. I think, we all are going to miss him like anything. His demise is an irreparable loss to Indian astronomy community. However, his legacy is a priceless gift to us.

Chiranjib Konar
Assistant Professor, Amity University, Noida, India

My first interaction with Prof. Swarup was at the GMRT which was also my first visit there. I feel honoured to have had the opportunity for the scientific and technical interactions with him. Talking to him was always motivating especially when he would tell the stories of Ooty Radio Telescope and the GMRT, he definitely had an impact. Will cherish the moments I was able to spend with him forever, he was and will be an inspiring scientist for generations to come.

Hariharan Krishnan
Postdoctoral Fellow, Arizona State University, USA

I am among the lucky ones who have met Prof. Govind Swarup. Since October 1995 when I met him for the first time, I have always been amazed by his energy and his extraordinary ability to impulse energy to others in order to accomplish what others would think impossible. Of course the GMRT has not been made by his hands, but by the hands, the intelligence and the devotion of hundreds of scientists, engineers and technicians who have been inspired by him. The G of GMRT means "Giant" not only because it is the world's largest meter-wavelength radio interferometer, but also because it has been imagined in the brain of a giant, Prof. Govind Swarup. We all miss him.

Lecavelier des Etangs Alain
Professor, Institut d'Astrophysique de Paris (IAP), Paris, France

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I am deeply saddened to hear the demise of Prof Govind Swarup.

I had the privilege of working on the GMRT project when it's design engineering was being carried out at Tata Consulting Engineers Limited. I recall my several close interactions with Prof Swarup during the GMRT dish design and sizing / selection of its drive elements. I was amazed with his deep knowledge of many engineering disciplines such as mechanical, structural and construction engineering, apart from his own core area of Physics and Astronomy.

I was in regular touch with him through telecoms and messages. I recall some of our recent messages on general technical matters. His eagerness to know something more & more, even at this age, was quite obvious from these messages. Prof Swarup was indeed a source of inspiration for me.

Kindly convey my condolences to his bereaved family including the extended family at NCRA.

M. K. Lokhande
formerly at Tata Consulting Engineers, Mumbai, India

It was quite saddening to get the news of Prof. Govind Swarup's passing. My first memories of him date back to 1989 at RAC Ooty, where I spent a few months as an intern. His passion for astronomy and the smile he carried stayed the same whenever I interacted with him over the next 30 years. The news of his passing was certainly unexpected -- it was only a couple of months back that we had a chat and he seemed enthusiastic and sharp as ever. It was an honor to work with him at GMRT, and to know him & keep in touch over the last so many years.

A role model and inspiration to so many, he lived life with passion, child-like curiosity and always with a smile. He leaves behind many memories to cherish, and many of his accomplishments & successes to celebrate.

Rakesh Malik and Usha Malik
former staff members NCRA, Pune, India

My interactions with Swarup was part of the Joint Astronomy Program course work in 1986-87 at IISc. During those days, the Ooty radio astronomy group had their building inside the IISc campus, where we used to take all our classes. He gave his classes on Radiative processes in Astrophysics in spite of all the attention being on the impending construction of GMRT and the group's plans to shift to Pune. His enthusiastic presence in the building had definitely a role in my growth as an astronomer. I saw the same enthusiasm when I last saw him discussing during the coffee breaks at the ASI Pune meeting in 2015. He is one of those persons who motivates people just by his

presence. I am at a loss to express my feelings by the news of his passing away.

I share here a photo taken sometime during 1986-87, where B. Ramesh, my batchmate, is talking to Swarup.

Divakara Mayya
Professor, National Institute of Astrophysics, Optics and Electronics (INAOE) Puebla, Mexico

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First of all, let me introduce myself. I am Nithin Mohan. I just completed my doctorate degree a few weeks ago from the Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, by defending my thesis in Cochin University of Science and Technology. I was working on the study of Venus using GMRT in collaboration with NCRA and notably Govind. In fact, the work can be said to be a brainchild of Prof. and I was a regular visiting student in NCRA and I used to interact with him almost on a daily basis during those days. He was my unofficial mentor and supervisor in NCRA and his passion and enthusiasm for science have always fascinated me. In the earlier days of my work, the results were hard to come by and I started losing motivation. But he always helped me with advice and tips to keep going and to try different approaches.

I really missed him for my open defence as he passed away 2 weeks before my defence. May his soul rest in peace. I thank everyone from NCRA for giving me this opportunity to speak a few words regarding Prof. Swarup. Thank you.

Nitin Mohan
Postdoctoral Fellow, NISER, Bhubaneswar, India (the last graduate student to work with Govind Swarup)

My association with Professor Govind Swarup dates back to 1987. He was a constant source of enthusiasm, inspiration and enlightenment. He had an amazing feeling for the Astrophysics as well as Technology.

I shall try to present three examples of our serious discussions to give an idea of how I see the great scientist and visionary.

1. We were working out various scenarios to model the gravitational lens system PKS 1830-211 (Ooty Lens - as Prof Swarup called it). He suddenly appeared in Mumbai, took all the computer generated figures, my scribblings and, somehow allowed

me to speak for a few minutes (which is rare). He was heading to USA, and in the waiting lounge and during the flight, he wrote the VLA proposal, submitted it and got the time - the referee commenting that next time we should not scribble a serious proposal like this.

2. With the new data and lens models, he was certain the lensing object was a spiral galaxy and after heated arguments on the reported possible spectral lines at multiple redshifts, Prof Swarup shouted that he has seen many many spiral galaxies and this one should be one producing 10^{21} - 10^{22} /cm^2 column density of Hydrogen. He was very eager to modify one band of the GMRT, under construction, to attempt to observe this system at 700 - 800 MHz. Prof Pramesh Rao prevailed on him to prevent disruption of GMRT work in the early 1990s, but possibly the lens model in Sunita Nair's Thesis is a robust piece of work (also published in journal/conferences).

3. Professor Swarup and Prof Bhide had a blue print of an Integrated five-year Master of Science programme, which I would consider to be the precursor of the IISER programme. Many times he lamented that people did not take his vision of the Sience Education seriously. Last year when I gave a preliminary write up of a proposed B.Tech in Engineering Physics with serious participation from Electrical and Mechanical Engineering Departments, he was so happy to go through it and give constructve suggestions, though his health was already failing.

Even erly this year, we had a few email communications relating to our lens work of 30 years ago.

Professor Swarup was the old Prof Swarup once we start discussions. He will remain fresh in my memories and will be a constant source of inspiration.

D. Narasimha
former professor, Dept. of Astronomy & Astrophysics, TIFR, Mumbai, India

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I first visited the Ooty Radio Telescope as an IISc Summer School student in 1981 and it was a truly awe inspiring and unforgettable experience. I remember standing there and looking upon, for the first time, at the magnificent telescope, fully 530 meters long and 30 meters wide, stretching down a mountain slope, with the sun glinting off its stainless steel reflector wires and my mind flashed back to the time I first heard of Prof. Govind Swarup as a school boy of 12 years. I was privileged to grow up at the Raman Research Institute Quarters in Vyalikaval, Bangalore, as my father worked, first with Prof. C. V. Raman and then with Prof. V. Radhakrishnan. I recall a get together for Diwali, where many scientists like Prof. Radhakrishnan, Prof. G. Srinivasan, Prof. N.V.G. Sharma, Prof. K. R. Anantharamiah and many others were discussing the ORT and I was awe struck by overhearing the story of how the telescope was built, and the drive and enthusiasm of Prof. Swarup and his small band of co-workers who had put together the ORT. I dare say that my career path was decided in that instant and many years later, I was invited by Prof. Govind Swarup, to talk about my PhD work at NCRA. He attended the talk and asked so many questions that I remember all the details of that one talk even today. His eyes shone bright, like burning coals and his enthusiasm and energy shone through them like beacons. Interacting with him left one almost breathless.

In the passing away of Govind, the pioneer of Radio Astronomy in India, our nation has lost a great son and the scientific community has lost a truly great scientist. It has been said that to be immortal, one has to either do something that one can write about or write something that one can read. Govind has done both in ample measure and will always be remembered for being a true leader of men, a builder of institutions, an excellent scientist and teacher, and above all a wonderful human being.

May his soul rest in everlasting peace.

Janardan Padmanabhan
former Dean, Physical Research Laboratory, Ahmedabad, India

I remember Prof. Govind swarup -FRS, with lots of respect ,admiration and reverence. He my was first boss.I joined TIFR- RAC-Ooty on 5th August 1970 and was highly impressed by the Cylindrical Large Radio Telescope, situated on a hill slope, among the beautiful Nilgiris Hills. When I met him first time, 'was impressed by his ever-smiling face and an ambitious technological plan for Astronomical Research in India. Although my stay at Ooty was of less than a year, but I maintained contacts with the team and Professor Swarup. During my Vice-chancellor ship of Defence Institute of Advanced Technology- Pune, I met him several times and also invited him to DIAT. During

my ISRO days, once we met at Hyderabad Airport, he enquired about my various developmental activities including high sensitivity microwave TC receivers and use of low-cost TEFLON Dielectric feeds for ground stations, at S,C and X band frequencies.

He invited me to Pune during the initial stages of GMRT design and installation, when a wide band feed was being designed for the 45-meter diameter antennas. For me he was a most respected role model to follow. His dynamism, analytical thinking, efforts towards motivating everyone around , to achieve technological and scientific goals, were unique, I considered Prof. Swarup to be an original thinker, a great scientist who had equal and commendable understanding of several fields: be it civil ,structural, mechanical, controls, electronics, computer and even survey and geodesics. Of-Course he was a great physicist who had a deep understanding of mathematics and various disciplines of science.

He had unique ideas about education system in India and discussed with me during my VC ship at Pune about it and thought organizations like ISRO and Atomic Energy should intervene. I understand ISERs were originally his ideas.

With warm regards

My humble homage to the great doyen of Indian Science (Late) Prof. Govind Swarup -FRS.

Surendra Pal
former Scientist, Indian Space Research Organisation
& former Vice Chancellor, DIAT, Pune, India

Prof. Govind Swarup was a very curious minded personality with courageous ideas that he was capable of bringing into reality and set an example of a farsighted, detailed oriented, and creative scientist. He always had a spark of inspiration in his eyes, full of enthusiasm and a cheerful smile, that made him different from others. He was always happy to communicate his ideas, experiences, and was open-minded to provide opportunities to people from different backgrounds of all age groups at the national and international levels. A perfect example of his ideas and creativity is the building and functioning of the GMRT- a world-class instrument and one of the most used Indian telescopes from the national to international level. GMRT has already laid the founding stone in revolutionizing the science of low-frequency radio astronomy since 2000 and continues to be one among the leading facilities to provide complementary science for the future (2027) SKA project. Prof. Swarup always inspired young students and had equally encouraged me during my Master's studies in 2000 to work on the GMRT data. Thanks to his initial encouragement as well as the opportunity provided to work with the GMRT array that, I could not only build my career in radio astronomy but also my personal life, as I met my husband who had the opportunity to visit and work at the GMRT under the Franco-Indian exchange program. I have been in contact with Prof. Swarup since 2001-2020 and he has always replied to my emails with appreciation, interest, and kindness. We used to have long hours of discussion where he shared his experiences about his initial days as a Ph.D. and a postdoc student and was happy to hear my ideas and give his inputs.
In 2005 when I had finished writing my thesis and asked him for inputs, he had said, 'You have done a good job and I am looking for a student to work with me on one of my projects and I want someone exactly like you. If you can find one then let me know.'

To me, he stands out as a perfect scientist with a combination of scientific and technical expertise as well as the ability to communicate his research in a passionate and inspirational way, that the future generation is going to miss.

My sincere condolences to his family, friends, colleagues in Pune, and the astronomical community in India. I pray that his soul rests in peace.

I had also invited him to give a public talk for the Franco-Indian meeting 'Galactic and extragalactic universe in the Maunakea Spectroscopic Explorer (MSE)/Square Kilometre Array(SKA)-and pathfinders era' that we are organizing in March 2021 at the IIA, Bangalore, as a gesture of thankfulness towards his contribution to mine as well as the careers of many other radio astronomers who have used the GMRT facility and was expecting his positive reply as always. I will miss him during my future visits to the NCRA.

Mamta Pandey-Pommier
University of Lyon, France

Dr. Govind Swarup Sir is an iconic figure and mentor for me. I came in his magnificent leadership from 1989, in Indian Institute of Science campus Banglore; where TIFR's centre was active and GMRT was emerging. Dr. Swarup Sir has given us

confidence.

His surprise visits to our lab always gave us great directions for developments of designs. I remember, he used to tell us that, develop your designs multiple ways, "Jisase ham bahot badhiya kam kar sakate hain". I have seen him guiding a carpenter for proper hammering to fix nails perfectly.

During his stay at GMRT, I never missed opportunities of evening walk with him. During walks he disclosed the treasure of science and technology of all over world for me. It was remarkable experience for me.

I wrote his biography in Marathi language as well as co-authored for a tributary article for journal of astronomical history and heritage.

During these interactions, I experienced his heartily attachment to science, insight of technology and far long vision for institutional progress.

Dr. Swarup Sir was an ideal example of 'Atmanirbhar Bharat' by creating land mark in radio astronomy. I also worked with him for establishing Khodad Rural Science Centre, a milestone example of a cognizance for a small village by an international scientist.

He used to tell us, "Diya tale andhera nahi hona chahiye". Working with Dr. Govind Swarup Sir is a cosmic proud for me.

Sudhir Phakatkar
staff member at GMRT, Khodad, India

I was shocked and saddened to hear that Prof. Govind Swarup passed away after a brief illness. I was very fortunate to have had a very long interaction with him from 1974 till August 2020. As recently as 10th August 2020, he assigned me the task of guiding the students of Fergusson College, Pune, to design a wideband radio frequency antenna for National competition. Such was his enthusiasm to encourage youngsters. I gave him the feedback about the progress on 14th August. With his demise our country has lost an outstanding experimental physicist, institution and instrument builder. A great visionary who could achieve his vision by motivating and encouraging a large number of engineers, scientists and students. His work has enabled India to be recognised among the global leaders for radio telescopes, enabling several major scientific discoveries to be made on the infrastructure that he built. He will ever be remembered for his great work and enthusiasm for the subject. We will all miss him. My deepest condolences to his bereaved family.

A Praveen Kumar
former senior Engineer at NCRA, Pune, India

I had met Prof. Govind Swarup for the first time at the end of 2016. I had just started work on my book at that time, and he was among the first few people whom I met. At that time, I had heard that he was a pioneer in radio astronomy and that he had built two telescopes in India. Despite having been a science journalist for nearly three decades, I did not have a deep knowledge of what he really did. As I learned about his life and work over the next three years, I realized that its full significance was not known outside the radio astronomy community. And I was astonished that his work had not been documented in detail in the popular literature.

During my interviews with him, I learned a lot about his character and the way he worked. I met him three times for long interviews. I had two Skype calls and about 30-40 phone calls over three years. We exchanged about 70-80 emails. At no time did he show any impatience with my questions or tell me that he was busy. He went into great detail answering emails, and went out of the way to find out information that he did not immediately have. It was extraordinary how much he remembered in his life. He had also documented a substantial part of his professional correspondence and made some of them readily available. I have rarely met a person who has been so tirelessly cooperative.

Hari Pulakat
Sciene Journalist and Senior Editor at Economic Times, India

I have pleasant memories of meeting Dr. Govind Swarup and his family during 1961-62 when I was doing my Ph. D. at Stanford University. During that time he and his family lived across the street. He was very passionate about building a Radio Telescope after returning to India. May His Soul Rest in Peace

N. G. Puttaswamy
Professor, Bangalore University, Bengaluru, India

From the heights of cutting edge Instrumentation and Science acknowledged the world over, Prof. Swarup had yet a very encouraging approach-ability for the very beginners, school students and teachers, some of which was our privilege to witness, as planetarium professionals.

In his outreach and educational interactions at a planetarium or when approached through mail by schools, he would always insist that the maximum of encouragement is to be given to any school student or teacher who would show interest and some initiative.

Thoughts about stretching the limits of innovation in instrumentation would light up his smile for the students - a uniquely refreshed smile, with every anecdotal recital.

Rathnasree Nandivada
Director, Nehru Planetarium, New Delhi, India

I was shocked and remain distressed to hear this news about Govind. It was a surprise to hear this as we saw him only what seems only a short while ago in 2019. We tend to think our connections with such people of enormous energy — physical and intellectual — those who are of such long term support, nurture, hope and enrichment of our own lives, are permanent. And so it is difficult to believe that we can no longer have an older friend just a short journey away in Pune or a telephone call away. If one has to name a single person, who has been so influential in literally putting independent India on the map of the world through the science of radio astronomy it was Govind Swarup. Govind was and remains so valued a colleague in the TIFR system, not only because he has made with his own hands, intellect and energy these wonderful telescopes, GMRT and ORT, which are prize tools of astronomy research for the Indian and world astronomical communities, not just because of his most important scientific contributions in radio astronomy about the Moon and the distant reaches of the universe, but also because he was one of the most important and easily approachable links to our past — to the legendary events and new horizons of astronomy that India and TIFR in particular launched into, in the then newly independent country. He was certainly one of my own enduring and important points of contact in the TIFR system after I arrived on its Mumbai campus at the end of 1981 and travelled within a month or two to Bangalore and Ooty to work in his group. I have benefitted enormously from his advice and counsel ever since, both for scientific and academic matters as well as in matters concerning my efforts to understand the past developments of scientific research in our Institute. His physical absence is being sorely missed. I share my grief with Govind's family members and colleagues even while I come to terms with this enormous loss for Indian science and world astronomy.

Alak Ray
former Professor, Dept, of Astronomy and Astrophysics, TIFR, Mumbai, India

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ONE of the pioneers of science research and education in India, Govind Swarup passed away in Pune on 7 September 2020.

Today India is one of the world's leading communities in studying the Universe at radio wavelengths, and it is largely because of Govind Swarup's groundbreaking achievements. This he achieved by conceiving and constructing some of the most innovative telescopes and instruments ever built for the purpose, and by inspiring generations of young engineers and physicists, whom he taught not only to dream of impossible things, but also how to achieve them.

Govind Swarup grew up in a small town in Uttar Pradesh, and when he went to study at Allahabad University in 1945, it had one of the best Physics departments in the country, built from scratch over a decade by Meghnad Saha. Even though Saha had left by then, many of his students and colleagues taught and mentored the bright crop of students the department continued to attract. Half a century later, talking to us, Swarup often fondly remembered his teachers – B.N. Srivastava,

who wrote the seminal textbook on Heat, along with Saha, that is still used in Colleges all over the country; K.S. Krishnan, who had worked with C.V. Raman in Calcutta on the discovery of the Raman Effect, and many others.

After independence, K.S. Krishnan moved to Delhi as the founding Director of the CSIR-National Physical Laboratory. In 1950, having finished his MSc, Swarup joined him there. Krishnan was at that time interested in the quantum theory of magnetism. Only a few years before, Yevgeny Zavoisky had been awarded the Nobel prize for the discovery of electron paramagnetic resonance. Krishnan set Swarup the task of measuring the spin resonance in materials at microwave frequencies. Swarup set about making the equipment from scratch, in less than two years, from radar parts left over from the Second World War to make measurements at a wavelength of 3 cm. This was the first sign of the innovativeness that became so much the "Swarup brand" throughout his entire life. If Indians are known for "jugaad", Govind Swarup was its embodiment.

At the URSI General Assembly in Sydney in 1952, Krishnan met some of the pioneering radioastronomers who were also modifying advanced radar equipment to build antennae to study the Universe. Greatly inspired by his talks upon his return, Swarup ventured to Australia to work at Potts Hill in Australia with Joseph Pawsey, building an array of 2 m dishes to receive signals at 500 MHz. After his return to India, Swarup set off to the USA to learn more, first at the Fort Davis station of the Harvard Observatory in Texas, where he built equipment to detect a radio burst from the Sun, and then at Stanford University in California, where he worked on his doctoral thesis with the famous R.N. Bracewell.

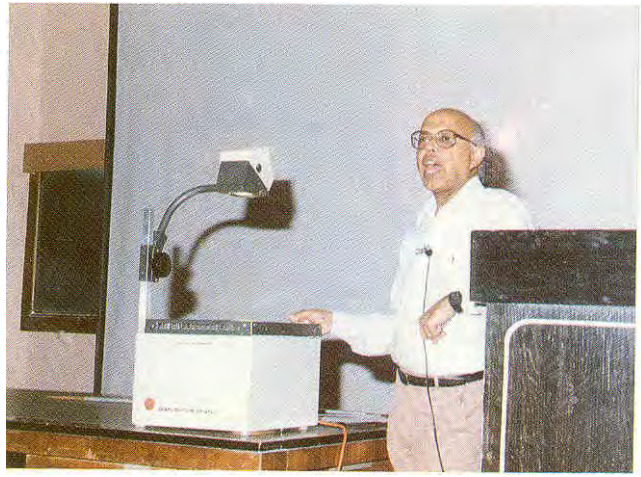
The Giant Metrewave Radio Telescope (GMRT) – established under the leadership of Prof. Govind Swarup for radio astronomical research at metre wavelengths
(Source: http://www.gmrt.ncra.tifr.res.in/)

After his PhD, Swarup joined the Stanford faculty, but in his heart he wanted to return to India, where the country's post-independence infrastructure for science and technology was just being set up. He was one of four Indian radiophysicists working in top laboratories in the USA, who wrote to research Institutions in India about their plans to join in this effort. Fortunately, a positive response from Homi Bhabha led Swarup to join the Tata Institute of Fundamental Research (TIFR) in Bombay, and establish a unique radioastronomy group there.
Under the leadership of Swarup, the TIFR group first set up a solar array with the 32 antennae that he had worked on in Australia, and had since been shipped to India. This was at Kalyan, near Bombay, following which Swarup, and his increasingly confident group of students and engineers, found a slope of a hill near Ooty that exactly matched the latitude of the place. Here they built the first unique giant telescope of Swarup's design – made of fine wire mesh on a monolithic parabolic cylindrical frame, half a kilometre long and 30 m wide. This was built ingeniously on this natural Equatorial mount, such that tracking celestial sources would be largely done by the rotation of the Earth, with a motor drive required for just one axis. Swarup also chose 327 MHz as the operating frequency, in the range of radio-frequencies that hadn't been well studied before.

Signing of MOU with Pune University, 29-11-1990

The Ooty Radio Telescope (ORT), which started to operate in 1969, made many pathbreaking measurements and discoveries, including that of new pulsars, quasars and gravitational lenses, and is still operational. Some of the measurements of the counts of radio sources made by Kapahi and Swarup, made with the ORT, went on to provide strong support for the Big Bang theory of Cosmology.

Road Naming Ceremony, 23-12-1994



First IUCAA Foundation Day speaker in 1989

The ORT did not just put India on the world map of Astronomy, it also produced a confident and ingenious bunch of young engineers and scientists, which, inspired by this visionary, was ready to take up any challenge. They moved to Pune to set up to build the world's largest radio-telescope array at low radio-frequencies – thirty 45-m light-weight wire- mesh dishes, spread over 30 km of vineyard territory along the Pune-Nashik highway. They operated at frequencies as low as 150 MHz, aimed at finding the spin-flip transition of hydrogen, ordinarily at 1420 MHz in the lab, but redshifted to much lower frequencies, at distances as far away as 90% to the edge of the Universe, to detect diffuse hydrogen before it collapsed to form galaxies.The Giant-Metrewave Radio Telescope (GMRT) is now one of the top astronomical facilities of the world for two decades, studying all sorts of sources from planets, stars to radiogalaxies and supermassive black holes. Observers from all over the world compete for time on this facility, which is over-subscribed three times over. As a Professor at the University of Birmingham in the UK, my students and I used to come several times a year to Pune to observe with the GMRT, and upon my return to India, I still use this unique instrument, which has now been upgraded, in which Swarup continued to play a role. The GMRT is now a pathfinder observatory for the Square Kilometer Array – the Next Big Thing in Radioastronomy.

Govind Swarup won many accolades in his life – the Shanti Swarup Bhatnagar award, the Padma Shri, the Grote Reber award and the Fellowship of the Royal Society, to name a few. But his greatest reward seemed to be in mentoring generations of peers and younger students, and he was very generous with his time and ideas. I first met him as an undergraduate, visiting the Ooty telescope on my scholarship tour. His unbridled enthusiasm was so infectious that half of the group, at the end of the day, wanted to be an astronomer like him! I cannot recall a single conversation with him in which he hadn't been excited about new things, managing to infect everybody around him with his enthusiasm.

Prof. Govind Swarup (extreme left) with Professor Jayant Narlikar while naming a road after Vainu Bappu

The frugality of Swarup's approach was outstanding – he and his group came up with innovative ideas to build things at a fraction of the usual cost, making it possible to make these world-beating facilities with the small budgets typical of our institutions. Equally remarkable was the way his mind worked – he could in an instant work out complicated physical models in his head in a very own intuitive approach. Rajaram Nityananda gives an example: "...I remember a serious debate on the force that wind exerts on a cylinder – my number was 20% higher than his, which meant a design for a radio telescope he was proposing had to be heavier to withstand wind forces. We even went to an institute of wind engineering in Chennai. He was right, of course."

Till his last day, everybody around him felt that breathless excitement with which he could infuse all who interacted with him. A hundred years from

NSSS-IUCAA, 29-01-2019

now, he will be remembered as the Man who came up with all the ideas, and knew how to turn these visions into the very tangible legacies he has left for us.

Somak Raychaudhury
Director, Inter University Centre for Astronomy and Astrophysics, Pune, India

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I was deeply saddened to hear of Prof. Govind Swarup's passing. Prof. Swarup recruited me into the world of radio astronomy. The giant observing facilities that he built were a great source of inspiration to me and so many other Indian astronomers. I had the humble opportunity to provide something back to Prof. Swarup by dedicating my most recent paper on Phased Array Feed to him.

Anish D. Roshi
Senior Observatory Scienties, Arecibo Observatory, Puerto Rico

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Govind Swarup was a towering figure, has had an amazing life and set an example to all of us. His vision to build the GMRT let to a world-class instrument. For me, he embodied the perfect scientist: the combination of his scientific and engineering skills have been essential to building the 'right' GMRT, while his people skills not only got the project from start to finish but also trained many students who made important discoveries and are having brilliants careers. Also, students and staff from Leiden observatory have benefitted from the very open atmosphere at the GMRT that has and is providing excellent GMRT data. Our thoughts are with his family, colleagues in Pune and astronomers from the whole Indian community. He will be sorely missed.

Huub Rottgering
Scientific Director, Leiden Observatory, Leiden, the Netherlands

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Dr G.Swarup is a great scientist of this century. The first time I met him in RAC Ooty in May 1971 during my college final year internship training of 35 days.We used to dine in the RAC canteen together. Later we met in Kodaikanal in 1974 during an ASoI conference when I was working in IIAP Bangalore (1974-1983) (under Dr Vainu Bappu and Dr J C Bhattacharyya - who was my boss and mentor) and subsequently in RRI Bangalore during seminars / lectures He was a very good teacher and trainer in his own capacity and was a problem solver. My condolences to the bereaved members of his family.

S. Sadasivam
former Scientist, Indian Institute of Astrophysics, Bengaluru, India

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It is hard to take in the absence of Govind amongst us. He was such a colossus. A colossus who I was very fortunate to have encountered right from the start of my astronomy career in 1982.

His sheer energy, brilliance, enthusiasm, being ever ready for discussions, his positive approach, all lent an encouraging, vibrant and stimulating atmosphere. We will all miss this unmatched towering figure in the radio astronomy community.

I am so happy to have continued being in touch with him in the last 15 years in various formal and informal occasions and the unforgettable time we had with Bina and Govind and their grand daughter at our place.

Lakshmi Saripalli
Raman Research Institute, Bengaluru, India

I had a fortune of interacting with on a number of occasions at NCRA/GMRT over many years of my small association with NCRA. His interactions with engineers and students were really lively and so much edicative. I also had an opportunity to organise his special ASET colloquium as part of the Homi Bhabha Birth Centenary Celebrations. We can not fill the void created by him, but we certainly try to emulate his greatest attributes - as a scientist and as a human being, that he is known for. We miss you sir.

B. Satyanarayana
Scientific Officer, TIFR, Mumbai, India

Sorry to learn about the passing away of our friend, Govind Swarup. I would like to send my condolences to Bina or other family member(s) who are alive. I will appreciate it if I can receive their contact email(s) if possible. Thanks.

Arjun Saxena
former Professor at Rensselaer Polytechnic Institute, USA

We all know Govind was an absolutely remarkable chap! He has made exceptional contributions towards pioneering and advancing Radio Astronomy in India and rightfully earned the title of "The Father of Radio Astronomy in India".

Today, as we have gathered to celebrate his life, I would like to share with you one of my most vivid memories of working with him.

About 3 decades ago, I had just finished my undergraduate education and started my first job, as a research scientist at NCRA. Govind spent a surprisingly generous amount of time with me, talking about everything ranging from the big picture of the project to the minutiae of engineering solutions. Often, sharing insights from Bracewell or engineering tricks from Ooty. Always, very inspiring.

My starter project was designing feeds for GMRT. As you may know, the analysis of the beam patterns under deflections due to gravity is not easy to compute and requires Finite Element Analysis. The analysis often took days to program and to compute. While working on this project, in one of my routine meetings, we were discussing the impact of a recent change in design and I had reams of printout from the analysis. He took the printout from me, briefly looked over and scheduled a meeting early next day. Mind you it was already late in the day.

Knowing Govind did not use computers, I was a little puzzled -- what was he going to do with the printout? It was full of numbers. He completely surprised me the next day. He found a few subtle errors! Apparently, overnight he had cross-checked the simulation, all manually, with rule-of-thumb tricks! I was blown away by his intellect!! Since then I have had this image in my mind of Govind working late into night, diligently and meticulously. And as if to fill out this image, we would see the lights still on, in his house, when we returned from late night dinners.

Years later, I appreciated much more about him. The trust he placed on young upstarts like me -- to solve challenging technical problems -- was exceptional. Perhaps, that is what kept him up at night. Or he must have been following the motto, trust but verify!

Nonetheless, It was life changing for me and I'm sure for many others. It nurtured a zeal and confidence to take on tough problems. Since those early days, I have worked with many brilliant researchers both in academia and in industry. I am still awed by Govind, more than anyone else! He has undoubtedly been a great role model for me and a whole generation of researchers. I feel grateful that I had the opportunity to work with him for 5 formative years of my research career!

Thank you for listening in this celebration of his life.

Izhak Shafran
former staff member at NCRA, Pune, India

My deepest condolences on the passing of the father-figure of your institute. Indeed, Govind was an inspiration to all of us in Indian astronomy and beyond, but you will surely miss his regular smil-

ing presence at various talks and events in the institute.

It is also hard to say who we will miss the most -- Govind the ever-curious, Govind the instrument-builder, Govind the great motivator, Govind the institution-builder, Govind the out-of-the-box thinker, Govind the friend of students and the young, Govind the world-famous radio astronomer? Perhaps all of them at different times.

I recall him enthusiastically attending talks and asking great questions even at his advanced age. I feel bad that I never quite interacted personally with him. However, I heard so many inspiring stories about him from different people (across age and experience) that I cannot but be positively uplifted.

I remember one somewhat direct incident involving Govind. Ashok Singal (who is retired for some time now) regularly sends emails to a few of us about his recent exciting papers on foundational aspects of electromagnetic emission mechanisms, relativity, radio jets, cosmology, etc. I checked out those papers on a few occasions and wrote back to congratulate him. Govind replied to almost all his emails with penetrating questions and very encouraging words (including everyone on the CC). This was Govind the ever-curious and Govind the great motivator.

Govind had a long and fulfilling life. We have learned a lot using the instruments that he conceived and built. Perhaps even more important was his ability to positively motivate and carry people along in achieving such impossible feats. Indian science must learn lessons from his life so that we add up to more than just the sum of our parts.

PS: I learned from Chanda & Arnab about Govind's key role in creating and sustaining the Joint Astronomy Programme (JAP) at IISc. Indeed, he turned whatever he touched into gold!

Prateek Sharma
Associate Professor, Indian Institute of Science, Bengaluru, India

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Much has been said and written and will be said about how Govind was a pioneer. For me, who met him as a fresh TIFR PhD student joining his group, Govind presented himself so differently from the scientists around.

With the sharp twinkle in his eye and smiling face he, at my very first meeting, cut right to the chase, to the science that excited him at that moment. When I first met him it was searching for evidence for proto-galaxies and measuring the deuterium line at 1m wavelength by building the Giant Equatorial Radio Telescope in Indonesia.

It was not just that the enthusiasm that flooded his whole demeanour and his two-word sentences was intensely infectious, which it of course was. The best thing was that he was a person who did not inspire awe. So right from the first moment, in very few words he would provoke us to argue back and criticise what he was saying and in that sense, he was the quintessence of the scientific method.

So although I don't think of him as one of my teachers as such, because he didn't do much of that, yet looking back, given that criticism is the backbone of the scientific method, he taught us the essence of what science was by being that himself.

Me Govind and Juniors, 19-03-2019

And he was such a proud person, not just of his achievements but also of his multiple influences, well beyond just scientists, being inspired deeply by Gandhi and the freedom movement, and the fun thing that he kept showing me was that using my wikipedia page I could trace my lineage via him, of course, back to Isaac Newton... Farewell Govind.

Prajval Shastri
former Professor, Indian Institue of Astrophysics, Bengaluru, India

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I am not a scientist, hence it is not correct on my part to comment anything on this. I know Prof Swarup as a true statesman and a simple humble Gentleman who had dedicated his life and services for the development of experimental science

and the smile on his face will always be remembered, by those who had interaction with him.

He was a good practical leader who would understand the real problem, encouraged debates, respected the merit and good ideas, consult with experts, and take decisions and responsibilities, always ready to take up challenges. He was a learner in every interaction, trying to gain the knowledge for the betterment of the society by interacting not only with the scientist but also with common people.

He understood the importance of National Institutional requirements in educational fields for the future generation of India and demonstrated the challenges and the understanding of scientists by building RAC Ooty and GMRT, which is one of the biggest Radio Telescope in the world built with much cheaper cost, which will motivate the younger generation to do more for the future.

Except few who are associated with him, many may not know his role in bringing up of many National Institutions, (IISERS) including one in Pune. If he would have been alive with good health, for few more years, he would have managed to build a Institutions/ Laboratories which will prevent our students going abroad for higher studies by this way saving, lakhs of cores, foreign exchange. He left this work to the remaining scientists, who have to accept as their challenge and execute. This will be the tribute you are giving to him and his ideas.
Thank you
Jai Hind.

Shankara Shetty
former Accounts Officer at NCRA, Pune, India

The security guard at the front gate of Pune University campus instructed the taxi driver. I looked along from the taxi parked by the curb. The driver walked back to the car.

"He says that the new institute is at the back. It's under construction," the driver mumbled under his breath. He pulled the taxi door shut and drove into the campus. I rolled down the window.

The city was cool and fresh from the rain. It was the summer of 1991. The early morning bustle of a strange town always fascinated me. In the subconscious unease of the unknown, it comforted with a warm nostalgic familiarity. The sweepers cleaning the neighborhood. The children waiting for the school bus. People loitering around their favorite breakfast corner. Folks jogging. Fresh vegetables glistening in the first morning light. An old man lost in his cigarette smoke and the morning newspaper. A radio blaring at a distance. People, joyfully greeting each other. Everything seemed nice.

We all woke up to the promise of a new day. Through the unpaved road, we reached the back of the campus. The place was peppered with a few newly built houses and incomplete buildings. This time it was my turn to seek directions. I got out of the car and walked towards a house. Seeing me approach, a man dressed in white walked out of his house and smiled, "Are you here for the exam?" "Yes, but--" I could barely speak. I knew the man. I knew him long before I had seen him on TV. He used to provide his expert commentary right before the beginning of my favorite show, Cosmos, by Carl Sagan. The man was well-renowned astronomer Dr. Jayant V. Narlikar.

"--If you continue on this road, you'll find the registration office. They will further guide you." He said with a smile. He waved behind us as we drove in that direction.

Back then, the Inter-University Center for Astronomy & Astrophysics (IUCAA) and the National Center for Radio Astronomy (NCRA) were relatively new institutes. They conducted a joint entrance examination for students inspired and eager to pursue a career in the field. I was very interested in radio astronomy. I was deeply fascinated by the idea of 'seeing' the invisible universe. I still am. To my surprise, there were too many of us. I had just finished my astronomy summer school at the Indian Institute of Science, where I had the privilege of studying under the leading scientists. I was brimming with immature confidence.

At the summer school, I had come across an introductory brochure of NCRA. In which I had learned that NCRA was building the world's largest radio telescope array. It was called the Giant Meter-wave Radio Telescope (GMRT). The meter-wave part meant that the telescope would search for extremely weak light coming from very distant objects (protogalaxies and protoclusters) that were in their early stages of the formation when the universe was very young. I was hooked for life.

The format of the admissions process was designed to eliminate in stages through written exams, interviews, and then the final interview. I, luckily, passed the hurdles and reached the last interview.

The interview was in a small office with a large window. I was ushered into the room. To my left wall was a large whiteboard. And huddled in the corner of the opposite wall by the window were four smiling gentlemen. One of them, whom I had already met, was Dr. Narlikar. To his left was another gentleman whose big, happy smile put me to ease right away. I gathered that he was from the NCRA part of the admissions committee. And to either side sat the other two men. I want to say that one of them was Dr. Kembhavi, but my memory is fuzzy on that. I nervously stood by the whiteboard. I had instinctively picked up the marker and was ready to write. After a brief introduction, the gentleman with a big smile started asking personal questions, mostly about my hometown. He seemed to know the place quite well. He then explained that a part of his family was from my hometown. And once my nerves were calm, the 'grilling' began.

At some point through the barrage of questions, the discussion switched to the cosmic background radiation (CMB), the embers of the hot origins of the universe. These were pre COBE times, but the consensus was that CMB had a blackbody spectral signature. I had sketched the Planck's blackbody curve on the board. That's when the gentleman from NCRA, with the big smile, took charge of the discussion. He honed in on the y-axis of the plot that I had sketched.
"What is on the y-axis?" He asked.
"The spectral density," I replied.
"Good. And what are the units?"

"Ah," I fumbled and then wrote the units somewhat apprehensively.

More questions followed; precise and expertly designed questions, just to nudge an inquisitive mind into self-discovering deeper relationships between physical quantities, often taken for granted in textbooks. Led by hand through these equations, I suddenly 'discovered' that within the limiting case of the Planck's law, the power from a distant object measured by a radio telescope was the same as its temperature. The radio telescope was a thermometer!

My sudden joy of discovery reflected brightly on the face of Dr. Govind Swarup. He had made me think differently about an issue that I thought I had understood. And this is how he made his first and lasting impact on me. In just a brief discussion, he taught me that the foundation of science is to never stop asking and investigating. There's often more than meets the eye. Just with his few well-poised questions, he had elevated me from the books to the inextricably linked real world of the actual implementation.

Upon my return from Pune, one day, when my mom was busy with her daily chores, I followed her around the house, sharing with her my experience from the summer school and Pune. I excitedly mentioned how this one man who also asked me questions about my hometown had dazzled me by teaching me new ways of scientific inquiry. She nodded and left the room. A few minutes later, she returned with an old photograph of a young man and a woman.

"Was that professor this man?" She asked, handing me the picture. I took the picture, a very young Dr. Swarup was smiling back at me.
"Yes!" I exclaimed, "How did--?"
"--Are you sure?"
"Yes, this is him... his younger self," I reassured.

My mom was ecstatic. The lady in the photograph was Mrs. Bina Swarup, my mom's long lost childhood friend.

And that's how we all got reconnected with Dr. Swarup and Mrs. Swarup. I did not get admitted to NCRA. I moved to the US to continue my education in radio astronomy and physics. Throughout the years, I stayed connected with Dr. Swarup.

During one of my trips to India in the late nineties, Dr. Swarup invited me to visit GMRT. Since the interview, this was the first time I was meeting him. At NCRA, I could tell that he was eager to show me his labor of love. He accompanied me to the telescope location, about 80 km from NCRA.

We survived the bumpy car ride and reached the remote site. At that moment, there were roughly thirty telescopes. Each was 45 meters in diameter. Up close, the telescopes were massive. The telescopes were arranged in a Y-shape across a 25 km area. The innovative design by Dr. Swarup had made GMRT one of the leading telescopes in meter-wave astronomy in the world. He told me that since the observed wavelengths were long, he designed the mesh-based dishes (radio antenna) instead of filled ones. This way, he saved the cost of metal per dish, and eventually, the total cost of the telescope.

The local village juxtaposed against the world's largest telescope was a sight right out of India. I was working at Caltech in those days and had access to a similar, but smaller array right outside my office. I was quite impressed by GMRT.

At the young age of 67, Dr. Swarup's zeal for science, especially radio astronomy, was contagious and inspiring. I stayed with him for the next few days. And just like the interview, this time, I got a priceless crash course in radio techniques from a world-renowned scientist who never made you think that he was one by his sheer humility and grace. Dr. Swarup was not only a scientist - he was an electrical engineer, a mechanical engineer, a leader, a mentor, a teacher, and forever willing to learn. He was a complete scientist. In today's world of suffocating specialization, that was such a breath of fresh air.

Besides his friendly and kind demeanor, Dr. Swarup was blunt when needed. He did not like it when, out of tradition, to greet him, I used to touch his feet. And he did not like me calling him Dr. Swarup. Reluctantly though, I was able to forego the feet touching. But he is forever Dr. Swarup to me.

He tried to recruit me a few times, but I was happy far away. Again he never minced his words and with a laugh once said, "Raju ban gaya gentleman!" (Local lad has become a gentleman). Even his insults were inspiring.

We stayed in regular touch. Whenever I needed advice, he was available. When he learned that I was planning a brief trip to India, he invited me to GMRT again. I happily took the offer. I stayed over in Pune for a couple of days. These trips required giving a colloquium talk. Back then, I was working on a Dark Energy project and had enough material to share. After the talk, he handed me over to the other professors and suggested a time when I stop by his office and retire for the evening and dinner.

"I have something to show you. Stop by at 4:00, sharp," he added.

I knocked on his door at 4:00, sharp. He invited me in. He seemed to be in a thoughtful mood. I assumed he was preoccupied.

But he turned to me and said, "Good talk. I have a question. Why at 1.8 z?"

I knew what he was asking. He was curious why Dark Energy suddenly seems to accelerate the universe after a random time (or z for redshift). I walked up to the board in his office, which was already cluttered with equations, and in the corner sketched the energy density vs. time (redshift) plot. It was quite a deja vu moment. The y-axis of the plot was the energy density of the universe. I did not write the units. Now I was old enough to know that units were irrelevant. You could set them to
whatever value that suited your needs. And the x-axis was time since the big bang.
Then I drew the matter density. A curve starting high close to the origin and then decreasing as the time on the x-axis increased. Next, I drew a horizontal line parallel to the x-axis. And where the line crossed over the curve, I marked that point as 1.8 z.

I did not say a word and turned to explain. I saw the familiar wide smile and a gleam in his eye. I knew immediately that he understood what I wanted to say.

"This is one of the best explanations I have seen. OK!" He said. I was proud to have shared my knowledge with him for a change. Dr. Swarup had a way of returning to the main topic. "Coming back, here's something I wanted to show you." He said as he took out a small black diary.
"Do you remember your first interview with us?" This must have been more than a decade now.
"Yes," I said. "I took some notes that day. Read this." He handed me the diary. It read (am paraphrasing) – he'd become an astronomer someday.
I was dumbfounded. I had no idea how to respond to this. I stood there quietly
holding the diary. He then took out another slightly larger diary and opened it. This was his autograph collection book. He showed me many signatures of people that I knew. I recall seeing S. Chandrasekhar's signature. Then he handed me a pen and asked me to sign the book. I couldn't. Instinctively, I refused. "Rubbish. Why not? This is my book." He exclaimed.
"But... this has Chandra and so many others... I don't belong here." I grumbled. "Just sign it."
So I did.

This was his way of encouragement and guidance. He made you feel welcomed.

I met Dr. Swarup a couple of more times since. The last time I met him in person was when I was on a historical trip across India with my mom. We decided to stop over in Pune and meet with the Swarup's.

Dr. Swarup suggested that now I know enough radio astronomy to show my mom around GMRT. I did. My mom was quite impressed by the telescopes. During our stay in Pune, we tried all kinds of amazing street food with Dr. and Mrs. Swarup

and had a blast. In 2008, after many discussions, Dr. Swarup and I agreed to work on a long-overdue collaboration. He wanted to do something weighty, something exciting, or not at all. I was on the same page.
"Read up on WMAP Cold Spot and then we'll talk," Dr. Swarup directed.

In short, there's a region of the sky, about 5 degrees (10 full moons) in size, which breaks away from the norm. It appears emptier than it should be. A survey of the region using radio telescopes indicated the same. This result had caught Dr. Swarup's attention.

There were a few tentative explanations proposed in the scientific literature, including that it could be some form of data aberration. I raised this issue with Dr. Swarup, and his response was, and I paraphrase, "I did not build a telescope to use statistics to find my answers. Let's go observe the thing and find it for ourselves."

Using GMRT, we were able to corroborate the previous observational results. Later, the results from the Planck satellite further confirmed the existence of the cold spot.

In other words, the mystery remains. But despite the best of our efforts, we were unable to complete the project to the extent that we had originally discussed and planned. This remained a point of our mutual dissatisfaction. Time flew by, and before we could revisit our project, I was invited for the 90th birthday of Dr. Swarup that was celebrated by NCRA. Sadly, I was unable to attend. I decided to send my regards through flowers and a brief note entitled – The Serendipity Of Meeting Dr. Swarup. And not until a few months ago, to my horror, I discovered that the article got lost in the mail and never reached him. I started to rewrite this.

Today I woke up to an ominous morning. The sky was bright red due to the smoke from the fires all around the San Francisco Bay Area. That's when the news arrived, my teacher, my mentor, my advisor, my guru ji Dr. Swarup had passed away.

The news was sudden and unexpected. It hit hard. I was already fondly reliving the past while rewriting this note. The loss became very personal and palpable.

I realize that now no one would be able to fill those shoes. But we all could aspire to walk the path defined by Dr. Swarup's unbridled curiosity, passion for lifelong learning, taking on and completing larger than life projects, and most importantly, humility and respect for others. Dr. Swarup was a great scientist, but above all, he was a marvelous human. I'd die a happy man if I were a fraction of what he was.

It will forever remain a source of deep sadness for me that Dr. Swarup did not read this note that I wrote for him. I will deeply miss him all my life.

Hemant Shukla
Scientist, Lawrence Berkeley National Laboratory, USA

I remember being awestrucked on my first sight of GMRT and when I stood beneath the gigantic dish. To me his creation of GMRT now sounds like 'Govind's Metrewave Radio Telescope.' During a conversation in 2015 at ICTS conference, I told him how the student-guide chain connects me to him, but to my pleasant surprise he enlightened me that this chain doesn't stop at him but goes back to many greats like Raman, and Newton. Govind, as we were trained at NCRA to call him and others by name irrespective of one's hierarchical position, will remain immortal in our hearts and will be remembered not only as the father of radio astronomy in India, but for his versatile persona as a visionary scientist, a great mentor, an institution builder, and a person of legacies.

Veeresh Singh
Assistant Professor, Physical Research Laboratory, Ahmedabad, India

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I vividly remember my first meeting with Govind, it was in 1992 when we were taken to GMRT as part of an IUCAA workshop trip. He took us to the first antenna that was being commissioned at that time. The way he explained GMRT to us and took us to the top of the antenna was very inspiring (he was more than 60 at that time). This revealed how much he was personally attached to the project and science to be carried out with GMRT. Simple few minutes interactions with him have inspired young minds to take up astronomy as their carrier. Govind was full of energy and excitement and always thinking about science till the very end. I am sure if we were to locate him in heaven, it will be very easy. Only thing we have to do is to locate the library and we will find him reading the latest science updates there!

R. Srianand
Professor, Inter University Centre for Astronomy and Astrophysics, Pune, India

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Prof. Govind Swarup was a member of the first Governing Council of the Indian Institute of Astrophysics during 1971 – 1978. He played a major role in the formative years of the Institute. He has since then continuously encouraged and supported all the endeavors of the Institute. We lost him in the golden jubilee year of the Institute.

▪ In the 4th meeting of the GC in 1971, Prof. Swarup's support to Prof. Vainu Bappu was very crucial to initiate the 90inch telescope project, when the 40" telescope was not yet functional. His strong support resulted in the detailed proposal.

▪ The 90inch project later became part of the 5th plan (1974-1978). Prof. Swarup was also instrumental in setting up a research committee and and engineering committee to oversee the project. His rich experience in setting up the Ooty radio Telescope helped the 90inch telescope project in a big way. The 90inch telescope was later dedicated to the memory of Prof. Bappu, which is now known as the Vainu Bappu Telescope.

▪ Prof. M.G.K. Menon has put on record the contribution of Prof. Swarup towards the management organization of the 90 inch telescope, in the GC minutes of 1978.

▪ Prof. Swarup had collaborated with Parthasarathy, who belonged to the Astrophysical Observatory in Kodaikanal during 1953-1955. The astrophysical observatory became the Indian Institute of Astrophysics in 1971.

▪ Prof. Swarup was a great supporter of setting up indigenous astronomical facilities in the country. As a member of the Governing Council (again) during 1993-1997, he supported the Institute to embark on the journey of setting up a telescope in the Himalayan region.

▪ In the last decade, once again, he has helped the Indian team behind the TMT project to sharpen the proposal and make sure that the efforts are directed towards a self-sufficient India, in terms of engineering and in particular, Optics. He has also been a pillar of support for the proposed National Large Optical-IR Telescope project, that is to be made in the country, set up by the country and for the country.

▪ A few photos of Prof. Swarup taken during the the inauguration of the indigenously built 90inch telescope are shown below:

During the inauguration of the Telescope on January 6, 1986, by the late Prime Minister Shri Rajiv Gandhi.

Prof. Swarup, curiously examining the control terminal of the 90 Inch Telescope, during its Inauguration. This telescope is now known as Vainu Bappu Telescope.

Annapurni Subramanian
Director, Indian Institute of Astrophysics, Bengaluru, India

The most talked about science-history story in TIFR is perhaps the one about how the idea for the Ooty telescope came as a revelation to Swarup, while sitting in the TIFR library. We heard it as fresh students, as senior students, and then as

members of the faculty, and I heard it the most times from Swarup himself! Every time, one could see the same enthusiasm and a certain happiness that matched the novelty of that idea itself. Govind was equally effervescent in talking about his ideas, and listening to the ideas from others. We all will miss him.
For me it was an association that started even before I saw TIFR, as for many others, in one of the pre-Ph.D schools. A man always in the lookout for "tomorrow's radio astronomy leaders", as he used to say. And he did find many.

Every time I watched the Ooty telescope waking up and rolling with its gleaming steel wires, I used to get goosebumps. It was not just a unique instrument. It was also the history of science here and the pointer to the possibilities. We have many proofs.

I will miss him, and we all will miss him.

C. S. Unnikrishnan
Professor, Tata Institute of Fundamental Research, Mumbai, India

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Like all great people, Prof. Swarup meant different things to different people. To me Prof. Swarup was the ultimate personification of what can be achieved. Working during an era where the very idea of creating large indigenously built scientific instruments was unheard of, Prof. Swarup created a whole set of megaprojects. I say created because he was the prime mover from imagining, conceptualising, designing, manufacturing and running telescopes from Kalyan to Khodad (via Ooty and Kenya). In resonance with Bhabha's desire to indigenise science, he personified this idea like no one else could. Others came on Bhabha's calling to pursue their own research interest. Swarup cam to create what was unthinkable in an environment which was severely self-limiting. Even in the times of some of the greatest names of Indian Science, he held a unique position and whose creations have inspired later generation like few others have done. It was his success that would inspire a whole generation of science leaders who eventually created large projects with indigenous effort and even contributed to large international projects. Until Prof. Swarup got working, the only large projects were in Space and Nuclear Sciences, and both had a heavy involvement of foreign scientists and technologies. Only Govind Swarup would have none of this. And he had the intellect, capability and commitment to undertake such an exercise.

It is said that when art critics meet, they criticize art, when painters meet they talk about brushes and paint media. Govind Swarup talked of new ways of creating science, technology and future itself. Criticising present was not on his mind, except as a window to see where we needed to improve. He worried about instruments, he worried about scientific ambiguities, and he worried about nurturing future talent. He worried about everything and whatever he thought about, he came up with realistic solutions. His mind worked on future plans, unconventional perspectives and looked for ways to implement these ideas. He always had more energy than everyone around him and had more interesting things to say than those around him. He could talk to the biggest and the smallest with equal sense of involvement. It took several hours of thinking to digest what Prof. Swarup could say in a few minutes. He forced you to think, through the sheer pressure of his thoughts. Just being in his presence was inspiring.

Others have undoubtedly followed him but Govind Swarup was a leader like no other. When he talked he only talked of creating and excitement of ideas and he would get visibly annoyed if you talked of mundane things. Even in the best of my dreams I can't imagine myself being anywhere close what Govind Swarup was. I am sure in being the way he was, he must have annoyed a lot of unworthy people however powerful, but they were never his audience.

There was no Govind Swarup before him and there will be none after. He will be missed like few of us will be.

Mayank Vahiya
former Professor, Dept. of Astronomy & Astrophysics, TIFR, Mumbai, India

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It is with great fondness I recall my long and very close association with Prof Swarup since 1974, when I joined the Radio Astronomy Centre (RAC) of Tata Institute of Fundamental Research (TIFR) at Ooty. He led his team by setting himself as an example, giving his 100% in anything he did. His multi-tasking abilities with minute attention to details and a no-compromise positive approach to any issue on hand was phenomenal and left a deep impression for one to emulate.

He was much more than a Boss - he was a friend, guide and mentor par-excellence, a confidante and father-figure, to whom one could turn to for advice and support on any issue, including personal ones.

It was a privilege to be associated as a core member of his team to realise many of his passions: The Ooty Synthesis radio Telescope (OSRT) as well as the Giant Metrewave Radio Telescope (GMRT); the latter from "Day Minus One", to encompass all the aspects starting from site selection to conceiving and realising the receiver system and to contribute in all phases of prototyping, performance verification, quality mass production and installation stages that led to successful commissioning followed by routine operation.

In his passing away, we have lost a truly gem of a person... An inspiration and great example for defining Dedication... I pray for his soul to rest in peace.

T. L. Venkatasubramani
former senior Engineer at NCRA, Pune, India

I wish to thank Prof. Gupta for giving me the possibility to convey the friendly farewell to Prof. Govind Swarup on behalf the whole Italian radio astronomical community, in particular of the many colleagues and friends in Bologna.

The starting of radio astronomy in our two countries is very similar, in scope and projects. Back in the late 60s, conversations, visits and letter exchanges took place between Prof. Swarup in India and Prof. Ceccarelli, Setti and their group in Bologna. In the very early 60s, the Bologna group of engineers and enthusiastic physicists built the so called "Medicinoscope", a mini-array working at 327 MHz, which had to serve as testbed for the Northern Cross Radio Interferometer, observing at 408 MHz, which was completed soon after, in 1964.
I was unable to recover original letters and other material exchange between Prof. Swarup and our group, but considerable share of information is known to have occurred at the time, when in parallel the Ooty Radio Telescope was designed.
As a matter of fact the two interferometers are almost identical.

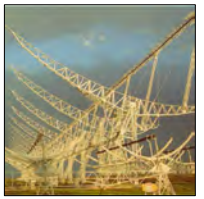
The Northern Cross is actually a T structure, and its E-W arm is identical in the finest details to the ORT, which has the advantage to be located on a site so favourable that a transit instrument in Medicina became a full track instrument in Ooty! ORT observing frequency matched that of the Medicinoscope, 327 MHz, which is of high cosmological interest.

It is very important to point out that radio astronomy has always fed very friendly and frank collaborations, which have resulted in amazing projects, and the share of knowledge at the time when the Northern Cross and ORT were designed and built is a genuine example of such collaborative attitude.

Only much later, in 1985, were the Italian colleagues able to visit ORT and Prof. Swarup. This was possible in December 1985, after the famous IAU Symposium 119, Quasars, held in Bangalore. They all report of the amazing experience at the meeting and at the radio telescope. ORT looked so familiar, and so different at the same time! A number of scientific collaborations between India and Italy started as a consequence of the Symposium and of the visit to Ooty.

Ooty Radio Telescope & Medicina Northern Cross
The birth of radio astronomy in India and Italy

ORT and E-W arm of the Northern Cross are IDENTICAL



The two radio telescopes represent the birth of modern radio astronomy in India and Italy, and from that moment on, both countries have followed their own paths of developments.

The Indian path has brought to uGMRT, the Italian path has developed in the higher frequency domain with 32m class parabolic antennas working as single dish as well as in VLBI mode. Since GMRT has started its operations, in very early 2000, the scientific collaborations between India and Italy have expanded considerably. I should say that the Italian radio astronomical community has become familiar with low frequency radio astronomy again thanks to the extensive use of GMRT, which has been possible thanks to the generous help of the Indian colleagues and

friends. Prof. Swarup has always enthusiastically supported such collaborations, whose scientific content he knew in detail. Each time I have met him when visiting Pune for my observing runs, he would come to me and ask about our projects and their progress, with bright eyes and genuine enthusiasm. I thought it was just amazing.

Italy would not be in the position to host a LOFAR station without the expertise developed using the GMRT. And now India and Italy are collaborating again, on a world scale, for the design and construction of the SKA.

It is impressive to see how much has happened in radio astronomy in both countries just in 50 years. I think this has been possible because our fathers, and Prof. Swarup has been one of them, have built and fed incredibly strong and healthy roots, and we should be really proud of this.

I wish to thank the organizers of this event, since we have the chance to share our sorrow for the loss of Govind, and at the same time we can thank him again with utmost gratitude for growing such a large family of radio astronomers, who have now the pleasure and responsibility to ensure that his projects, ideas and enthusiasm can be continued.

Tiziana Venturi
Director, Instituto di Radioastronomia, INAF, Bologna, Italy

With the passing of Govind Swarup, India, and the world, have lost a great leader and visionary. His contributions and those of the many he mentored and inspired have made and kept Indian radio astronomy at the forefront in many areas. His ability to envision and then bring to fruition major projects was astounding. I met Govind around 40 years ago during my second visit to India when I went to Mumbai and Ooty and spoke with him again on nearly all of the succeeding two dozen visits I made to work in Bangalore and Pune, mostly with Gopal-Krishna. His positive energy, enthusiasm for his work, and passion for getting things right was always evident. He asked difficult, but invariably enlightening, questions about the work we were doing. My deep condolences go to his family and colleagues.

Paul Wiita
Professor, The College of New Jersey, USA

It was a great shock to hear about the sad demise of Prof Govind Swaroop today evening. He has inspired more than a generation of Radio Astronomers & Engineers in India. As the recipient of the Padmashree award for his yeoman contribution to Radio Astronomy in the country, he will be remembered very fondly by the astronony community in particular and science community in general for a long time to come. May his soul rest in peace.

A. G. Kulkarni
former Director, S.P. Planetarium, Vadodara, India

I joined TIFR as Personal Assistant to Professor Govind Swarup on 8th July 1986 and continued till 31st August 1996, earlier I had worked with Professor Ishwar Prakash and Dr R S Murthy in ICAR, eminent in their fields, vertebrate ecology and soil science.

Soon I found myself in an altogether different but unbelievably high pedestal. I could not believe myself - a human being can handle so many projects/issues/people with utmost ease and composure, concurrently giving an ear to the lowest in the ladder, ensuring optimum productivity at all levels. I was given to understand that Prof. Swarup as a renowned astronomer and his passionate goal of building GMRT.

My main task was to take dictation and transcribe. And, soon realised that radio astronomer Prof. Swarup - equally adroit at all aspects of engineering - civil, electrical, mechanical, electrical, structural, electronics, servo control, optical fibre communication, spectrum management and a host of allied fields - wanted me not to depend wholly on Isaac Pitman, rather invent my own techniques of handling the dictation. I remember my first attempt was at coining an easy outline of my own for 'interstellar scintillation'. To my pleasant surprise, I also realised soon that Prof. Swarup was not insistent upon verbatim translation but was happy so far as the reading goes well.

In 1997, I was given a residential telephone, which was a personal luxury those times, reminding me about the Onida TV commercial 'owner's pride, Neighbour's envy'.

The dictation sessions were - quite lengthy extending to several hours, specially when relate to

lectures, popular articles and technical/scientific briefs - very unique and special. As I take dictation, Prof. Swarup was very watchful and would stop whenever he felt that I had some doubt. He would then talk to me (remember his time was very precious) in simple language and will continue only when he is convinced that I have understood a little about it. I remember his lecturing to me 1998 almost for 5 minutes about optical fibre communication and it's strength and future prospects.

Another astonishing aspect of the dictation sessions was correction and modification. Occasionally Prof Swarup would want me to modify or add something in the already dictated text. While I would be struggling to locate the point (Pitman shorthand depends on straight/curved lines - doubled and halved - and dots, ticks, circles, etc), Prof. Swarup would place the tip of his pointing finger at the exact point, he wanted the correction to be made. Though I never asked Prof. Swarup about the secret, it continued to pop up in my head "how did Prof. Swarup manage it". Back in Bangalore in 1999 I saw tv news about a Hollywood movie directed by Manoharan Knight Shyamalan "The Sixth Sense" and I told myself 'yes, this is it.'

During the decade 1986-96, Prof. Swarup received close to 10 coveted national/international awards and recognitions, each time, it was yet another working day. Still, I vividly recollect the day Prof. Swarup returned from UK after signing the Register of the Royal Society London - so happy with a scintillating halo around.

I shifted to Bangalore in 1997 and whenever Prof. Swarup arranged important meetings at Bangalore, I was involved in recording the minutes.

Prof. Swarup used to keep me informed about his sojourns at Bangalore and we used to meet, once at my home too. Prof. Swarup was too eager to know about our son and daughter and also evinced keen interest when I set up a terrace garden. Prof. Swarup played a stellar role in catapulting me to an administrator.

To conclude, I reproduce a message from Prof. Swarup I received on 13th April 2020.
"You and Meera must be very proud of your son and daughter and their families. Regards, Govind Swarup."

T. S. Viswanathan
CAM Banglore
former staff member NCRA, Pune, India

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