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Highlights from the observatories

Compiled by D. J. Saikia

A pulsar in a supernova remnant

Since pulsars are rotating neutron stars which form during supernova explosions, one would expect the supernova remnants (SNRs) to be associated with pulsars. However, of ∼1500 known Galactic pulsars (http://www.atnf.csiro.au/research/ pulsar/psrcat/), only ∼20 have been associated clearly with one of the 231 known SNRs in our Galaxy (http://www.mrao.cam.ac.uk/ surveys/snrs/ and Green 2004). Increasing the number of known pulsar SNR associations could provide useful insights towards understanding the evolution of massive stars as well as the formation and evolution of neutron stars.

During March−April 2005, a search for pulsars in selected supernova remnant targets, was carried out using the Giant Metrewave Radio Telescope (GMRT) in the phased array mode at 610 MHz by Yashwant Gupta, Dipanjan Mitra, Dave Green and A. Acharyya. This resulted in a new detection of a 61.86 millisecond pulsar in the supernova remnant G21.5−0.9. A characteristic age of ∼4900 yr was inferred for this pulsar, which is not incompatible with the estimated age of the supernova remnant. It was found that this pulsar has a spin−down luminosity that is the second highest, after the Crab pulsar (Gupta, Mitra, Green & Acharyya 2005). An independent discovery of this pulsar using the Parkes telescope and the Green Bank Telescope was reported by Camilo et al. (2006).

Outburst in RS Ophiuchi

The well-known recurrent nova RS Ophiuchi had an outburst on 2006 February 12. The RS Oph system consists of a massive white dwarf and an M2-3 III giant with an orbital period of 460 days (Anupama & Mikołajewska 1999; Fekel et al. 2000). The high-velocity ejecta from the nova, which arises due to a thermonuclear runaway on the white dwarf surface caused by accreting matter from the companion star, interacts with the wind of the red giant companion. This leads to a shock wave which propagates into the red giant's wind, providing us with an astrophysical laboratory for studying the propagation and evolution of such shocks.

The recent outburst of RS Ophiuchi has been studied extensively across the spectrum ranging

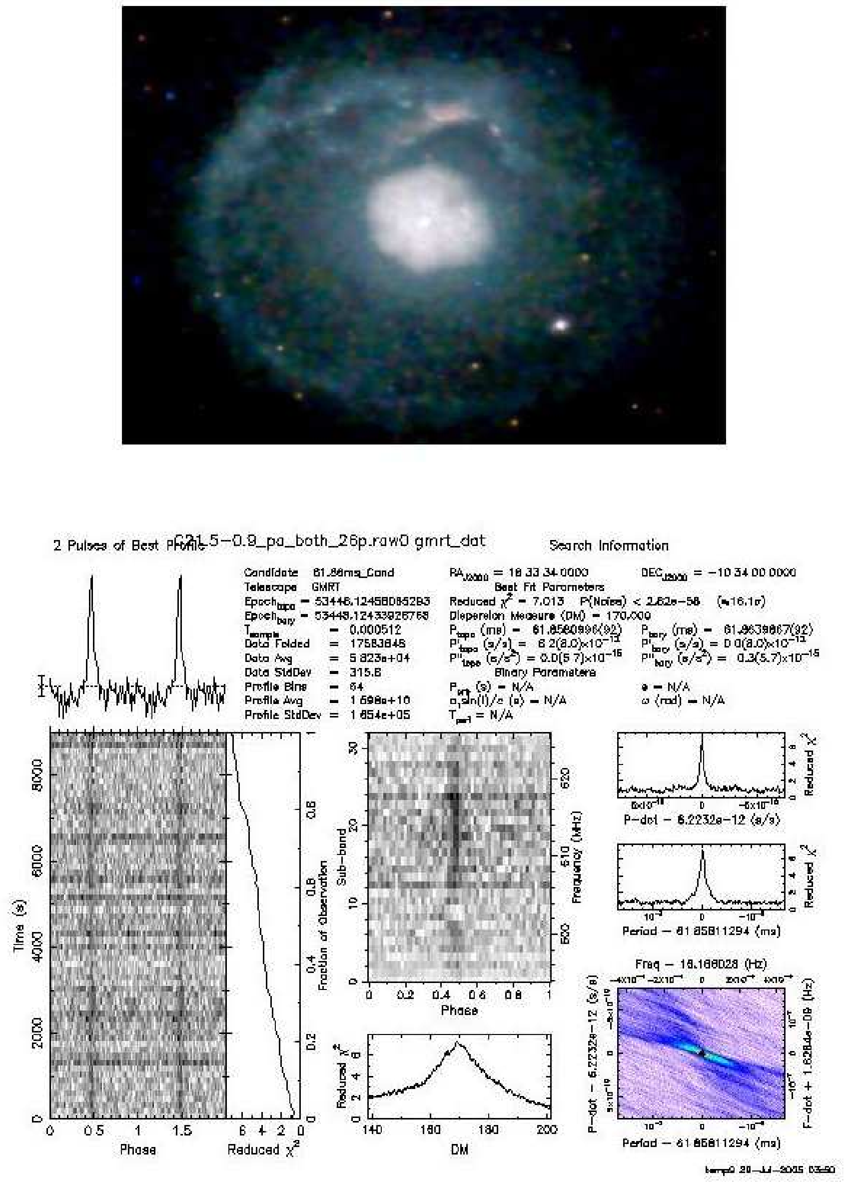

Figure 1. The newly discovered pulsar (J1833−1024, shown in the bottom panel) in the supernova remnant G21.5−0.9, whose image taken with the Chandra x-ray telescope is shown in the top panel (Matheson & Safi-Harb 2005). The pulsar is thought to be located very close to the centre of this remnant. Bottom panel: The top left corner shows two pulses of the final folded profile obtained for the pulsar candidate. The strength of the detection over the 2.5 hr observing duration is fairly constant, as is its presence across most of the 32 MHz observing band. The bottom middle figure shows that the best signal is obtained around a dispersion measure (DM) of 170 pc cm^{-3} and the figures on the right show the localisation of the pulsar signal in the period and period derivative domains (Gupta, Mitra, Green & Acharyya 2005).

from x-rays (Sokoloski et al. 2006; Bode et al. 2006), and optical (Iijima 2006; Buil 2006; Fujii 2006) to infrared (Evans et al. 2006; Monnier et al. 2006) and radio (O'Brien et al. 2006) wavelengths. While x-ray observations detect a blast wave that expands into the red-giant wind, the high-resolution radio images show evidence of an asymmetric shock wave, with the non-thermal emission being jet-like, and collimated by the central binary system (O'Brien et al. 2006).

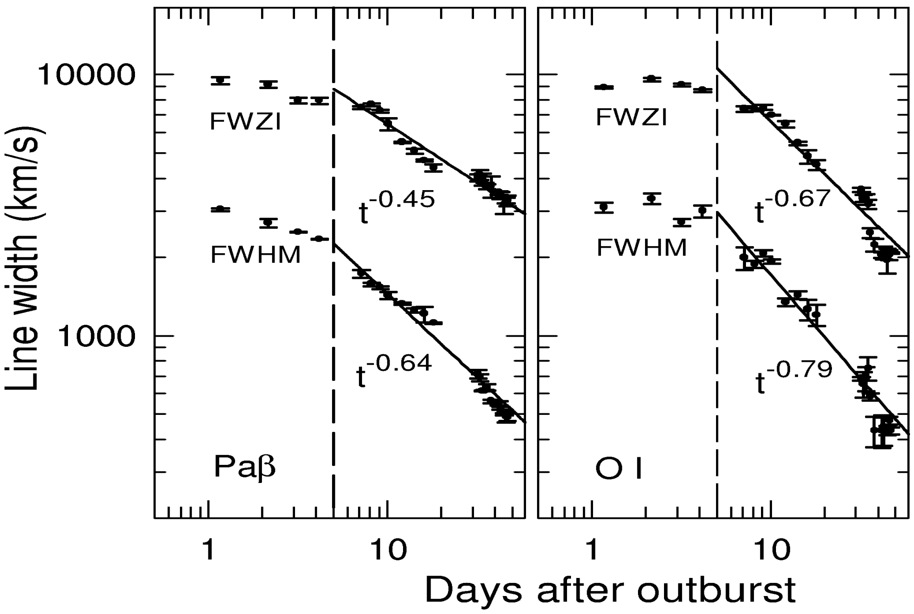

Figure 2. The behaviour of the deconvolved line widths for the Paβ 1.2818μm and the OI 1.1287μm lines is shown. The line widths imply a free expansion phase for the infrared shock front for the first four days - the region to the left of the dashed drop lines. This phase is followed by a decelerative phase which is best described by a power law decline in the shock velocity with time. The different power laws used for fitting are marked in the figure; data points are shown with 1σ error bars (Das, Banerjee & Ashok 2006).

Ramkrishna Das, Dipankar Banerjee and Nagarhalli Ashok have presented near-infrared spectra and reported the detection of an infrared shock wave, which manifests itself through a narrowing of the emission lines. This is the first detection of such a shock wave in the infrared in a recurrent nova. The evolution of the shock has been traced through a free expansion stage to a decelerative phase, broadly consistent with current shock models. They also suggest that the white dwarf in the RS Oph system has a high mass and could be a potential SNIa candidate (Das, Banerjee & Ashok 2006). At radio frequencies RS Oph has been detected at low frequencies, namely 235, 325, 610 and 1400 MHz with the GMRT (see Anupama & Kantharia 2006) and is being monitored systematically using both the GMRT and the 2-m Himalayan Chandra Telescope (HCT).

Fluorine in cool extreme He stars

Fluorine has a stable, yet rather fragile, isotope, ^{19}F, which is readily destroyed in stellar interiors. The high F abundances measured in the asymptotic giant branch (AGB) stars could provide some clues towards understanding the production of fluorine, and its abundance in our Galaxy. It is believed that in AGB stars ^{19}F is produced in the He-rich intershell region and then dredged up to the surface (Forestini et al. 1992). Since extreme helium (EHe) stars are expected to have gone through an AGB phase (Pandey et al. 2006), flourine could be present in their atmospheres and this could provide a test of flourine production in AGB stars.

From a program involving observations with the W.J. McDonald Observatory's 2.7-m telescope, the 2.3-m Vainu Bappu Telescope and CTIO, Gajendra Pandey has reported the detection of neutral fluorine (F I) lines in the optical spectra of cool EHe stars. These are the first identification of F I lines in a star's spectrum, and show that fluorine is over abundant in EHe stars, which suggests the synthesis of fluorine in these stars. Possible scenarios for this have been explored (Pandey 2006).

McNeil's Nebula

A new reflection nebula in the L1630 cloud in Orion surrounding a young stellar object was discovered by Jay McNeil on the night of 2004 January 23 (McNeil 2004). The object is the faint optical counterpart of an infrared source, which had gone into outburst producing the reflection nebulosity. The object was later designated as V1647 Orionis. NIR images taken with the Gemini telescope show that the object has brightened by about 3 magnitudes relative to the 1998 2MASS measurements, while spectroscopic observations show strong features of CO and hydrogen Brγ in emission in the IR. Optical observations show that Hα appears in emission with a P Cygni profile (Reipurth and Aspin 2004). Vacca, Cushing & Simon (2004) suggest that V1647 Ori is a heavily embedded low-mass Class I protostar, surrounded by a disk, whose brightening is due to a recent accretion event, while Ábrahám et al. (2004) suggest that it is possibly a Class II protostar of age about 0.4 Myr.

D.K. Ojha and his collaborators have presented a detailed study of the post-outburst phase of McNeil's nebula (V1647 Orionis) using optical and near-infrared photometric and low-resolution optical spectroscopic observations using the 2-m HCT and 1.2-m Mt. Abu telescopes during the period 2004 February – 2005 December. They find that V1647 Ori has faded by more than 3 magnitudes since February 2004, and McNeil's nebula itself has also faded considerably. Optical spectroscopic observations indicate a weakening in the powerful stellar wind, while the photometric observations suggest an EXor, rather than an FUor event. Studies of the nebula indicate a large scale disk-like structure (or envelope) surrounding the central source (Ojha et al. 2006).

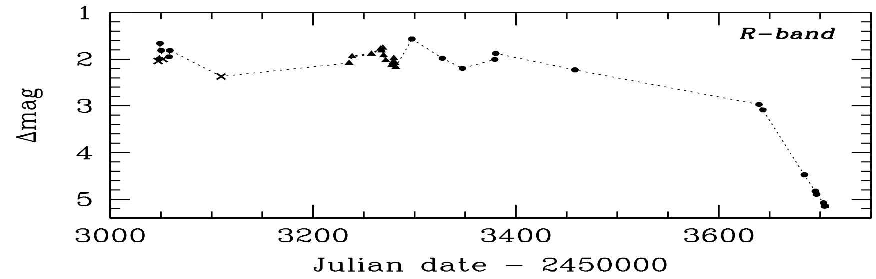

Figure 3. The optical light curve of V1647 Ori in *R*-band (Ojha et al. 2006). The differential magnitudes are relative to a single comparison star, which appears constant to within 0.05 mag. The filled circles show the measurements of Ojha et al. (2006) from 2004 February to 2005 November. The cross symbols show the photometric measurements from McGehee et al. (2004). The filled triangles are the *R*-band photometric observations by Semkov (2004) during the period 2004 August – October.

The peculiar Type Ib supernova SN 2005bf: Explosion of a massive He star with a thin hydrogen envelope?

Studies of Type Ib and Ic supernovae, which are both hydrogen deficient at maximum light, and also lack deep Si II absorption near 6150 Å, are important for understanding their properties, progenitors as well as the physics of the events. In addition, such studies are interesting because there appears to be a connection between bright and energetic SN Ic events and GRB sources (Mazzali et al. 2003). The Type Ib supernova SN 2005bf was discovered independently by Monard (2005) and Moore & Li (2005) on April 5.722, 2005 (UT), at a magnitude of about 18.0, in the SB(r)b galaxy MCG +00−27−5.

G.C. Anupama and her colleagues have presented optical spectroscopic observations of SN 2005bf obtained near the maximum, and optical photometric observations during the maximum and subsequent decline, with the 2-m HCT at the Indian Astronomical Observatory (IAO), Hanle using the Himalaya Faint Object Spectrograph Camera (HFOSC). The light curves indicate that the maximum occurred nearly 40 days after the date of explosion. At maximum, SN 2005bf was brighter and bluer than other SNe Ib/c. They suggest that the SN possibly ejected $\sim$ 0.31 $M_\odot$ of ^{56}Ni, which is more than the typical amount. The spectra of SN 2005bf around maximum are very similar to those of the Type Ib SNe 1999ex and 1984L about 25-35 days after the explosion, displaying prominent He I, Fe II, Ca II H & K and the near-IR triplet P Cygni lines. Except for the strongest lines, He I absorptions are blueshifted by $\lesssim$ 6500 km s^{-1}, and Fe II by $\sim$ 7500−8000 km s^{-1}. No other SNe Ib has been reported to have their Fe II absorptions blueshifted more than the He I absorptions. Relatively weak Hα and very weak Hβ may also exist, blueshifted by $\sim 15,000$ km s^{-1}. They suggest that SN 2005bf was the explosion of a massive He star, possibly with a

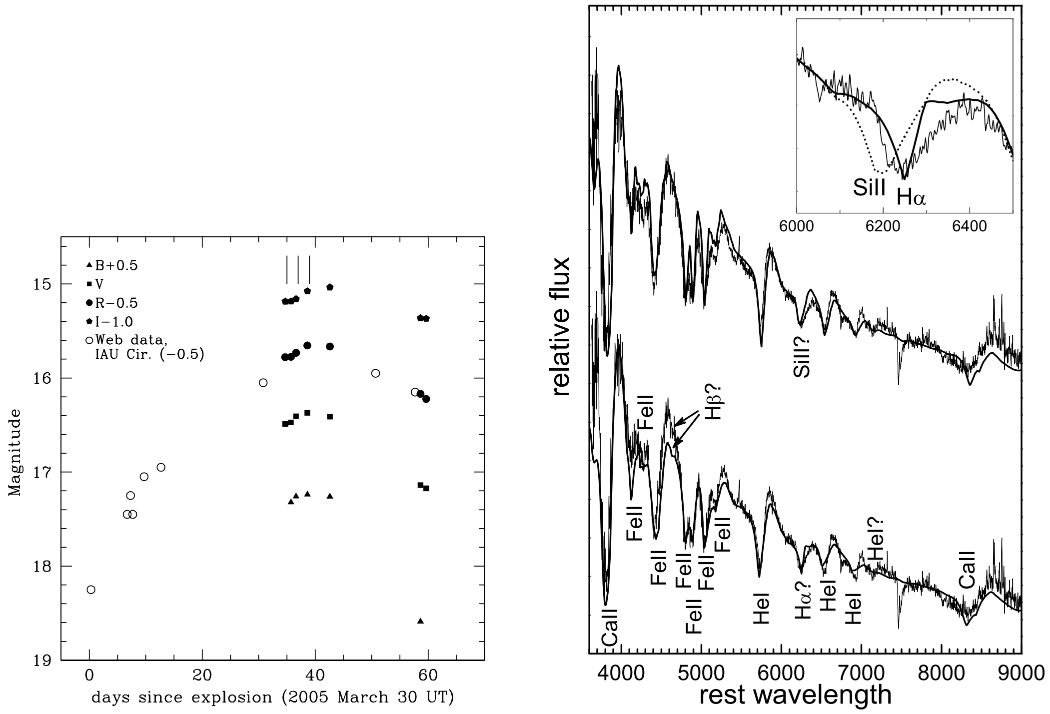

Figure 4. Left panel: The *BVRI* magnitudes of SN 2005bf. For clarity the *BRI* magnitudes are offset by +0.5, −0.5 and −1.0 magnitudes, respectively. Also included in the figure with the *R* band magnitudes are the unfiltered CCD magnitudes obtained by amateurs and those reported in the IAU circulars. Vertical lines mark the dates of spectroscopic observations. Right panel: The day 35 (May 4) spectrum of SN 2005bf (thin line) compared with a synthetic spectrum (lower spectrum thick line) that has $v_{\rm phot}$ = 8000 km s^{-1} and contains lines of He I, Ca II, Fe II and H. The thick line in the upper spectrum is the synthetic spectrum without lines due to H, but Si II included and $v_{\rm phot}$ = 6500 km s^{-1}. Inset shows the 6245 Å absorption with fits due to Hα and Si II by thick and dotted lines respectively (Anupama, Sahu, Deng, Nomoto, Tominaga, Tanaka, Mazzali & Prabhu 2005).

trace of a hydrogen envelope (Anupama, Sahu, Deng, Nomoto, Tominaga, Tanaka, Mazzali & Prabhu 2005).

In a later paper, which also included data from the HCT, Tominaga et al. (2005) showed that the light curve had two maxima, and declined rapidly after the second maximum. They estimate the ejecta mass to be of $\sim$ 6 – 7 M$_\odot$, with a kinetic energy of $\sim$ 1.0 – 1.5 $\times$ 10^{51} ergs, a high peak bolometric luminosity $\sim$ 5 $\times$ 10^{42} erg s^{-1}, and a large ^{56}Ni mass of $\sim$ 0.32 M$_\odot$. They suggest that the progenitor was initially massive (M$\sim$ 25 – 30 M$_\odot$) and had lost most of its H envelope (Tominaga et al. 2005).

Low-metallicity galaxies

It is important to study the Hɪ distribution and kinematics in galaxies with low metallicity so that one can understand the mechanisms by which the star-formation that was subdued in these galaxies for long, got triggered. This can provide important clues about the process of galaxy formation and evolution. Ekta and Jayaram Chengalur are making a systematic study of these galaxies using the GMRT. The Hɪ data for a few metal-poor galaxies, show clear signs of interaction with a neighbour in all of these. In the extremely metal-deficient galaxy SBS 1129+576 which has a weighted mean oxygen abundance of 12+log(O/H) = 7.41±0.07, or 1/18 of the solar value, Hɪ observations show that the galaxy is strongly interacting with a companion galaxy, SBS 1129+577, located ~27 kpc from it. In both SBS 1129+576 and SBS 1129+577, there appear to be a good correspondence between regions with high Hɪ column density and those with ongoing star formation (Ekta, Chengalur & Pustilnik 2006).

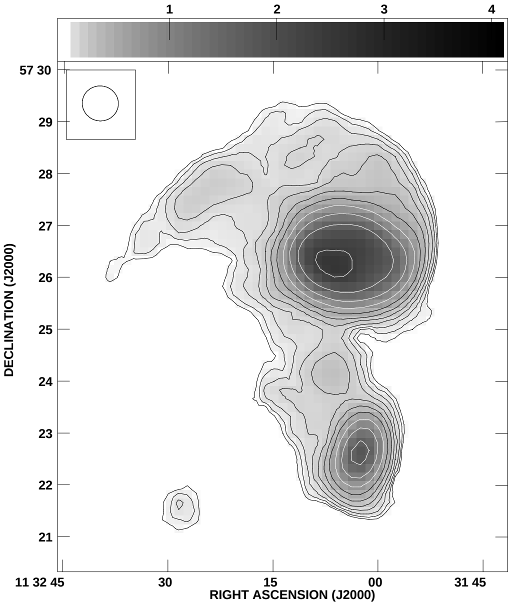

Figure 5. Integrated Hɪ emission map of the SBS 1129+576 and SBS 1129+577 in contours. The resolution is 42 × 40 arcsec^2 and the contours are at 3.0, 4.5, 6.8, 10.2, 15.2, 22.8, 34.3, 51.4, 77.1, 115.6 and 173.5 × 10^{19} atoms cm^{-2}. The same map is shown in grey-scale over column density range of 2.6 × 10^{19}–2.7 × 10^{21} atoms cm^{-2} (Ekta, Chengalur & Pustilnik 2006).

AGN activity in x-ray underluminous galaxy groups

The hot intracluster medium (ICM) in clusters of galaxies appears to be heated by some non-gravitational sources, in addition to what is expected from matter falling into the gravitational potential. Besides the effects of supernovae and accretion shocks, an interesting possibility is heating by an active galactic nucleus (AGN). This has been motivated by the existence of x-ray deficient bubbles and the close correlation of radio emission and these bubbles in some cases. These bubbles are expected to rise in the cluster atmosphere due to buoyancy and expand in size, thereby heating the gas.

Croston et al. (2005) studied the x-ray luminosity and temperature (L_x-T) relation in a sample of poor clusters, and found some evidence that the radio loud objects deviated the most from the scaling relationship. However, an extrapolation of the L_x-T relation to poor clusters showed that all poor clusters deviated from the scaling relationship.

K.S. Dwarakanath and Biman Nath observed the most deviant, radio quiet clusters from the sample of Croston et al. to detect low surface brightness and steep-spectrum radio emission in them which could be due to earlier AGN activity, but have not been detected in the existing surveys. The GMRT low-frequency observations at 235 and 610 MHz did not detect any diffuse emission. The upper limits on the total energy in relativistic particles is $\sim 3\times 10^{57}$ ergs, which is more than a factor of 100 less than that required to explain the decreased x-ray luminosities in the AGN-heating scenario. Alternatively the AGN activity could have ceased ~4 Gyr ago, so that the relativistic particles would have diffused to an extent (~250 kpc) which would be below the detection limits of the current observations. These results suggest the possibility that the ICM may have been pre-heated before the assembly of galaxy clusters (Dwarakanath & Nath 2006).

Radio relics and halos in clusters of galaxies

Radio halos and relics are low-surface brightness sources with steep radio spectra, and sizes which can extend to over a Mpc. While radio halos are usually located near the centre of a cluster and has a reasonably regular structure, the relics are located in the periphery of the clusters and exhibit a wider variety of structures. There are approximately 20 radio halos and 20 relics known (e.g. Bacchi et al. 2003; Giovannini & Feretti 2004, and references therein; see Feretti 2003 for a review). Besides understanding the physics of these structures these could provide useful insights towards understanding the clusters of galaxies and their formation and evolution.

Tiziana Venturi and her collaborators have presented the first GMRT results of their search for giant radio halos in the redshift range z=0.2–0.4. They found three new halos, which are in the clusters A 209, RXCJ 2003.5–2323 and RXCJ 1314.4–2515, and one radio relic in A 521, and two relics in RXCJ 1314.5–2515. They suggest that their results are consistent with the particle re–acceleration model for the origin of non–thermal radio emission in galaxy clusters (Venturi, Giacintucci, Brunetti, Cassano, Bardelli, Dallacasa & Setti 2006).

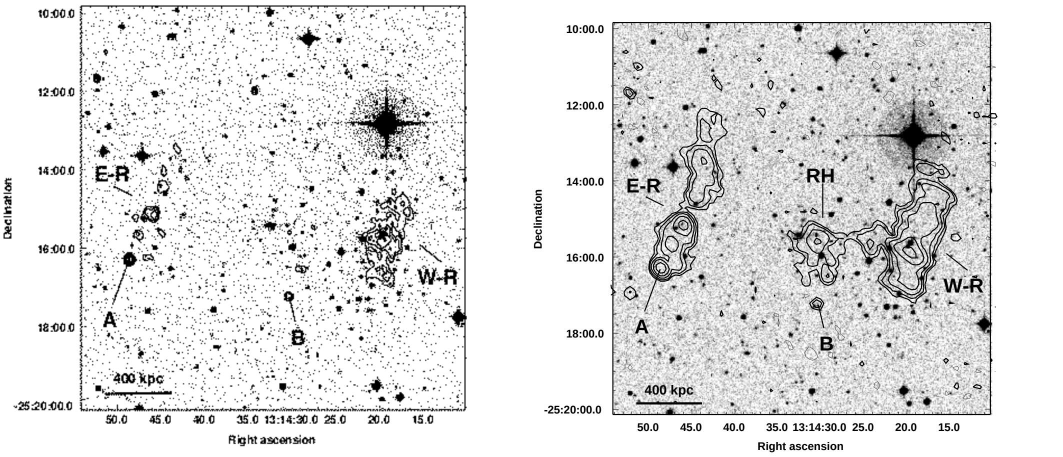

Figure 6. Left panel: GMRT 610 MHz radio contours for the cluster RXCJ 1314.4–2515 superposed on the POSS–2 optical plate. The 1σ level in the image is 60 μJy b^{-1}. Logarithmic contours are reported, starting from ±0.18 mJy b^{-1}. The HPBW is 8.0″ × 5.0″, p.a. 15°. Right panel: GMRT 610 MHz radio contours for the cluster RXCJ 1314.4–2515 superposed on the POSS–2 optical plate. The 1σ level in the image is 60 μJy b^{-1}. Logarithmic contours are reported, starting from ±0.2 mJy b^{-1}. The HPBW is 20.0″ × 15.0″, p.a. 39°. The western and the eastern relics are labelled as E–R and W–R respectively, RH indicates the radio halo, and the individual point sources in the relics/halo region are indicated as A and B (Venturi, Giacintucci, Brunetti, Cassano, Bardelli, Dallacasa & Setti 2006).

A unique infrared flash from the afterglow of GRB 050319

The gamma ray bursts (GRBs) which are amongst the most energetic events in the Universe appear to be due to collimated emission from the core-collapse of a massive star, or coalescence of neutron stars or black holes in a binary system. The dissipation of energy by the outflow as it is slowed down by the surrounding material leads to an afterglow whose light curve decays with time. Occasionally a rapid flash is observed to occur along with the GRB which has been interpreted to be due to 'reverse shocks'. Koshy George, Dipankar Banerjee, Thyagarajan Chandrasekhar and Nagarhalli Ashok have reported the detection of a late flash from the GRB 050319 (George et al. 2005) using the 1.2-m Mt. Abu Infrared Telescope. This is only the second IR flash to be ever detected from a GRB, and poses interesting theoretical questions.

The rapid dimming of the IR flash in GRB 050319, occurring ~6.15 hr after the gamma-ray emission and fading by ~2.2 mag over ~4 min, can be seen in the images and the lightcurve shown in Fig. 7. GRB 050319 is at a redshift of z = 3.24 (Fynbo et al. 2005), which corresponds to a luminosity distance of 28.36 Gpc (H_0 = 71 km s^{-1} Mpc^{-1}, $\Omega_M = 0.27$ and $\Omega_\Lambda = 0.73$) making it one of the most distant GRBs. In this source, the flash occurred ~6 hr after the γ-ray emission, well after the afterglow became visible, making it unlikely to be due to a reverse shock. Although the authors have considered the possibility of a dust echo around the progenitor

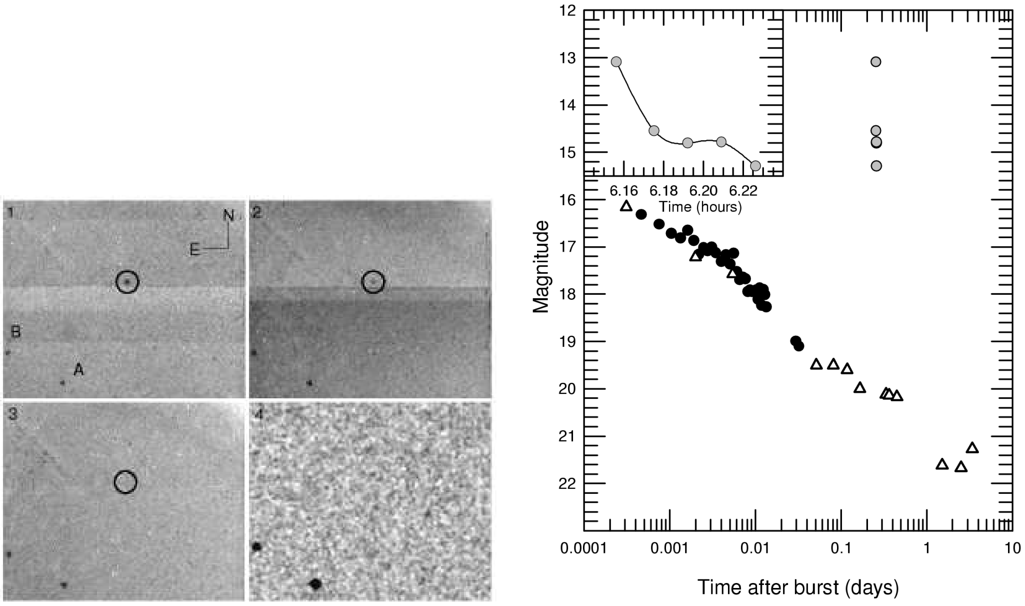

Figure 7. Left panel: 1.25 μm J band images (3.2'x4') of the GRB 050319 field from the 1.2-m Mt. Abu Infrared Telescope using the near-IR imager/spectrograph. The IR afterglow (encircled) was detected in five images and was below the detection limit in the sixth. Here the first, second and sixth frames are presented (marked 1, 2 and 3) to show the detection, fading and disappearance. The 2MASS field is shown in frame 4. Right panel: J band observations (filled grey circles) superposed on the R band light curve of GRB 050319 to accentuate the fast IR fading. The majority of the R band data (filled circles) is from Woźniak et al. (2005) while the rest (triangles) are from GCN circulars. The rapid fading of the IR flash is seen more clearly in the inset (George, Banerjee, Chandrasekhar & Ashok 2006).

producing the characteristics of the observed flash, the feature is not well understood (George, Banerjee, Chandrasekhar & Ashok 2006).

Radio, millimeter and optical monitoring of GRB030329 afterglow: constraining the double jet model

The GRB of 29th March 2003 which is at a resdhift of 0.1685 (Greiner et al. 2003a,b) corresponding to a distance of $\sim$ 870 Mpc, has one of the brightest optical and radio afterglows detected till date (Peterson & Price 2003). The spectral signature of a supernova (SN2003dh) was seen a few days after the burst (Stanek et al. 2003), providing the first unambiguous evidence of association between GRBs and supernovae. In addition to the supernova there were suggestions of jet-like components with different opening angles and Lorentz factors (Berger et al. 2003).

L. Resmi and her collaborators have presented the results of an Indo-European GRB collaboration involving observations at radio, millimeter and optical wavelengths over about a year. While the radio observations were carried out with the GMRT, the optical observations were made with the 2-m HCT and the 1-m Sampurnanand Telescope of ARIES. The millimeter observations were conducted for more than a month at ESO and IRAM. They find that the data can be fitted by the jet models, and suggest that the optical re-brightening could be a re-energization of the jet, which resulted in the initially narrow jet being converted into a more energetic wider jet (Resmi et al. 2005) .

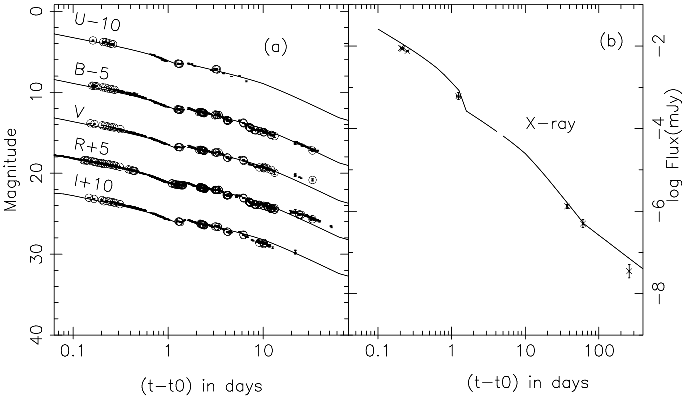

Figure 8. Left panel: The optical lightcurve of the afterglow of GRB030329, shown with the prediction of a model which assumes a transition of an initially narrow jet to a wider jet at ∼ 1.5 days. Right panel: X-ray observations reported by Tiengo et al. (2003, 2004), with predictions of the model. The flattening seen at late times is due to the transition into non-relativistic regime at ∼ 63 days (Resmi et al. 2005).

J0041+3224: A new double-double radio galaxy

One of the important issues concerning galaxies is the duration of their AGN phase and whether such periods of activity are episodic. For the radio-loud objects, an interesting way of probing their history is via the structural and spectral information of the lobes of extended radio emission. A striking example of episodic jet activity is when a new pair of radio lobes is seen closer to the nucleus before the ‘old’ and more distant radio lobes have faded. Such sources have been christened as ‘double-double’ radio galaxies (DDRGs) by Schoenmakers et al. (2000), although examples of sources with episodic activity have been highlighted earlier by Subrahmanya, Saripalli & Hunstead (1996) and Lara et al. (1999). Approximately a dozen or so of such DDRGs are known in the literature.

D.J. Saikia, Chiranjib Konar and Vasant Kulkarni have reported the discovery of a new DDRG, J0041+3224, identified from observations made with the GMRT of candidate DDRGs from the B2 sample. The inner and outer doubles are aligned within ∼4° and are reasonably collinear with the parent optical galaxy. The time scale of interruption of jet activity has been

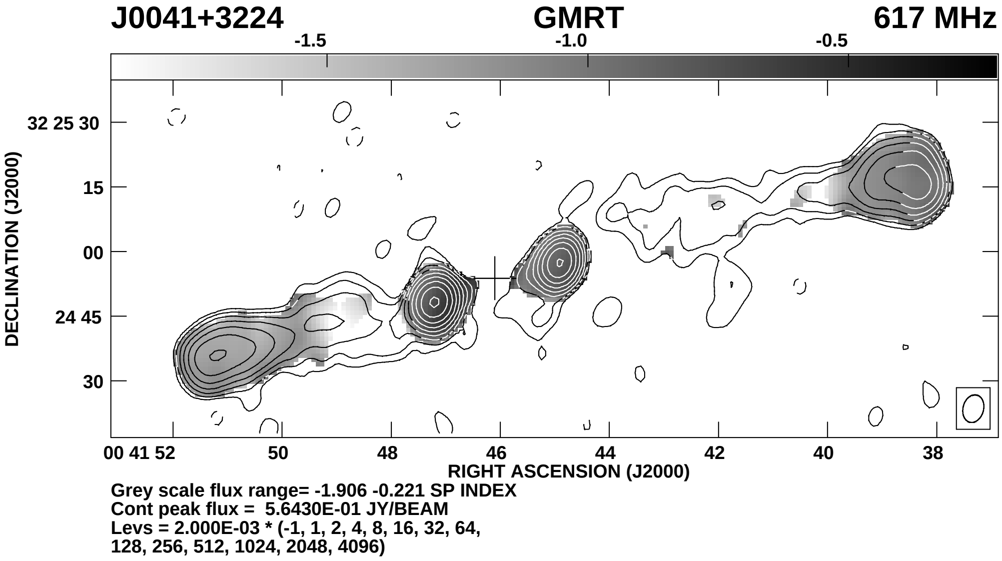

Figure 9. The GMRT image of J0041+3224 at 617 MHz with an angular resolution of ~5.6 arcsec. The spectral index image obtained by smoothing a VLA 4860-MHz image to that of the 617-MHz one is shown superimposed on the 617-MHz image in gray scale. The inner younger lobes have flatter spectral indices than the outer, older lobes (Saikia, Konar & Kulkarni 2006).

estimated to be ~20 Myr, similar to other known DDRGs. For a sample of known DDRGs, they have examined the symmetry parameters and find that the inner doubles appear to be more asymmetric in both its armlength and flux density ratios compared with the outer doubles, although they appear marginally more collinear with the core than the outer double. These trends need to be explained by models for such sources (Saikia, Konar & Kulkarni 2006).

Spectral ages of DDRGs

Low-frequency GMRT observations along with high-frequency VLA observations can play an important role in determining spectral ages of radio sources. Chiranjib Konar, D.J. Saikia, Marek Jamrozy and Jerzy Machalski have reported their initial results of a study of a sample of DDRGs, where they have presented new radio observations at frequencies ranging from 240 to 4860 MHz of the well-known, DDRG, J1453+3308, using both the GMRT and the VLA. These observations enabled them to determine the spectra of the inner and outer lobes over a large frequency range and demonstrate that while the spectrum of the outer lobes exhibits significant curvature, that of the inner lobes appears practically straight. The break frequency, and hence the inferred synchrotron age of the outer structure, determined from 16−arcsec strips transverse to the source axis, increases with distance from the heads of the lobes towards the nucleus. The maximum

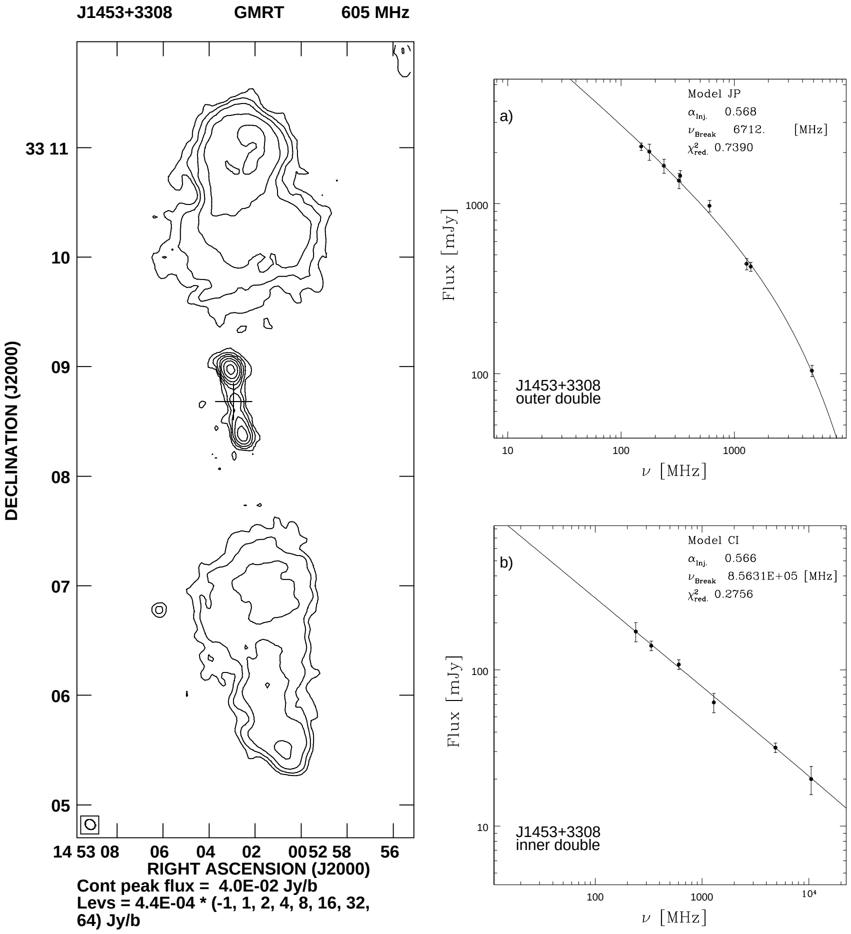

Figure 10. The GMRT image of the DDRG J1453+3308 at 605 MHz with an angular resolution of ~5.4 arcsec. Spectra of the outer and inner doubles fitted with the models of radiative losses. Upper panel: the outer double fitted with the Jaffe & Perola (1973) model; lower panel: the inner double fitted with the continuous-injection (Kardashev 1962; Pacholczyk 1970) model. (Konar, Saikia, Jamrozy & Machalski 2006).

spectral ages for the northern and southern lobes are ~47 and 58 Myr respectively. Because of the difference in the lengths of the lobes these ages imply a mean separation velocity of the heads of the lobes from the emitting plasma of 0.036c for both the northern and southern lobes. The synchrotron age of the inner double is about 2 Myr which implies an advance velocity of ~0.1c, but these values have large uncertainties because the spectrum is practically straight (Konar, Saikia, Jamrozy & Machalski 2006).

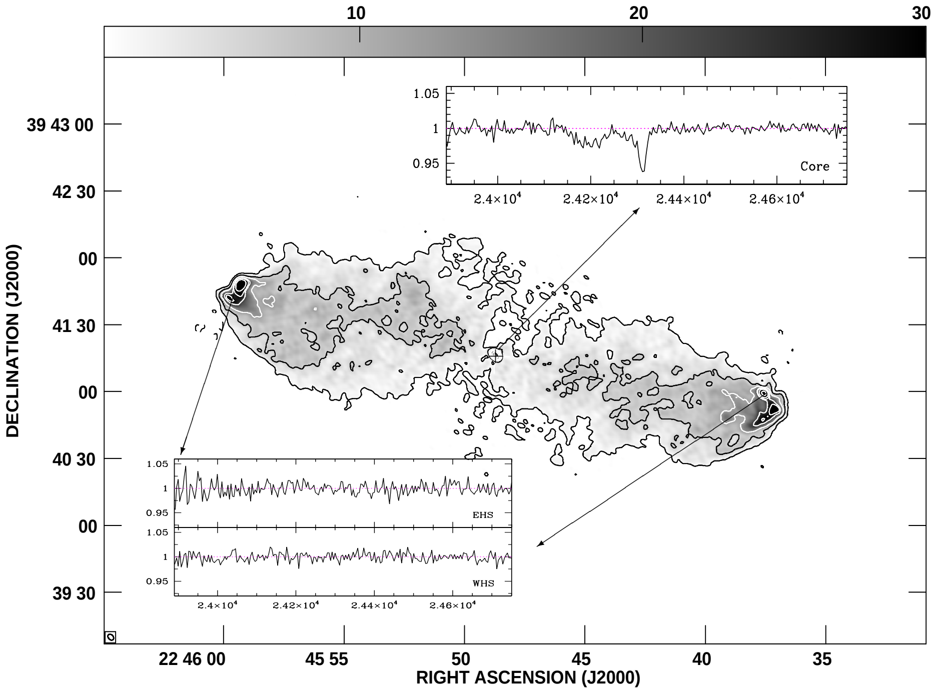

Figure 11. GMRT image of the radio galaxy 3C 452 with a resolution of ∼2.7″. The HI spectra at the peak intensity pixel in the eastern hotspot (EHS), core and western hotspot (WHS) are shown. For these, x-axis and y-axis are heliocentric velocity in km s^{-1} and normalised intensity respectively (Gupta & Saikia 2006).

Hɪ gas in the nuclear regions of radio galaxies

An understanding of the properties of the gaseous environments of radio galaxies and quasars could provide valuable insights towards understanding the phenomenon of radio activity associated with these objects and their evolution. Such studies also enable us to test consistency of these properties with the unified schemes for these objects. An important way of probing the neutral component of this gas over a wide range of length scales is via 21-cm Hɪ absorption towards radio sources of different sizes. These range from the sub-galactic sized compact steep-spectrum (CSS) and gigahertz peaked-spectrum (GPS) sources, which are believed to be young ($<10^5$ yr), as compared with the larger sources which could extend to over a Mpc and are typically $\sim10^8$ yr old. A survey of Hɪ and OH absorption towards a sample of 27 radio sources using the Arecibo 305-m telescope and the GMRT has led to one new detection towards the radio galaxy 3C258, while five previously known Hɪ absorption systems, and one galaxy detected in emission, have been studied with improved resolution and/or sensitivity (Gupta, Salter, Saikia, Ghosh & Jeyakumar 2006). Combining their observations with available information in the literature, they reported the Hɪ column density to be anticorrelated with source size, consistent with earlier results (Pihlström, Conway & Vermeulen 2003; Vermeulen et al. 2003), and some evidence in favour of jet-cloud interactions playing an important role in determining the ionization and kinematical properties of the ambient gas.

As part of a study of HI absorption towards the central regions of active galaxies, Neeraj Gupta and D.J. Saikia have reported the discovery of of 21-cm HI absorption towards the core of the Fanaroff-Riley II radio galaxy 3C 452 (J2245+3941). There are only a few other FRII sources with known HI absorption. The absorption profile is well resolved into three components; the strongest and narrowest component being coincident with the velocity corresponding to [O III] emission lines while the other two components are blue-shifted with respect to it by ~30 and ~115 km s^{-1}. If the systemic velocity of the host galaxy is determined from low-ionization lines, which are red-shifted with respect to the [O III] doublet by about ~200 km s^{-1}, then both the [O III] emission and 21-cm absorption lines are associated with outflowing material. The neutral hydrogen column density is estimated to be $N(HI)=6.39\times10^{20}(T_s/100)(f_c/1.0)^{-1}$ cm^{-2}, where T_s and f_c are the spin temperature and covering factor of the background source respectively (Gupta & Saikia 2006).

Detecting cold gas at intermediate redshifts: A GMRT survey using Mg II systems

The diffuse interstellar medium exhibits a wide range of physical conditions such as temperature, density and radiation field that are influenced by in-situ star-formation, cosmic ray energy density, photoelectric heating by dust as well as mechanical energy input from both impulsive disturbances such as supernova explosions and steady injection of energy in the form of stellar winds. Therefore, understanding the physical conditions in the gas and the processes that maintain these is important for understanding galaxies and their evolution. The damped Lyman-α systems (DLAs), with log N(H I)≥20.3, are a major reservoir of H I at high z and possibly the progenitors of present-day galaxies (see Wolfe et al. 2005). At high z, despite many attempts, only a handful of DLA galaxies have been detected based on line and/or continuum emission (see Möller, Fynbo & Fall 2004).

Our understanding of physical conditions in DLAs at $z \geq 1.8$ is based primarily on the absorption lines of H_2 molecules and atomic fine-structure lines. A systematic search for H_2 in DLAs at ($z_{\rm abs} > 1.8$) has resulted in a detection in ~15% of the cases (see Ledoux et al. 2003). Detecting 21-cm absorption line is one complementary way to probe the nature of absorbing gas. There have been several systematic searches for 21-cm absorption in DLAs undertaken by various groups (Briggs & Wolfe 1983; Lane 2000; Kanekar & Chengalur 2003, Curran et al. 2005) with limited success. To date, in the literature 38 DLAs have been searched for 21-cm absorption, resulting in 17 detections most of which occur at $z < 1$.

Intervening H I 21-cm absorption systems at $z \geq 1.0$ are very rare and only 4 confirmed detections have been reported in the literature. Despite their scarcity, they provide interesting and unique insights into the physical conditions in the interstellar medium of high-z galaxies. Moreover, they can provide independent constraints on the variation of fundamental constants. Neeraj

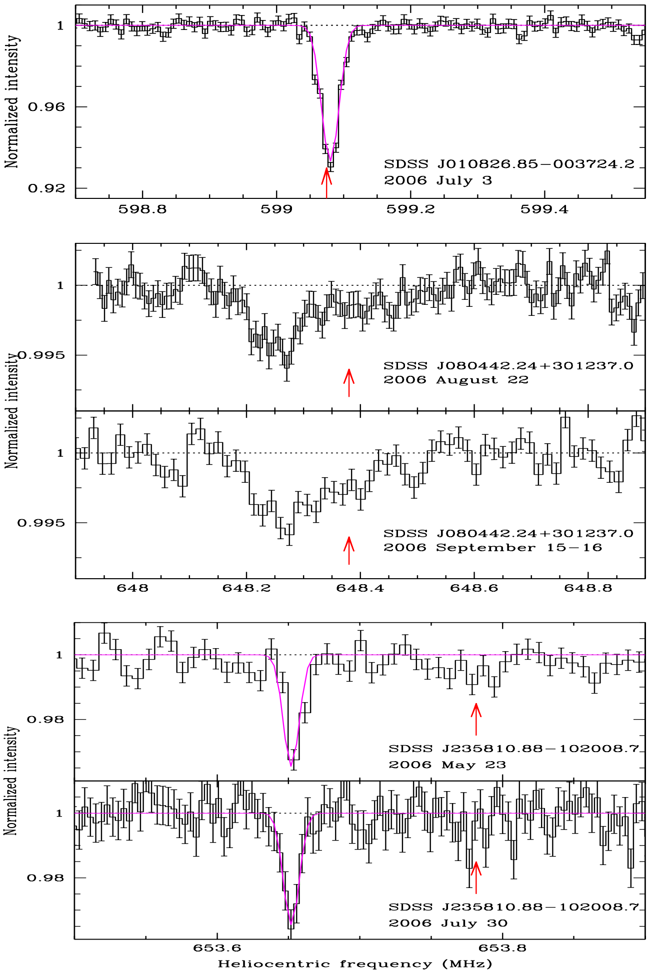

Figure 12. GMRT H I spectra of the sources with 21-cm absorption. Single Gaussian fits are overplotted in the case of J0108−0037 and J2358−1020. Arrows mark the expected positions of 21-cm absorption based on the metal absorption lines (Gupta, Srianand, Petitjean, Khare, Saikia & York 2006) .

Gupta, Raghunathan Srianand, Patrick Petitjean, Pushpa Khare, D.J. Saikia and Don York have reported recently 3 new detections based on their ongoing GMRT survey for 21-cm absorbers at $1.10 \leq z_{\rm abs} \leq 1.45$ from candidate damped Lyman-α systems, almost doubling the number of detections in this redshift range. The 21-cm lines are narrow for the $z_{\rm abs} = 1.3710$ system towards SDSS J0108−0037 and $z_{\rm abs} = 1.1726$ system toward SDSS J2358−1020. Based on line full-width at half maximum, the kinetic temperatures are ≤ 5200 K and ≤ 800 K, respectively. The 21-cm absorption profile of the third system, $z_{\rm abs} = 1.1908$ system towards SDSS J0804+3012, is shallow, broad and complex, extending up to 100 km s^{-1}. The centroids of the 21-cm lines are found to be shifted with respect to the corresponding centroids of the metal lines derived from SDSS spectra. This may mean that the 21-cm absorption is not associated with the strongest metal line component (Gupta, Srianand, Petitjean, Khare, Saikia & York 2006).

GMRT observations of the sub-mJy population at 610 MHz

Radio sources stronger than a few mJy are usually associated with AGN, while at lower flux densities the radio source counts are dominated by the radio-quiet objects in early-type galaxies and contributions from starbursts in late-type galaxies.

Marco Bondi and his collaborators have made GMRT observations of the VVDS-VLA Deep survey at 610 MHz to study the sub-mJy population of radio sources. Deep VLA observations at 1.4 GHz have yielded a catalogue of 1054 radio sources detected down to a 5σ limit of $\simeq 80\mu$Jy. They report evidence of a significant change in the dominant population of radio sources below 0.5 mJy (at 1.4 GHz). The median spectral index is significantly flatter ($\alpha = -0.46 \pm 0.03$; where α = S$\propto \nu^{\alpha}$) for sources between 0.15 and 0.5 mJy compared with the brighter sources ($\alpha = -0.67 \pm 0.05$), and possibly consists largely of AGN. However, between 0.10 and 0.15 mJy at 1.4 GHz, the median spectral index steepens again ($\alpha = -0.61 \pm 0.04$) possibly due to the contribution of starburst galaxies. They also present a sample of 58 candidate ultra-steep sources which are weaker than other similar samples by one to two orders of magnitude and are worth exploring to find out the nature of these sources (Bondi et al. 2006).

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