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Highlights from the observatories

Compiled by D.J. Saikia

1. GMRT discovery of a millisecond pulsar

A binary millisecond pulsar has been discovered in the globular cluster NGC1851, located about 12.6 kpc from us, by a team consisting of Yashwant Gupta and Ishwara-Chandra from NCRA, along with Paulo Freire and Scott Ransom. Globular clusters are rich repositories of pulsars, most of which belong to the category of recycled, millisecond pulsars. The discovery comes from a targeted search of selected globular pulsars carried out by this team in February 2003 with the Giant Metrewave Radio Telescope (GMRT), at a frequency of 327 MHz. The survey used the phased array beam formed from the central square antennas of the GMRT to observe each target cluster for about one hour.

All the scans of NGC1851 taken in February 2003 revealed the presence of a pulsed signal with a period of around 4.991 ms, at a dispersion measure of 52.15 (see Fig. 1). Follow-up observations carried out in December 2003 confirmed the presence of the pulsar. Significant variations in the period were observed at different epochs, clearly indicating a binary pulsar (Fig. 1). Detailed analysis revealed a most unique fact about this pulsar: the orbit is highly eccentric (e=0.889) – the most eccentric orbit of any known binary pulsar. The orbital period is 18.7850 days and the semi-major axis of the orbit projected along the line-of-sight is 36.4 light seconds. The inferred minimum companion mass is 0.9 $M_\odot$. Using the interferometric mode of the GMRT, a radio map of the globular cluster was made and this showed a faint point source located only about 0.1 arcminutes from the center of the cluster, allowing the team to pin down the precise location of the pulsar. The discovery of the pulsar has been reported by Freire et al. (2004).

Standard evolutionary models for the formation of binary millisecond pulsars predict the majority of such objects to have low-mass white dwarf companions in nearly circular orbits, and this has been confirmed by the bulk of the globular cluster pulsars found to date. Hence, pulsars like this new discovery in NGC1851 are peculiar objects and indicate the presence of other mechanisms of formation. Exchange encounters, in which a binary star exchanges its companion for a more massive star, are thought to be likely explanations. Such encounters have a much higher likelihood of occurrence in the dense stellar environments of globular clusters. Follow-up observations of this new pulsar are under-

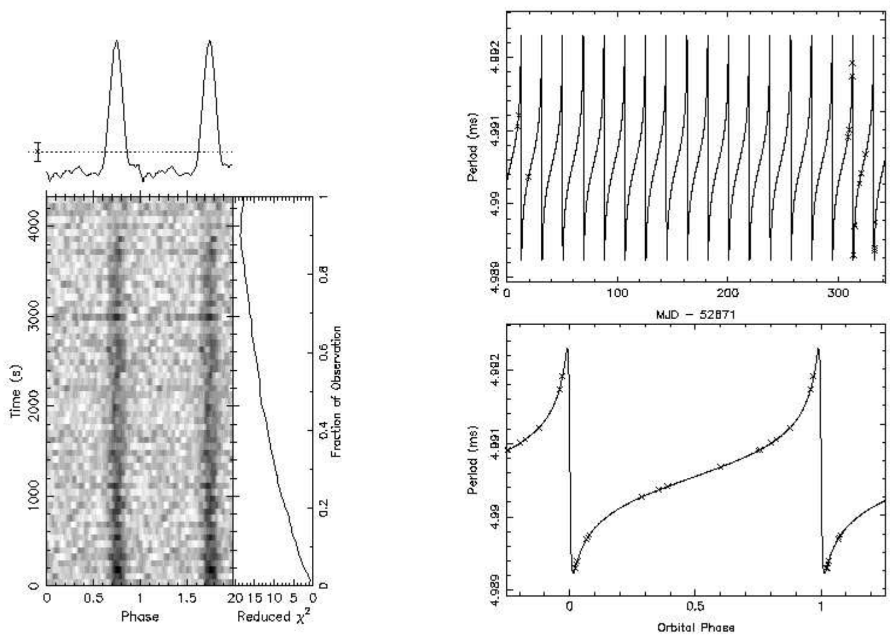

Figure 1. Left: Discovery observation for NGC1851A, in the globular cluster NGC1851. Pulsed emission is persistent throughout the scans. The pulse profile is rather narrow (top), corresponding to the time resolution of the system for this dispersion measure (DM). **Right:** The measured rotational periods of NGC 1851A, as would be observed at the barycentre of the solar system. These are clearly affected by a changing Doppler shift caused by binary motion. In the upper figure, the rotational period is displayed as a function of the Modified Julian Date (MJD), while in the lower one, the rotational period is displayed as a function of the orbital phase. The solid lines indicate the prediction of the best fit model.

way to determine more details of the orbit and the companion. Interesting possibilites of measuring some relativistic effects in the binary orbit will open up if the companion is determined to be a compact object.

2. GMRT observations of CH_3CHO towards Sgr B2

The giant molecular cloud complex Sgr B2, which is located close to the Galactic centre, hosts a variety of large molecules, many of which have not been detected elsewhere in the Galaxy. Most of these molecules are confined to a compact core (size ~ 0.1 pc, called the Large Molecular Heimat (LMH)) in the Sgr B2 cloud (e.g. Miao et al. 1995, Mehringer et al. 1997, Snyder et al. 2002). This is in keeping with models of the formation of complex molecules, according to which dust grain chemistry is important for the formation of these

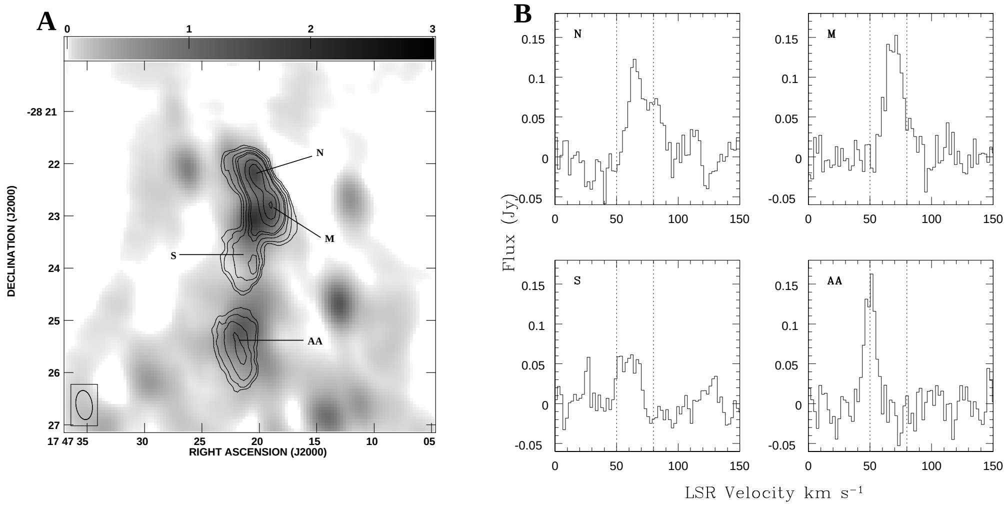

Figure 2. Left: Integrated CH_3CHO emission towards Sgr B2 (contours) overlaid on the 1065 MHz continuum emission (greyscale). The spatial resolution is $34'' \times 19''$. The greyscale ranges from 0 to 3.0 Jy/beam. The contours are at 90, 150, 250, 350, 415, 710, 1000 and 1275 Jy/beam m/s. **Right:** Spectra towards the four regions marked in the left panel.

molecules (e.g. Charnley et al. 1992, Charnley et al. 1995). When these dust grains are heated (typically by radiation from hot stars that form in molecular cloud cores), the grain mantles evaporate, releasing the molecules in gaseous form. Complex organic molecules are hence generally expected to be found only in compact hot molecular cloud cores. If correct, this is a fortuitous circumstance, because present mm-wave telescopes have fairly small fields of view. However, recent mm-wave studies have found indirect evidence that some organic molecules are anomalously widespread in Sgr B2 (Hollis et al. 2001, Martín-Pintado et al. 2001), but because of the limitations of the field of view of mm-wave telescopes, it has not been so far possible to obtain a direct image of their spatial distribution.

The acetaldehyde molecule is peculiar in that it has rotational transitions that give rise to lines in the cm wavelength of the spectrum. In particular it has a spectral line at 1065 MHz, arising the $1_{10} \rightarrow 1_{11}$ K transition (Kleiner et al. 1996). This transition was originally detected towards Sgr B2 by Gottleib (1973), using a single dish telescope. The GMRT is the first interferometric instrument with excellent sensitivity at 1065 MHz. Using the GMRT, Jayaram Chengalur and Nissim Kanekar have obtained high resolution images of the 1065 MHz acetaldehyde emission towards Sgr B2. Their GMRT image of the integrated 1065 MHz acetaldehyde emission from Sgr B2, as well as spectra towards selected regions are shown in Fig. 2. The relatively large field of view of the GMRT (compared to mm-wave interferometers) allows one to establish by direct imaging that, (unlike is the case for other large molecules), acetaldehyde is wide spread in Sgr B2. In particular, they detect emission over a $\sim$ 10 pc region, orders of magnitude larger than the 0.1pc sized LMH in which most other large molecules are confined. The GMRT observations also help establish that (i) the 1065 MHz emission is mased, (ii) that the large scale as well as fine scale distribution of acetaldehyde is probably related to the presence shocks (from cloud-cloud collisions on large scales and from processes related to star formation on small scales) in Sgr B2. Note that since the GMRT has a hybrid configuration, (with antennas distributed in both a central compact cluster as well as Y arms), Chengalur and Kanekar have been able to image the emission with angular resolution ranging from a few arcminutes to a few arc seconds. More details can be found in Chengalur and Kanekar (2003).

3. An extended radio halo in the edge-on galaxy NGC 3079

Our understanding of the interstellar medium (ISM) and disk-halo interface in our own and other galaxies has become increasingly sophisticated in recent years. The ISM itself has "evolved" to a dynamical multi-phase system in which supernovae play an important agitating role. The discovery of discrete "connecting" features throughout the disk-halo interface as well as thick disks and halos in our own and other galaxies has led to various models involving gas circulation between the disk and halo regions. High latitude features or halos have now been observed in every ISM component, though not necessarily all in the same galaxy.

Such features are best detected directly by observing edge-on galaxies with sufficient sensitivity and resolution. NGC 3079 is unusual amongst spiral galaxies in that it displays two well-defined radio lobes extending $\sim 30''$ (2.4 kpc, assuming a distance of 16.5 Mpc) from the nucleus (Duric et al. 1983), which are clearly out of the plane of this edge-on (84°) system. Within the eastern radio lobe is a "bubble" of Hα emission extending to 550 pc and displaying outflowing velocities up to 1000 km s^{-1}, as shown by Hubble Space Telescope (HST) observations (Cecil et al. 2001 and references therein). Recent Chandra spacecraft images have also revealed X-ray emitting gas that is spatially correlated with the emission line gas (Cecil et al. 2002).

NGC 3079 has been studied by Judith Irwin and D.J. Saikia with the GMRT at 326, 615 and 1281 MHz. The 615 MHz data (Fig. 3) reveal the largest radio continuum loop which has yet been associated with this galaxy. This feature is hinted at in the Westerbork Northern Sky Survey (WENSS) image. The loop extends to the east, has a central minimum located at RA = 10 02 07.4, DEC = 55 42 37, has a diameter of $64''$ (5.1 kpc) parallel to the major axis and extends to $2.2'$ (11 kpc) from the major axis. This is much farther than the minimum vertical scale height measured from the 326 MHz data and confirms that a very extensive radio continuum halo exists around NGC 3079. The two western extensions visible in the 326-MHz image are seen prominently at 615 MHz as well. These reach $\sim 2'$ (9.6 kpc) from the plane. These results are described in Irwin and Saikia (2003).

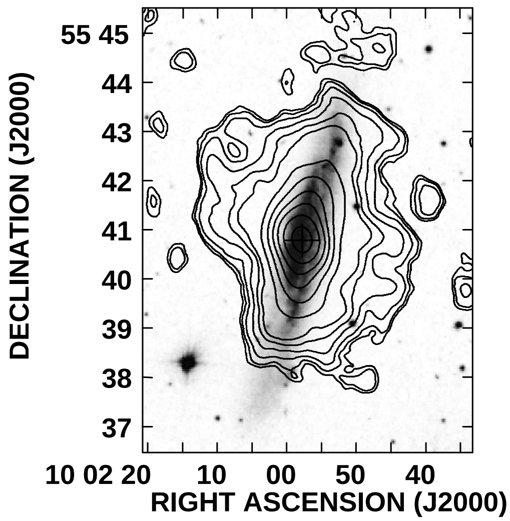

Figure 3. The 615-MHz image of NGC3079 in contours is shown superimposed on the DSS image in grey scale. The peak brightness is 832 mJy beam^{-1} and the resolution is approximately 40×30 arcsec^2 along a position angle of 11°.

4. An echelle spectrograph for the 2.3m Vainu Bappu Telescope

An echelle spectrograph has been recently commissioned for use with the 2.3m VBT at the Vainu Bappu Observatory. This has been reported by N.K. Rao and his group.

The spectrograph is a fiber-fed instrument where the spectrograph is kept on a Millet Griot vibration-free stable platform separated from the observing floor structure. At the prime focus of VBT, the f/3 beam is fed to the input end of the optical fiber of 100 μm diameter. At the prime focus, 100 μm corresponds to 2.7$''$ of the sky; hence the fiber receives most of the starlight under normal seeing conditions. The optical fiber obtained from Polymicro Technologies has cladding of 140 μm and has very high transmission efficiency (better than 85 % in the optical region). The star light is fed to the optical fiber with the help of a light launching system. This system contains an off axis mirror which sends a part of the star light to the guiding CCD, and the guiding of the star on fiber is carried out from the telescope control room. The same assembly contains calibration lamps for wavelength calibration and flat fielding; hence the light from these sources has the same optical path as the star light. The fiber brings light to the spectrograph, which is a Littrow configuration with the same optical element (of focal length 75.5mm) serving as collimator and camera. The star light transported by optical fiber is converted to a f/5 beam of size 151mm with the help of a focal converter. The camera has the corrected field of about 60mm diameter. An echelle grating (with 52.6 grooves/mm) with ruled surface of 408mm × 208mm and blaze angle of 70^o is used that gives nearly uniform intensity over orders 40 to 90 covering the entire optical range. A LF5 prism with apex angle 40 degree is used as predisperser in the first pass and as order separator in the other pass. It has a length of 165mm and the two sides of 188mm length and base length of 128mm. The spectrum is recorded on 2048 × 4096 pixel CCD system with 15 μm pixel size. The CCD used is a back illuminated thinned Marconi chip placed in LN2 cooled dewar. The entire system is placed in a temperature and humidity controlled dust-free coudé laboratory. With a slit of 54 μm, we get a resolution of 72,000 and spectral coverage of 4000 to 10000 Å. A comparison of the line strength measurements made using this spectrometer for Arcturus with those measured on the spectral atlas of the Arcturus shows that the two agree within 2mA. This instrument can be also used in slitless mode to reach fainter magnitude (11mag) at a resolution of 27,000. The operation of the spectrograph is menu driven and the selected wavelength region is brought on the CCD chip with calculated movement of the echelle grating and cross disperser.

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