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National Centre for Radio Astrophysics
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

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Contents

Academic Activities

Instruments and Facilities

Other Activities

Publications, Lectures, etc

Academic

Solar Wind

IPS observations of the solar wind during the period around May 11, 1999 when the earth was engulfed by a region of low density, low velocity solar wind, were analyzed and have yielded interesting results. Unlike the single point measurements given by satellites in space (like ACE), the IPS has probed the entire southern inner heliosphere and shows that solar wind densities and velocities were globally diminished during the period May 3-17, 1999 for which data were available from the Ooty Radio telescope. The IPS data also reveal a small subset of closely spaced sources to the west of the Sun that show a steep drop in the inferred densities to an immeasurably low value around May 11, 1999. This morphology has been shown to be a "void-within-a –void". It has been pointed out that the magnetic field on the Sun which was reversing during this period may have played a major role in generating the subsidence event. Archival of IPS data, after initial processing, is being attempted. The archived IPS data will be available after a specified period to any interested user of the data. *[V. Balasubramanian, P. Janardhan, S. Srinivasan, and S. Ananthakrishnan]*.

The magnetic configuration of a mass ejection site was reported, based on the multi-wavelength investigations of a coronal mass ejection (CME) associated with an eruptive flare event that occurred on 2001 April 2 at about 11 UT. The timings and positions of the radio bursts, the Hα eruption, and the CME onset as well as the magnetic field configuration suggest a release of energy at the null point and as indicated by the Moreton wave, the eruption starts close to the chromospheric or low-coronal level. The results support the 'break-out' scenario suggesting that the energy release is followed by magnetic reconnection between the low-lying loops near the separatrix and the loop system above them. *[P.K. Manoharan and M.R. Kundu (University of Maryland, Department of Astronomy, USA)]*.

Based on earlier results, an empirical model has been developed to predict the arrival of CMEs at 1 AU and the predictions are in good agreement with the actual travel times of CMEs. The present model shows the nature of radial evolution of speed of CMEs and its importance to be considered in the future MHD models of CME propagation. We also find that the gas dynamic piston-shock relationship can be used to extend the CME arrival model to the 1-AU speed and arrival times of interplanetary shocks. *[P.K. Manoharan, N.*

Gopalswamy (GSFC, NASA, USA), S. Yashiro and A. Lara (Catholic University of America, USA), and R.A. Howard (NRL, USA)]

In the outer corona and interplanetary medium, the most common solar radio bursts are type III bursts. We examine their durations, intensities, and other characteristics in the hectometric frequency range and compare them to several groups of control events. We conclude that simple criteria, based on hectometric data alone, can identify the majority (~80%) of type III-L radio bursts, which are associated with >20 MeV SEP proton events, while excluding almost 100% of the control events. *[R.J. MacDowall (GSFC, NASA, USA), A. Lara (Catholic University of America, USA), P.K. Manoharan, N.V. Nitta (Lockheed Martin, USA), A.M. Rosas (Catholic University of America, USA), and J.-L. Bougeret (Paris-Meudon Observatory, France)]*

Nearby Galaxies

Radio continuum observations of the edge-on spiral galaxy NGC 5775 at 617 MHz with the Giant Metrewave Radio Telescope (GMRT) and at 850 μm with the Sub-millimetre Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT) have been presented. These observations have shown the existence of dust at high latitudes, extending to about 5 kpc from the disc of the galaxy, and spurs of non-thermal radio emission. The 617 MHz and 850 μm distributions are compared with one another and a strong correlation has been found between metre wavelength radio emission and sub-millimetre emission in the disc and at high latitudes. This suggests that there may be a more fundamental relationship between cold dust and synchrotron radiation other than the link via star formation *[D.J. Saikia with Rupinder Brar and Judith Irwin, Queen's University, Canada]*.

The superwind galaxy NGC1482, known to have a remarkable hour-glass shaped optical emission line outflow on both sides of the galactic disk, has been studied at radio wavelengths with both the GMRT and the VLA. The outflow extends to about 1.5 kpc above the disk of the galaxy, and has a velocity of nearly 250 km s^{-1}. The lower-resolution GMRT and VLA images at 610 and 1400 MHz show the central region to be well resolved with evidence of more extended diffuse emission and a non-thermal spectral index. The VLA 8-GHz image of the central region shows a number of distinct components which are likely to be a mixture of SNRs and HII regions. An estimate of the supernova rate suggests that the energy generated by the starburst is adequate to drive the outflow *[Ananda Hota and D.J. Saikia]*.

Continued observing and data analysis work on key project on disk galaxies. GMRT data at a couple of frequencies towards two galaxies UGC4961 and UGC11909 were analyzed. A bridge of emission connecting a small group of

galaxies near UGC4961 earlier seen at 1465 MHz was clearly detected at 325 MHz. *[S. Ananthakrishnan, N.G. Kantharia, R. Nityananda]*

Our Galaxy

Galactic Centre observations at 610 MHz: From the GMRT 610 MHz observations, the emission from the central compact object known as the Sgr A* has been detected, which is the lowest frequency detection of this object. There is an HII region Sgr A West seen along the same line of sight as the Sgr A*, which is shown to be optically thick at 620 MHz. The detection of Sgr A* indicates that it is located in front of the Sgr A West. Based on earlier 960 MHz observations, it was expected that the emission from the Sgr A* below about 800 MHz gets absorbed due to the free-free process. However, our detection at 610 MHz clearly shows that this is not so and their estimated flux density at 960 MHz is a factor of 2 lower than what is measured at 610 MHz with the GMRT. This discrepancy cannot be explained by its spectrum. Refractive Interstellar Scintillation over the last 25 years could have caused this discrepency. *[Subhashis Roy, A. Pramesh Rao]*.

Magnetic field near the Galactic Centre: Rotation Measure observations of extragalactic sources: Except the central 200 pc of the Galaxy, the magnetic field in the inner 5 kpc region of our Galaxy has not been measured in the past. Therefore, observations were carried out to estimate the RM towards 45 polarised sources using the 4.8 and the 8.5 GHz band of the ATCA and the VLA. These observations have shown that the estimated RM is quite large (~500 rad/m^2) and there is a large scale magnetic field in the central region of the Galaxy. This large scale magnetic field points towards us at both positive and negative longitudes, thereby indicating that it is not generated by any current loop created due to the rotation of the Galaxy around its axis of rotation (dynamo model). The present observations support a model in which this large scale positive magnetic field is a result of the concentration of the primordial magnetic field at the galactic centre. Concentration of the primordial magnetic field is believed to generate the bi-symmetric spiral configuration of the magnetic field seen in some galaxies. The estimated volume filling factor of the plasma responsible for the RM is about 10^{-5}, which indicates that the plasma is arranged in the form of dense clumps, whose sizes are ~35 pc and electron desnsity ~20/cm^3. These ionised clouds are likely to be the ionised outer envelope of the molecular clouds in the region. The estimated physical parameters of the clouds matches quite well with what was postulated earlier to explain the detection of the Galactic ridge Radio Recombination line in the inner Galaxy. The Faraday screen sampled by these observations has an outer scale 30', which is much larger than the scale size of 10" observed near

the Non-thermal filaments in the Galactic Centre. *[Subhashis Roy, A. Pramesh Rao & Ravi Subrahamanyan (ATCA)]*.

GMRT radio recombination line observations of the HII region G24 at 1280 and 610 MHz and VLA observations at 1420 MHz were made. Our analysis shows that the dominant hydrogen recombination line emission at 1280 MHz originates in the diffuse gas, while at 1420 MHz, the dominant emission is from the compact dense region. The lines appear at slightly different velocities. *[N. G. Kantharia with W. M. Goss, Anish Roshi, Niruj Mohan, F. Viallefond]*

The UTR-2 telescope in Ukraine, operating near 26 MHz was used to obtain data towards the supernova remnant CasA. Data spanning several days were analyzed to obtain this spectrum, which is rich in alpha, beta and gamma lines. The gamma lines originate at levels near n = 930, which are the highest quantum levels ever observed from the interstellar medium. We have also observed other positions in the galactic plane using the UTR-2 telescope and the Gauribidanur array operating at 34 MHz. This data is being analyzed. *[N.G. Kantharia, Sergei Stepkin, A. A. Konovalenko, Udaya Shankar, Avinash Deshpande]*

Radio continuum images of three Galactic HII regions, S201, S206, and S209 near 232, 327, and 610 MHz were obtained using GMRT. Since the GMRT has a mix of short and long baselines, therefore, even though the data have high spatial resolution, the maps are still sensitive to diffuse extended emission. We found that all three HII regions have bright cores surrounded by diffuse envelopes. We used the high resolution afforded by the data to estimate the electron temperatures and emission measures of the compact cores of these HII regions. Our estimates of electron temperatures are consistent with a linear increase of electron temperature with Galacto-centric distance for distances up to 18 kpc (the distance to the most distant HII region in our sample). *[A. Omar, J. N. Chengalur, A. Roshi]*

Active Galactic Nuclei

The compact steep spectrum (CSS) and gigahertz peaked spectrum (GPS) sources are widely believed to be young radio sources, with ages $\leq 10^6$ yr. If the activity in the nucleus is fuelled by the supply of gas, one might find evidence of this gas by studying the structural and polarization characteristics of CSS sources as these evolve through this gas. Polarization observations of a sample of CSS sources have been presented and these have been combined with information available in the literature, to show that CSS sources are more asymmetric in the polarization of the outer lobes compared with the more extended ones. This could be possibly due to interaction of the jets with infalling material, which fuels the radio source. A possible dependence of the

polarization asymmetry of the lobes on redshift has also been investigated, since this might be affected by more interactions and mergers in the past. No such dependence is found for the CSS sources, suggesting that the environments on the CSS scales are similar at different redshifts. However, the polarization asymmetry of the oppositely-directed lobes is larger at higher redshifts for the more extended sources, possibly reflecting the higher incidence of interactions in the past *[D.J. Saikia and Neeraj Gupta]*.

The role of radio polarimetric observations in understanding the nature and evolution of CSS and GPS sources has been explored and reviewed. The principal conclusions include: (i) the GPS objects do not appear to be a single homogeneous class of objects; (ii) Faraday depth effects are very strong in the inner 3 kpc of GPS and CSS objects; (iii) there is evidence of increased ionization near bends in some CSS objects probably due to jet-ISM interaction *[(D.J. Saikia with W.D. Cotton (NRAO, USA), D. Dallacasa, C. Fanti and R. Fanti (Istituto di Radioastronomia, Italy), A.R. Foley (NFRA, The Netherlands), R.T. Schilizzi (JIVE, The Netherlands), R.E. Spencer and S. Garrington (Jodrell Bank Observatory, England)]*.

MERLIN, global VLBI and VLBA observations of the high-luminosity, CSS quasar B1524-136 at cm wavelengths have been presented. These observations reveal well-defined radio jets on both sides of the active nucleus, a situation which is almost unique amongst high-luminosity radio quasars. However, the radio jets on opposite sides are very dissimilar, and the overall radio structure appears highly distorted. Possible models and implications of these observations have been discussed *[D.J. Saikia with F. Mantovani and M. Bondi (Istituto di Radioastronomia, Italy), W. Junor (University of New Mexico, USA), R. Ricci (SISSA, Italy) and C.J. Salter (Arecibo Observatory, Puerto Rico)]*.

Radio observations of the CSS QSOs 3C43 and 3C454 have been made with the VLA, MERLIN and VLBA at 2, 6 and 18 cm to examine the Faraday rotation in these highly bent sources. 3C43 is weakly polarized at 18cm at mas resolution and has a large rotation measure near the bend in the jet. This result is interpreted as indicating jet-ISM interaction. 3C454 is relatively strongly polarised and has high rotation measure along the jet visible in the high-resolution 18cm images. There is no brightening of the jet near the bend to the west indicating that it is not caused by a jet-cloud collision, and may simply be a hydrodynamic instability magnified by a small angle to the line of sight. However, there are clear differences in the sign and magnitude of the Faraday rotation measured at long and short wavelengths. This is interpreted as being due to thermal plasma mixed with the jet. Likely detection of circular polarization at 18cm supports this interpretation *[D.J. Saikia with W.D. Cotton*

(NRAO, USA), R.E. Spencer and S. Garrington (Jodrell Bank Observatory, England)].

Multifrequency radio observations of the radio galaxy 3C459 using MERLIN, VLA and the EVN, and an optical HST image using the F702W filter have been presented. The galaxy has a very asymmetric radio structure, a high infrared luminosity and a young stellar population. The eastern component of the double-lobed structure is brighter, much closer to the nucleus and is significantly less polarized than the western one. This is consistent with the jet on the eastern side interacting with dense gas, which could be due to a merged companion or dense cloud of gas. The HST image of the galaxy presented here exhibits filamentary structures, and is compared with the MERLIN 5-GHz radio map. EVN observations of the prominent central component, which has a steep radio spectrum, show a strongly curved structure suggesting a bent or helical radio jet. The radio structure of 3C459 is compared with other highly asymmetric, Fanaroff-Riley II radio sources, which are also good candidates for studying jet-cloud interactions. Such sources are usually of small linear size and it is possible that the jets are interacting with clouds of infalling gas which are fuelling the radio source *[D.J. Saikia with P. Thomasson and T.W.B. Muxlow (Jodrell Bank Observatory, England)]*.

A number of giant radio sources, defined to be those with an overall projected size ≥1 Mpc, whose structures were unclear from existing observations have been imaged using the VLA and the GMRT. It has been shown that the primary energy loss mechanism for these giant sources is inverse-Compton scattering with the cosmic microwave background radiation, rather than synchrotron radiation losses, consistent with earlier studies. Their spectral ages have been estimated and a number of new radio cores have been identified *[Chiranjib Konar, D.J. Saikia, C.H. Ishwara-Chandra and V.K. Kulkarni]*.

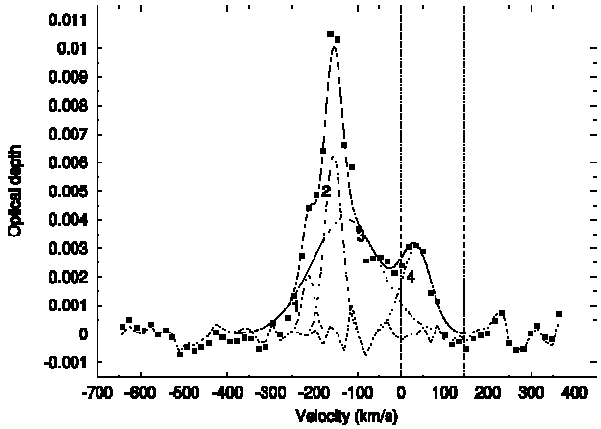
This year saw the successful completion of the first phase of the long-term project to make a systematic search for intra-night optical (R-band) flux variability in a matched sample of 26 powerful ($M_B < -24$), hence genuine quasars confined to seven narrow redshift bins between z ~ 0.2 to 2. Each of these 7 sets contains the major quasar types, namely, Radio-quiet quasars (RQQs), radio lobe-dominated quasars (LDQs), radio core-dominated quasars (CDQs) and/or BL Lac object. Using the 1m Sampurnanand optical telescope of the State Observatory, Naini Tal, each of the quasars was monitored continuously on at least 3 nights for a typical duration of ~ 6 hours per night and typical sampling rate of 5 data points per night, using the 2048x2048 Wright CCD as an N-star photometer. The entire program spanned a total of 113 nights during 1998-2002, as part of the PhD thesis project of C.S. Stalin of the State Observatory, Naini Tal. *[Gopal Krishna, C.S. Stalin and Ram Sagar]*

The extra-ordinarily dense temporal sampling and high sensitivity attained in this program have led to a number of new results of direct relevance to the theories of the 'Central engine' of AGN. Firstly, it could be convincingly demonstrated for the first time that, like blazars, radio-quiet quasars (RQQs) also exhibit intra-night optical variation on hour-like time scale, albeit the variations are several times less pronounced both in amplitude (upto 3%) and duty cycle (~15%). The clear detection of rapid optical variability of RQQs provides a strong clue that the central engines of RQQs are also capable of ejecting powerful relativistic jets of synchrotron plasma, but these jets are probably 'snuffed out' due to severe inverse-Compton losses while traversing out to parsec scale where they can become transparent to their radio emission. Thus, the oft-postulated `fundamental difference' between the central engines of radio-loud and radio-quiet quasars in NOT supported. It is further shown that the intranight variability of RQQs is much less pronounced simply because of the expected modest misalignment of their jets from the line-of-sight. It is also established for the first time that similarly mild intra-night variability and small duty cycle characterize the radio-loud quasars (excepting blazars) and therefore radio-loudness is far from being a sufficient condition for rapid optical variability, even for radio core-dominated quasars. Instead, optical polarization is shown to be the main factor. These findings are being reported in a series of publications *[Gopal-Krishna, C.S. Stalin, Ram Sagar (State Observatory, Naini Tal) and Paul J. Wiita (GSU, Atlanta)]*.

The analyses of two BALs seen in the spectrum of the QSO SDSS J160501.21-0112200 have been presented. The UVES spectrum shows two well detached BALs at z(abs)=4.685 and 4.855. The system at z(abs)= 4.855 covers the background source completely suggesting that the gas is located outside the BLR. On the contrary the system at z(abs)= 4.685 has a covering factor of ~0.9. The observed H I absorption line together with the limits on C II and Si II absorptions suggest that $16<\log N(\mathrm{H\ I})\ (\mathrm{cm}^{-2})<\sim 17$ in z(abs) = 4.855 absorption system. Comparison with models show that the observed column densities of N V, Si IV and C IV in this system require that N is under abundant by more than a factor 3 compared to Si if the ionizing radiation is similar to a typical QSO spectrum. This is contrary to what is usually derived for the emission line gas in QSOs. We show that the relative suppression in the N V column density can be explained for Solar abundance ratios or abundance ratios typical of Starburst abundances if an ionizing spectrum devoid of X-rays is used instead. Thus, if the composition of BAL is like that of BLR then it is most likely that the cloud sees a spectrum devoid of X-rays similar to what we observe from this QSO. This is consistent with the fact that none of our models have high Compton optical depth to remove X-rays from the QSO. Similar arguments lead to the conclusion that the system at z(abs)= 4.685 as well is not Compton thick. The estimated black hole mass is $8\ 10^8$ solar mass suggesting the accretion onto the seed black hole must have started as early as z = 11

[Neeraj Gupta with R. Srianand (IUCAA), P. Petitjean (IAP, France) and C. Ledoux (ESO, Germany)].

HI 21 cm-line absorption in red quasars: The study of redshifted HI 21 cm-line absorption at high-redshifts would provide interesting and important information regarding the distribution and kinematics of neutral hydrogen. We have started a program to search for HI 21 cm-line absorption in a sample of high-redshift (z > 1) radio loud 'red' quasars and galaxies with the Giant Metrewave Radio Telescope.

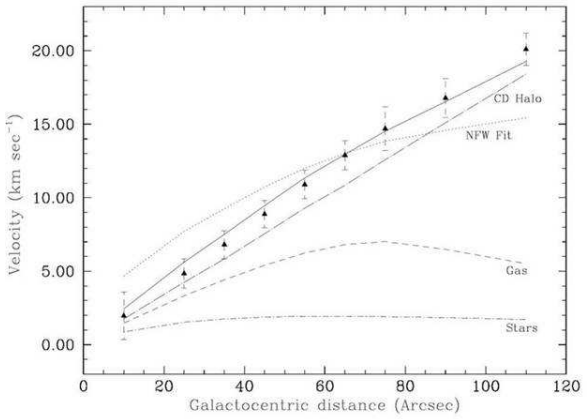


We have detected HI 21 cm-line absorption in one of the red quasar 3C 190 at a redshift of 1.1946 (see figure). The absorption is broad and complex and most of the absorption is blue-shifted with respect to the systemic velocity. The core of 3C 190 is self-absorbed at this frequency, therefore the absorption is towards the hotspots. Comparison of the radio and deep optical images reveal linear filaments in optical, overlapping with the south-west radio jet. We propose that the blue-shifted HI absorption is due to the gas shocked by the advance of the south-west jet. We have also searched for HI 21 cm-line absorption in a larger sample of red quasars and galaxies to establish whether the probability of detection of HI 21 cm-line absorption is larger compared to normal objects. *[C.H. Ishwara-Chandra and K. S. Dwarakanath]*.

Cosmology

Deep GMRT 21cm absorption spectra of 10 damped Lyman-alpha systems (DLAs), of which 8 are at redshifts $z > 1.3$ were obtained. HI absorption was detected in only one DLA, the $z = 0.5318$ absorber toward PKS1629+12. This absorber has been identified with a luminous spiral galaxy; the spin temperature limit ($T_s < 310$K) derived from our observations continued the trend of DLAs associated with bright spirals having low spin temperatures. In seven of the remaining 9 systems, the observations placed strong lower limits on the spin temperature of the HI gas. We combined this sample with data taken from the literature to study the properties of all known DLAs with 21cm absorption studies. The sample of DLAs which have been searched for 21cm absorption now consists of 31 systems, with T_s estimates available in 24 cases; of these, 16 are at $z < 2$ and 8 at $z > 2$, with 11 (all at $z < 1$) having optical identifications. For the latter 11 DLAs, we found that all of the low T_s DLAs have been identified with large, luminous galaxies, while all the DLAs with

high spin temperature (T_s > 1000K) have been identified either with LSBs or dwarfs. Further, we found no correlation between impact parameter and spin temperature; it is thus unlikely that the high measured T_s values for DLAs arise from lines of sight passing through the outskirts of large disk galaxies. Instead, the spin temperature of DLAs appears to correlate with the host galaxy type. The trend (noted earlier by Chengalur & Kanekar 2000) that low z DLAs exhibit both high and low T_s values while high redshift (z > 3) DLAs only show high spin temperatures is present in this expanded data set. Based on this difference in spin temperatures, the Gehan test rules out the hypothesis that DLAs at z > 2 and DLAs at z < 2 are drawn from the same parent population at 99% confidence level. Finally, we used the new GMRT spectra along with 2 spectra from the literature to estimate upper limits on the fraction of cold HI, f_{CNM}, in DLAs at $z \gtrsim 3$. For local spirals, $f_{CNM} \sim 0.5$; in contrast, we find that $f_{CNM} < 0.3$ in all 7 high z absorbers, and $f_{CNM} < 0.1$ in 5 of the 7 cases. *[N. Kanekar & J. N. Chengalur]*.



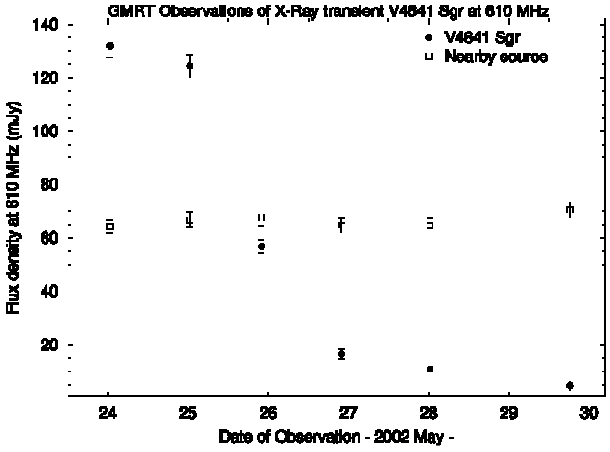
Mass models for Camelopardalis B obtained using GMRT observations. Camelopardalis B is the faintest galaxy for which such a model has been applied. The points are the observationally derived rotation curve. The total mass of gaseous disk (dashed line) is 6.6x10^6 Msun.The stellar disk (short dash dot line) has a stellar mass of 0.7x10^6 Msun. The best fit total rotation curve for the constant density halo model is shown as a solid line, while the contribution of the halo itself is shown as a long dash dot line (the halo density is 13.7x10^-3 Msun/pc^-3). The best fit total rotation curve for an NFW type halo (for c=1.0) and is shown as a dotted line. Our data clearly favour a constant density halo over the theoretically predicted NFW type halo.

We obtained deep, high velocity resolution (~ 1.6 km/sec) Giant Meterwave Radio Telescope HI 21cm synthesis images, as well as optical broad band images, for the faint ($M_B \simeq 10.9$) dwarf irregular galaxy Camelopardalis B. We found that the HI in the galaxy has a regular velocity field, consistent with rotational motion. Further, the implied kinematical major axis is well aligned with the major axis of both the HI flux distribution as well as that of the optical emission. Camelopardalis B is the faintest known galaxy with such relatively well behaved kinematics. From the HI velocity field we derive a rotation curve for the galaxy. The rotation curve can be measured out to galacto-centric distances > 4 times the optical scale length. The peak (inclination corrected) rotation velocity v_o was only ~ 7 km/sec — the high velocity resolution of our observations was hence critical to measuring the rotation curve. Further, the peak rotational velocity was comparable to the random velocity v_r of the gas,

i.e. $v_o/v_r \sim 1$. This made it crucial to correct the observed rotation velocities for random motions before trying to use the kinematics to construct mass models for the galaxy. After applying this correction we found a corrected peak rotation velocity of ~ 20 km/sec. On fitting mass models to the corrected rotation curve we found a good fit for a constant density halo with a density of $r_0 \sim 12\ M_{/}/pc^3$. This density is well determined, i.e. it has a very weak dependence on the assumed mass to light ratio of the stellar disk. We also found that the corrected rotation curve cannot be fit with an NFW halo regardless of the assumed mass to light ratio. Finally we compiled from the literature a sample of galaxies (ranging from normal spirals to faint dwarfs) with rotation curves obtained from HI synthesis observations. The complete sample covers a luminosity range of ~ 12 magnitudes. From this sample we found *(i)* that Camelopardalis B lies on the Tully-Fisher relation defined by these galaxies, provided we use the corrected rotation velocity, and *(ii)* a weak trend for increasing halo central density with decreasing galaxy size. Such a trend is expected in hierarchical models of halo formation. *[A. Begum, J. N. Chengalur, U. Hopp]*

Compact Objects

X-ray binaries are the brightest X-ray sources in the sky, and exhibit a wide variety of phenomena like rapid variability and outbursts. A small fraction of the X-ray binaries also show strong radio emission. The basic phenomena of radio emission from X-ray binaries is similar to that of quasars, both in morphology and physics, hence these are known as microquasars. We have observed several microquasars with GMRT. The black-hole candidate microquasar V4641 Sgr was observed with GMRT in June 2002 at two frequencies, (610 MHz and 244 MHz) simultaneously. The source rapidly decayed in a few days. *[C. H. Ishwara-Chandra and A. Pramesh Rao]*



We have observed another Galactic microquasar GRS 1915+105 with GMRT at 1.28 GHz for several days. We have seen several isolated radio flares of varying magnitudes (20 – 50 mJy) and durations (6 – 35 min) these were modelled as due to adiabatically expanding synchrotron emitting clouds (synchrotron bubbles) ejected from the accretion disk. By

applying this model, we have provided a new method to estimate the electron power-law index *p*, hence the spectral index, from single frequency radio observations. This method does not require correction for the optical depth time delay effects which may be important in the case of optically thick radio emission. Using our estimated value of *p* and simultaneous multiwavelength data from literature, we have calculated the time of ejection of the synchrotron plasma and the time delays at different observed frequencies. Our estimates were in good agreement with the observed time delays. *[C. H. Ishwara-Chandra, J. S. Yadav, and A. Pramesh Rao]*

Radio detection of a gamma–ray burst: Gamma Ray Bursts are intense bursts of Gamma rays coming from the sky for a short duration of a few seconds. It is very important to follow up the observations of GRBs at various bands of electromagnetic spectrum. We have observed one such GRB, GRB030329, shortly after the burst. The GRB was detected with GMRT with a flux density of 0.25 mJy at 1280 MHz. *[A. Pramesh Rao, C.H. Ishwara-Chandra, and D. Bhattacharya]*

It was shown that the radio integrated profile (IP) of the millisecond (ms) pulsar PSR J0437–4715 varies slowly, over time scales of several hundred periods and longer. It was also shown that the variation in the third component of its IP is correlated with the rate of occurrence of the most intense spikes in that component. However, The Ooty Radio Telescope (ORT), which obtained this data at 327 MHz, has only a single linear polarization. Both papers argued that these profile variations are intrinsic to PSR 0437–4715, and not caused by Faraday rotation in the variable ionosphere. An entirely independent ORT data are used to lend further support to this argument. *[M. Vivekanand]*.

Pravdo et al claimed that the phase resolved x-ray spectrum in Crab pulsar (PSR BV0531+21) shows a spectral hardening at the lending edge of the first peak of its integrated profile (IP); this was a new and unpected result. Their data was reanalyzed as well as some other related data, and it was argued that the spectrum is as likely to be unvarying i.e., neither hardening nor softening. *[M. Vivekanand]*

Deshpande & Ranking claim that the frequency of the very narrow feature, in the spectrum of radio flux variations of PSR B0943+10, is an alias of its actual value. For this they need to interpret the narrow feature as a very stable pattern of drifting sub pulses on the polar cap of this pulsar, within the framework of the Ruderman & Sutherland model. Several factors within the same framework were discussed that may perturb a very steady pattern of drifting sub pulses, leading to a broadening of spectral feature. It was found that one should be cautious in (1) identifying such very narrow spectral features with a very stable pattern of drifting sub pulses, and (2) use this picture to resolve the issue of

aliasing in PSR B0943+10. They also claim to have detected an amplitude modulation on the above phase modulation. It was argued that both these claims are unjustified. *[M. Vivekanand]*

Emission Geometry of Radio Pulsars: Though a lot is known about the properties of the observed radio radiation from pulsars, there are still unanswered questions about the exact location and geometry of the regions in the pulsar magnetosphere that produce this radiation. I have been working on the problem of understanding the emission geometry from a detailed study of the number and location of emission components in the pulsar signal. A new technique for identifying emission components using single pulse data had been developed in our earlier work (Gangadhara and Gupta, 2001, *ApJ*, **555**) and a novel interpretation of the locations of the conal emission components had allowed us to develop a technique for estimating the height and magnetic field line location of the emission cones in the pulsar magnetosphere. We have applied these techniques of analysis and interpretation to several more pulsars for which high quality single pulse data was taken using the GMRT in the 325 MHz band. The results from this work (Gupta and Gangadhara, 2003, ApJ, 584) support our initial conclusions, in that we find clear evidence for the following *(i)* pulsars with multi-component profiles have multiple (two to three) concentric, hollow cones of emission *(ii)* the typical emission heights for these cones in the pulsar magnetosphere range from ~ 100 to ~ 1000 km *(iii)* emission height for a given cone is a function of the radio frequency, being lower for the higher frequencies *(iv)* the magnetic field lines associated with these emitting cones are not located at the edge of the open field line region, but lie in the range ~ 0.2 to 0.7 of this boundary *(v)* there is some evidence that the wider cones originate on further out field lines. The fairly precise localisation of the emission regions allowed by our work should provide valuable clues to better understanding the as yet unsolved problem of pulsar emission physics. *[Y. Gupta with R.T. Gangadhara (Indian Institute of Astrophysics, Bangalore)]*.

Understanding the remarkable pulsar B0826-34: Pulsars that exhibit drifting sub-pulses in their single pulse data provide valuable insight into the emission mechanism of radio pulsars. In this context, PSR B0826-34 is remarkable, as it has a very wide pulse with emission seen over most of the pulsar period, implying an almost aligned rotator geometry, i.e. rotation and magnetic axes almost parallel. Furthermore, the single pulses show a remarkable and complex pattern of drifting sub-pulses, including significant variations in the drift rate and even reversals of the sign of the drift, which are apparently in disagreement with popular models like the Ruderman and Sutherland model that attempt to explain the basic phenomenon of drifting sub-pulses. We have started a detailed study of this pulsar, using high quality single pulse data taken with the GMRT. Our initial analysis of the drift behaviour at 318 MHz has revealed evidence for the presence of as many as 7 sets of

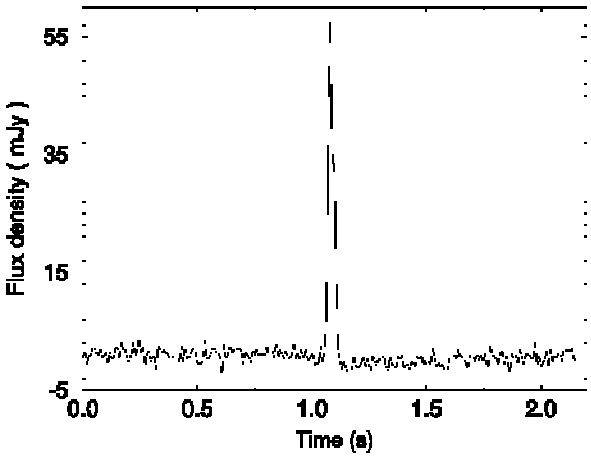
drifting pulses within the pulse window, with significant variations of the drift rate, including apparent reversals, that are correlated across all the sets. We think that the observed drift rate is not the real one, but is an aliased version, produced because of our inadequate sampling (of once per pulsar rotation period) of the underlying sub-pulse drift pheonmena. The drift rate variations, including the reversals, can then be explained as small (~ few percent) changes of the true drift rate on the polar cap, which we think could be caused by minute fluctuations of the neutron star's surface temperature. We have been able to solve for the geometrical parameters for this pulsar and are able to model the distribution of the emission regions as 14 or 15 sparks circulating in a ring around the magnetic axis, at 0.44 of the radius of the polar cap. We believe that several aspects of pulsar emission physics can be studied with the kind of detailed study of this pulsar that we have initiated. *[Y. Gupta with J. Gil, Dr. M. Sendyk, J. Kijak (University of Zielona Gora, Poland)]*.

Study of pulsar dispersion measure (DM): Simultaneous multi-frequency observations of pulsars can be used as a tool to obtain accurate estimates of their dispersion measures. The GMRT is ideally suited for such multi-frequency observations. I had initiated a program for such observations of a selected set of pulsars. A large fraction of this data has been analysed and forms part of the M.Sc. thesis of Mr. Amrit Ahuja. Our preliminary results (*Ahuja et al*, 2002, *BASI*, **30**) show that we can estimate pulsar DMs with an accuracy of 1 part in 10000 or better. This will allow us to monitor minute changes in the DMs with time that are produced by random fluctuations of plasma density in the inter-stellar medium of our Galaxy, and hence probe the nature and physics of these fluctuations. For some pulsars, we found that our inferred DM shows small but significant difference with respect to the known, catalogue value of the DM -- these are being investigated in detail. Also, in a few pulsars, we found that the value of DM obtained from measuring the delay between two different pairs of frequencies is slightly different. This could have implications for the locations of the emission regions (for different frequencies) in the pulsar magnetosphere, and is being investigated in detail. *[Y. Gupta with A.L. Ahuja, A.K. Kembhavi (IUCAA, Pune)]*.

Multi-frequency studies of pulsars: Simultaneous multi-frequency observations (MFOs) of pulsars also provide powerful means to study different aspects of the radio emission process. We had carried out a coordinated experiment with the GMRT, Jodrell Bank and Effelsberg radio telescopes simultaneously observing the same pulsars at different frequencies. Significant progress was made in the analysis and interpretation of this data. New results related to *(i)* the polarization behaviour of single pulses *(ii)* pulse energy and spectal studies *(iii)* frequency dependence of pulsar nulling *(iv)* frequency dependence of pulsar emission regions have emerged from these studies and

these are in the process of being published, and some more apects are under investigation. *[Y. Gupta with several colleagues from UK, Germany and USA.]*

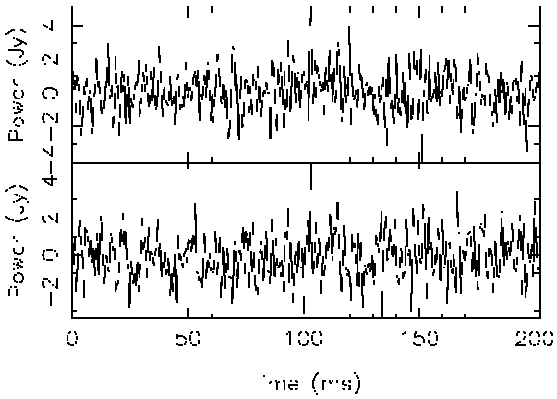
Parkes high Galactic latitude multibeam search: The observed spatial distribution of Milli-second pulsars (MSPs) is nearly isotropic and many such pulsars have been observed at high Galactic latitudes. A new survey with Parkes radio tele-scope using the 20 cm multibeam receiver was started in November 2000 to search such pulsars. The survey covered a region around the southern Galactic plane between longitudes 220^o and 260^o and latitudes |b|< 60^o. The observations for the survey were comple-ted in December 2002 and 36 pulsars, which include 14 new pulsars, have been discovered in the data analyzed so far. Four of the new pulsars are MSPs, which is consistent with the expected number. Three of these are binary pulsars. *[B. C. Joshi with M. Burgay, A.G. Lyne, R.N. Manchester, A. Possenti, F. Camilo, N. D'Amico, M. Kramer and M. McLaughlin]*



The figure shows integrated profiles for the first pulsar, PSR J0818–3233, in Parkes high Galactic latitude survey.

Rotational instabilities in pulsars: Few pulsars occasionally exhibit a sudden increase in the rotation rate called pulsar glitch. These are useful probes to study the internal structure of the neutron stars. About 76 glitches in 25 pulsars have been reported to date. A massive glitch in PSR J1806–2125 was detected in the data on a large sample of pulsars, being timed at Jodrell Bank for several years. The magnitude of this glitch was ~2.5 times greater than any previously observed glitch and 16 times greater than the mean glitch size. In addition, a further 14 glitches were detected in 9 pulsars, 6 of which have glitched for the first time. This includes the third largest glitch in PSR B1930+22 and four recent glitches in PSR B1737–30, which continues to exhibit frequent glitches. A database of more than 100 glitches is currently being compiled for statistical studies. *[B.C. Joshi with A.G. Lyne, G. Hobbs, A. Krawczyk, J. Gil, and C. Jordan]*

Search for Giant pulses in millisecond pulsars: Giant pulses, which are occasional individual pulses with intensity typically 100 times the average intensity, have been seen in three pulsars to date and their origin is not well understood. Eight millisecond pulsars (MSPs) were observed using GMRT to search for Giant pulse emission. Giant pulses at very high signal to noise ratio were detected in PSR B0531+21 and their distribution at 610 MHz was obtained. Large amplitude pulses were also detected for the first time in PSR J0218+4232 and B1957+20. Both these pulsars have a high strength of magnetic field at light cylinder. These data, together with the previously reported Giant pulses in PSR B0531+21, PSR B1937+21 and PSR J1821-64, suggest a connection between the strength of magnetic field at light cylinder and the existence of giant pulses in MSPs. *[B.C. Joshi with M. Kramer, A.G. Lyne]*



A large amplitude pulsar (LAP) in PSR J0218+4232. The upper plot shows the dedispersed single puse data in 610.0 – 618.0 MHz subband and the lower plot for those in 618.0 – 626.0 MHz. The LAP, observed in both bands, has an intensity approximately 50 times the mean intensitv.

Development of Coherent Baseband Receiver for Astronomy: A new digital receiver for pulsar observations called Coherent On-line baseband receiver for astronomy (COBRA) was commissioned at Jodrell Bank Observatory. It consists of 16 bandpass samplers and a Beowulf cluster of 91 dual-processor nodes based on 1.13 GHz Pentium III processors connected by Scalable Coherent Interface (SCI). It is capable of processing 80 MHz bandwidth on-line. The pulsar signal is processed digitally in software to remove the effect of dispersion in the interstellar medium using the technique of coherent dedispersion. The resulting high time resolution profiles are useful in a variety of applications for pulsar research. *[B.C. Joshi with A. G. Lyne, M. Kramer, A. J. Holloway, T. Ikin]*

Instrumentation and Facilities

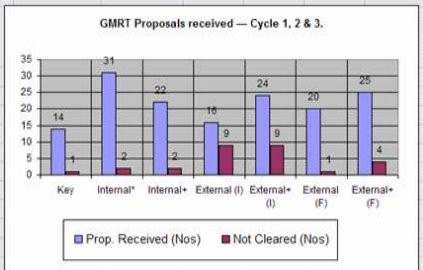
Giant Metrewave Radio Telescope

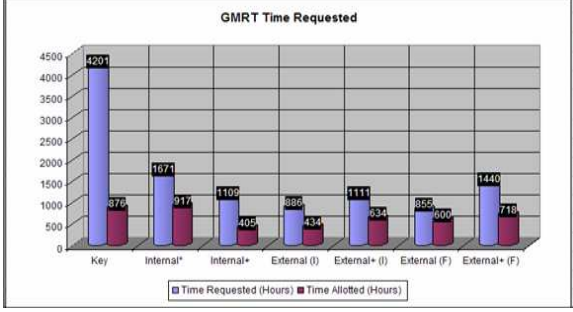
From the beginning of 2002, the GMRT has run as a full fledged international observational facility for radio astronomy below 1.4 GHz, in three cycles. Each cycle, approximately six months, consisted of ~40 proposals refereed and allotted time by an independent GMRT Time Allocation Committee (GTAC). To allow for such extensive routine operation, teams of engineering staff were on rota duty at the GCC (GMRT Control Centre) and were able to maintain availability of 27 or more antennas for most of the time, through preventive maintenance, build up of spares, close monitoring and rapid replacement. Approximately, thirty six hours are used for a weekly maintenance shutdown, and in addition two one-month shutdowns were needed for work on the correlator and other systems. The statistics from the three cycles are shown below.

GTAC Statistics

Categories	Prop. Received	Time Requested	Time Allotted	Not Cleared
	(Nos)	(Hours)	(Hours)	(Nos)
Key	14	4201	876	1
Internal*	31	1671	917	2
Internal+	22	1109	405	2
External (I)	16	886	434	9
External+ (I)	24	1111	634	9
External (F)	20	855	600	1
External+ (F)	25	1440	718	4
Total	152	11273	4584	28

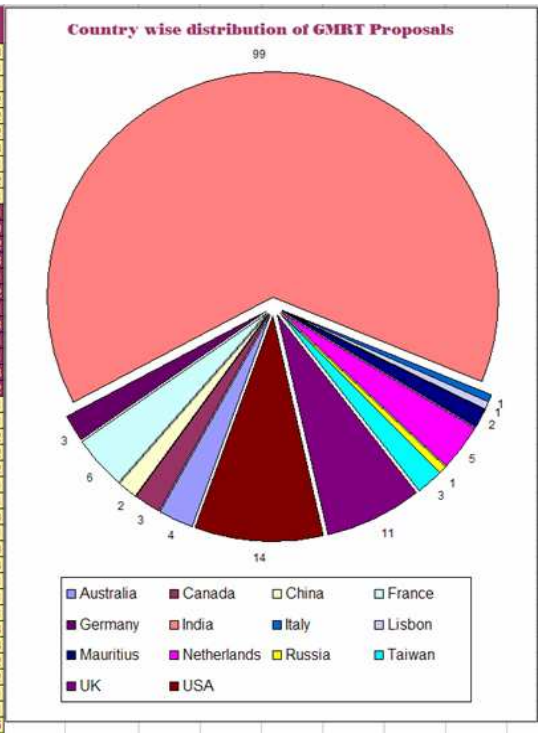
* Including One ToO proposal





Categories	
Key:	Key proposals
Internal:	PI and Co-PIs from TIFR
Internal+:	PI from TIFR, Co-PI non-TIFR
External (I):	PI & Co-PIs not from TIFR, but from other Indian Institutions
External+ (I):	PI non-TIFR, with atleast one Co-PI from TIFR
External (F):	PI & Co-PIs from abroad
External+ (F):	PI from abroad, with atleast one Co-PI from TIFR

Institute-wise distribution of Principal Investigators of GMRT Proposals		
Univ. Melbourne	Australia	3
Univ. New South Wales	Australia	1
McGill Univ.	Canada	1
Queen's University	Canada	2
NAOC	China	2
CEN, Saclay	France	2
IAP	France	3
Sap, CEA-Saclay	France	1
Inst. Physikalisches	Germany	2
Max-Planck Institute	Germany	1
HCRI, Allahabad	India	1
Indian Institute of Astrophysics	India	9
ISRO	India	2
IUCAA	India	8
Nehru Planetarium	India	1
PRL	India	2
Radio Astronomy Centre	India	1
RRI	India	8
SNBNCBS	India	1
Space Phy. Laboratory, Trivandrum	India	1
NCRA-TIFR, Pune	India	53
TIFR, Mumbai	India	12
IRA-CNR	Italy	1
Centre for Astron. Astrophy	Lisbon	1
Mauritius Radio Telescope	Mauritius	2
ASTRON	Netherlands	2
NFRA	Netherlands	2
Univ. Amsterdam	Netherlands	1
ASP	Russia	1
ASIAA, Taiwan	Taiwan	3
ARI, Liverpool John Moores Univ.	UK	1
Cardiff Univ.	UK	3
Jodrell Bank Observatory	UK	4
MRAO, Cambridge	UK	1
Oxford Univ	UK	1
Univ. Durham	UK	1
NAIC	USA	4
NRAO	USA	4
NRL	USA	2
Univ. Maryland	USA	2
Univ. of Zielona Gora	USA	1
Univ. Vermont	USA	1
Total		155



A 16 MHz correlator systems with an improved design ("second sideband") was added to the existing 16 MHz system which has been working since 1999. Control and acquisition software was written and the new system tested in a stand-alone mode. Integration of the two sidebands is in progress. *[S.K.Sirothia and the correlator group]*.

Apart from steady bug correction and upgrades of the data acquisition software., the following jobs have also been carried out: *(a)* a distributed control system for the new LSB correlator, *(b)* installation and configuration of new data acquisition nodes, *(c)* development of software to transfer information on antenna based faults into data files so that bad data can be flagged, *(d)* software for offline analysis of GMRT data files, include software to produce GMRT maps in a standard epoch. *[J. Chengalur]*

The L-Band feed and Front-end system of GMRT was upgraded with modified package design, 0.141 inch semi-rigid cables for interconnections, newly designed RF Control and Monitor card, new gasket made of RTV Silicone gasket maker compound & sturdy mounting plates. This upgrade resulted in reliable performance of the L-band feed and ease of servicing. The upgraded feeds were installed in antennas W-01, W-03 and C-01. *[A. Praveen Kumar and the front-end group]*

Low Loss cable with about 10 times better phase stability was installed in GMRT antennas C-00, C-01, C-02, C-03, C-04, W-04 and S-03.This resulted in the improvement of RF signal levels at all the Frequency bands of GMRT and about 9 dB improvement in the 1390 sub-band of GMRT. *[A. Praveen Kumar and H.S. Kale and the front-end and the mechanical group]*

Brazilian Decimetric Array

The prototype of the Brazilian Decimetric Array (BDA) consisting of five numbers of 4m diameter dishes was developed with the help of the NCRA, in the INPE campus, Sao Jose Dos Campos, SP, Brazil. M.R.Sankararaman visited the INPE during 2002-03 and helped the BDA astronomers and engineers in developing the dish, Alt-Az mount and drive-systems, dual polarization L band feeds and analog electronics. He completed the assignment with the demonstration of interferometric fringes using a pair of antennas in adder and multiplier modes. He conducted a lecture course on Radio Interferometry Instrumentation and co-authored three papers on the BDA project, during his stay with the group. *[M.R. Sankararaman]*

Dipole Array Antenna, Mexico

The Instituto de Geophysics, Unam, Mexico is building a large Dipole Array Antenna covering an area of 70 x 140 square meters at Coeneo, Mexico in the frequency band 138.9 - 140.4 MHz. The array consists of 64 rows of dipoles placed in the e-w direction, each row consisting of 64 dipoles and the associated electronics. The principal aim of the array (mexart) is to study the passage of large-scale interplanetary disturbances by observing the scintillation index of unresolved radio sources. We have worked for four months in the detailed implementation aspects of the array, working out the permitted tolerances in dipole fabrication & installation, package design and routing plan for all the associated electronic sub-assemblies and cables. Because of cost constraints and faster mass production, we have made a thorough market survey and designed the packages using readily available metallic housings which are mass manufactured at very low costs. We also identified suitable PVC pipes and couplings which were readily available in the market. This resulted in the speedy implementation of the array without the involvement of mechanical workshop. We also trained the engineers in RF product design, measurements involved in the phased array antennas, theory of phased arrays and beam forming networks. We also conducted courses for university students covering radio astronomical measurements and phased array antennas. We have cleared all the implementation aspects to the concerned Engineers and they would be able to bring all the 64 outputs from 64 e-w rows in equal amplitude and phase to the central Building. Dipole

tuning and a suitable matching network design were also incorporated. *[A. Praveen Kumar and G. Sankarasubramanian]*

Awards, Distinctions, Invited Talks, Visits, etc.

National and International Involvement

J.N. Chengalur

Member SOC, Astronomical Society of India Meeting 2002

Member Hanle Utilization Group

Member SOC, Astronomical Society of India Meeting 2003

Member SOC, IAU25 JD 21, *Astrochemistry of external galaxies*, Sydney Australia.

Gopal Krishna

SOC member for the IAU Joint Discussion 18: Quasar cores and Jets (IAU General Assembly, July, 2003, Australia)

Convenor, GMRT Time Allocation Committee (GTAC)

Member, Advisory Committee for Shanti Swarup Bhatnagar Prize in Physical Sciences (2002)
Member, 'Physical Sciences Research Committee' of CSIR

Y. Gupta

Member, Inter Union Commission for Allocation of Frequencies (IUCAF).

R. Nityananda

Editor, Journal of Astronomy and Astrophysics, Indian Academy of Sciences, Bangalore.

Member, Council of Editors, Resonance, Indian Academy of Sciences, Bangalore.

Member, Academic Programme Advisory Committee, S.N. Bose National Centre for Basic Sciences, Kolkata.

D.J. Saikia

Member of the Committee for examining possible merger of BASI and JAA.

T.L. Venkatasubramani

Member, Radio Astronomy Frequency Committee for the Asia Pacific (RAFCAP)

Member, The National Frequency Allocation Planning 2002

Member, National Working Group for World Radiocommunication Conference – 2003

Visits

Sunita Barve

Library, Sterrenkundig Instituut, Anton Pannekoek, Amsterdam, The Netherlands, June 15–30, 2002.

Library, Institut d' Astrophysique, Paris, France, June 25 – 26, 2002.

Library, Strahoviensis, Prague, Czechoslovakia, July 4, 2002.

Libraries of Raman Research Institute, Bangalore, Indian Institute of Astrophysics, Bangalore, Indian Institute of Sciences, Bangalore, and National Aeronautics Laboratory, Bangalore, November 25 – 26, 2002.

J.N. Chengalur

Indian Institute of Technology, Kharagpur, June 9 – 16, 2002.

Gopal Krishna

National Radio Astronomy Observatory, USA, October 11-15, 2002

Georgia State University, Atlanta, USA, October 16-24, 2002

Y. Gupta

Arecibo Observatory, September 2001 to August 2002

Oberlin College, Ohio, August 2002 to October 2002

Max Planck Institute for Radio Astronomy, Bonn, November 2002 and January 2003

Institute of Astronomy, University of Zielona-Gora, Poland, December 2002 – January 2003.

B.C. Joshi

Workshop on simultaneous multi-frequency Pulsar Observations, Amsterdam, The Netherlands, May 27 – 29, 2002

Radio Pulsars, Chania, Crete, Greece, August 26 – 29, 2002

XXII Meeting of Astronomical Society of India, Thiruvananthapuram, India, February 13–15, 2003

N.G. Kantharia

Institute for Radio Astronomy, Kharkov, Ukraine, June 8 – July 21 2002.

Observatoire de Paris, Paris, November 15 – December 10, 2002.

P.K. Manoharan

American Astronomical Society meeting, June 2002.

SHINE Workshop, August, 2002.

COSPAR General Assembly, October 2002.

A. Praveen Kumar

Indian Institute of Technology, Delhi, April 2002.

California Institute of Technology, Pasadena, USA, April 22 – 27, 2002.

University of California, Berkeley, USA, April 27 – May 2, 2002.

SETI Institute, San Hose, USA, April 2, 2002.

Instituto de Geofisics, UNAM, Mexicom May 3 – June 30, 2002.

Tata Institute of Fundamental Research, Mumbai, VIth International Conference on Optoelectronics, Fiber optics and Photonics (PHOTONICS 2002), December 16 – 18, 2002.

ISRO Satellite Centre, CMG Group, December 30, 2002 – January 1, 2003.

Subhashis Roy

Gemini Observatory, Hawaii to attend the Galactic Center Conference 2002, 4–8 November 2002.

D.J. Saikia

Jodrell Bank Observatory, August and September 2002.

G. Sankarasubramanian

Deputed to the Mexican IPS Array Construction Project under Indo-Mexican Scientific Exchange Programme, June 19, – August 20, 2002.

Indian Institute of Technology, New Delhi,
3-day short course on Ansoft – Microwave Design Tools, Centre for Applied Research in Electronics, December 2002.

T.L. Venkatasubramani

Busan, South Korea as a Delegate of the Govt. of India to participate in the Fourth meeting of the Asia Pacific Telecommunity Conference Preparatory Group for WRC-2003.

M. Vivekanand

TIFR Mumbai, I ASTROSAT Workshop on Pulsar Astrophysics, Feb 11 – 17, 2002.

Awards and Distinctions

Sunita Barve

International Membership Librarian Award for the year 2002-2003 from Special Library Association's Physics Astronomy Mathematics Division, USA.

Invited Talks (Speaker, Title, Occasion, Place, Date)

J.N. Chengalur

HI observations of dwarf galaxies
Cosmology and the high redshift universe, IUCAA–IFA Workshop, IUCAA, February 8, 2003.

Gopal Krishna

Radio galaxies and the star formation history of the universe
AGN: From central engine to host galaxy
Observatoire de Paris, July, 24, 2002.

Radio galaxies and magnetization of the IGM
NRAO Workshop 'Radio Astronomy at the Fringe'
Green Bank, USA, October, 12, 2002

Radio Galaxies and the Star Formation History of the Universe
Georgia State University, Atlanta, USA, October 15, 2002

Role of radio galaxies in the evolution of the universe
22nd Meeting of the Astronomical Society of India
Trivaendrum, February 15, 2003

B.C. Joshi

New Generation Software Based Instruments for Pulsar Observations
XXII Meeting of Astronomical Society of India,
Thiruvananthapuram, India, February 14, 2003

R. Nityananda

Giant Metrewave Radio Telescope: Status and prospects
IAU 8th Asian–Pacific Regional Meeting, National Centre of Sciences,
Tokyo, Japan
July 2, 2002.

Six faces of Subrahmanyan Chandrasekhar
Physics Department, Pune University,
October 10, 2002.

Gravity and Light
8th Vaidya–Raichaudhuri Endowment Award Lecture, IUCAA
December 12, 2002.

Our Solar System and others
Introductory School on Astronomy and Astrophysics, Fergusson College
December 2002.

The Giant Metrewave Radio Telescope
Raman Memorial Conference – 2002, Inaugural talk, Department of Physics, University of Pune, Pune
February 21, 2003.

GMRT and Radio Astronomy
Valedictory Function, Institute of Armament Technology, Pune
February 7, 2003.

A. Praveen Kumar

The analog receiver of GMRT
ASET forum talk at TIFR Mumbai, July 12, 2002.

S. Suresh Kumar

Wavelength Division Multiplexing (WDM) Sensors and application
Workshop on Fiber Optic sensors, Institute of Armament Technology, Girinagar, Pune, August 23, 2002.

T.L. Venkatasubramanai

The analog receiver of GMRT
ASET forum talk at TIFR Mumbai, July 12, 2002.

Non DAE Research Projects

Publications

In journals (Authors, Title, Journal, Vol. No., Page, year.)

A.L Ahuja, **Y. Gupta**, A.K. Kembhavi, & **V.K. Kulkarni**
Tracking Pulsar Dispersion Measures using the GMRT
Bulletin of the Astronomical Society of India, **30**, 701 (2002).

Ayesha Begum, Jayaram N. Chengalur & U. Hopp
The little galaxy that could: kinematics of Camelopardalis B
New Astronomy, **8**, 267 (2003).

N.D.R. Bhat, & **Y. Gupta**
Pulsar Scintillation in the Local Interstellar Medium: Loop I and Beyond
Astrophysical Journal, **567**, 342 (2002).

Rupinder Singh Brar, J.A. Irwin and **D.J. Saikia**
High-latitude dust and the 617 MHz-850 μm relation in NGC 5775
MNRAS, **340**, 269, astro-ph/0212277 (2003)

Jayaram N. Chengalur & Nissim Kanekar
HI 21 cm imaging of a nearby damped Lyman-alpha system
A&A, **388**, 383 (2002).

M. Choudhury, A.R. Rao, S.V. Vadawale, **C.H. Ishwara-Chandra** & A.K. Jain
Disk-jet connection in Cygnus X-3.
A&A, **383**, L35, (2002).

W.D. Cotton, D. Dallacasa, C. Fanti, R. Fanti, A.R. Foley, R.T. Schilizzi, R. Spencer, **D.J. Saikia** and S. Garrington
Polarimetry of GPS and CSS Sources
PASA, **20**, 12 (2003)

W.D. Cotton, R. Spencer, **D.J. Saikia** and S. Garrington
Faraday rotation in the CSS QSOs 3C43 and 3C454
A&A, **403**, 537 (2003)

J. Gil, **Y. Gupta,** P.B. Gothoskar, & J. Kijak
Frequency Dependence of Pulsar Radiation Patterns
Astrophysical Journal, **565**, 500 (2002).

Gopal-Krishna, C.S. Stalin, Ram Sagar and P.J. Wiita
Clear Evidence for Intranight Optical Variability of Radio-quiet Quasars
Astrophys. J. (Letters), **586**, L25, 2003.

Neeraj Gupta, R. Srianand, P. Petitjean and C. Ledoux
Outflowing material in the zem = 4.92 BAL QSO SDSS~J160501.21-011220.0
A&A, in press, astro-ph/0305124 (2003)

Y. Gupta, & R.T. Gangadhara
Understanding the Radio Emission Geometry of Multiple-Component Radio Pulsars from Retardation and Aberration Effects
Astrophysical Journal, **584**, 418 (2003).

G. Hobbs, A.G. Lyne, **B.C. Joshi**, M. Kramer, I.H. Stairs, F. Camilo, R.N. Manchester, N. D'Amico, A. Possenti and V.M. Kaspi
A very large glitch in PSR J1806-2125
Monthly Notices of Royal Astronomical Society, **333**, L7, 2002.

C.H. Ishwara-Chandra, J.S. Yadav and **A. Pramesh Rao**
Evidence for synchrotron bubbles from GRS 1915+105.
A&A, **388**, L33 (2002).

B.C. Joshi, M. Burgay, A.G. Lyne, R.N. Manchester, A. Possenti, F. Camilo, N. D'Amico and M. Kramer
A high latitude search for Pulsars
Bulletin of Astronomical Society of India, **30**, 687, 2002.

B.C. Joshi, A.G. Lyne, C. Jordan, A. Krawczyk, J. Gil
Observations of rotational instabilities in radio pulsars
Bulletin of Astronomical Society of India, **30**, 691, 2002.

Nissim Kanekar & **Jayaram N. Chengalur**
A deep search for 21-cm absorption in high redshift damped Lyman-alpha systems
A&A, **399**, 857 (2003).

A. Karastergiou, M. Kramer, A. Johnston, A.G. Lyne, N.D.R. Bhat & **Y. Gupta**
Simultaneous single-pulse observations of radio pulsars. II. Orthogonal polarization modes in PSR B1133+16
Astronomy & Astrophysics, **391**, 247 (2002).

A. Krawczyk, A.G. Lyne, J.A. Gil and **B.C. Joshi**
Observations of 14 pulsar glitches
Monthly Notices of Royal Astronomical Society, **340**, 1087, 2003.

R.J. MacDowall, A. Lara, **P.K. Manoharan**, N.V. Nitta, A.M. Rosas, and J.-L. Bougeret
Long-duration hectometric type III radio bursts and their association with solar energetic particle (SEP) events
Geophys. Res. Lett., **30**, 2003.

P.K. Manoharan
Solar Wind
Lecture Notes in Physics, Springer, 2003, in press,

P.K. Manoharan and M.R. Kundu
Coronal Structure of a Flaring Region and Associated Coronal Mass Ejection
Astrophysical Journal, **592**, in press.

F. Mantovani, M. Bondi, **D.J. Saikia**, W. Junor, W., C.J. Salter and R. Ricci
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Tech.Note:MxA/TR/2k2-01, 7 pp.

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Other activities

Lectures / Lecture Courses Given Elsewhere

Sunita Barve

Information access in developing countries with special reference to Astronomy libraries in India
Special Libraries Association Conference, Los Angeles, USA, June 9, 2002

Special Libraries Association: various awards available for the developing country librarians
Pune Librarian's Network Forum, IUCAA, Pune, October 29, 2002.

The use of Microsoft Access in Library Management
Conducted a 1-day workshop for PULISAA in Department of Library and Information Science, Jayakar Library, Pune University, January 18, 2003.

J.N. Chengalur

Extra Galactic Astronomy for Cosmologists
Lecture Series at the SERC School on Astrophysics
Indian Institute of Technology, Kharagpur, June 3 – July 3, 2002.

Galaxies
Lecture Series at the IUCAA–NCRA VSP/VSRP Programme,
May–June 2002

Y. Gupta

Introductory Radio Astronomy
Lecture Course at the Department of Physics, Oberlin College, Ohio, August to October, 2002.

C.H. Ishwara Chandra

Radio Astronomy,
Eight lectures, 3rd Post Graduate Course in Space and Atmospheric Science, Center for Space Science and Technology Education in Asia and Pacific (CSSTEAP), affiliated to United Nations, Physical Research Laboratory, Ahemadabad, November 11 – 15, 2002.

B.C. Joshi

Coherent On-Line Baseband Receiver for Astronomy
Conference on Radio Pulsars, Chania, Crete, Greece, August 29, 2002

A search for Giant pulses in Millisecond Pulsars
Conference on Radio Pulsars, Chania, Crete, Greece, August 26 – 29, 2002

A study of Giant pulses in PSR B0531+21 with GMRT
XXII Meeting of Astronomical Society of India, Thiruvananthapuram, India, February 13-15, 2003

N.G. Kantharia

Radio recombination lines
2 lectures, IUCAA–NCRA summer school 2002, May – June 2002.

Carbon recombination lines
Institute for Radio Astronomy, Kharkov, Ukraine, July 2002.

P.K. Manoharan

Multiwavelength study of a coronal mass ejection: Eruption from AR\#9393
American Astronomical Society, 200th meeting, USA, June 2002.

Speed evolution of coronal mass ejections in the inner heliosphere
SHINE workshop, Canada, August, 2002.

An empirical model to predict the 1-AU arrival of IP shocks
34th COSPAR Scientific Assembly, USA, October 2002.

Propagation of Coronal Mass Ejections from Sun to 1 AU
34th COSPAR Scientific Assembly, USA, October 2002.

A study of coronal magnetic field configuration associated with a CME
34th COSPAR Scientific Assembly, USA, October 2002.

R. Nityananda

Astrophysical Processes
A set of 5 lectures, IUCAA–NCRA Summer School – 2002
May 20 – 24, 2002.

Status and use of GMRT
National Symposium on Astrophysics, “Sun, Stars and the Extragalactic Universe, Centre for Research and Education in Science and Technology,

Hosakote, Bangalore
August 8, 2002.

Signals in Radio Astronomy – I
Observational Astronomy – II (for JAP Students), NCRA–TIFR, Pune
June 18, 2002.

Signals in Radio Astronomy – II
Observational Astronomy – II (for JAP Students), NCRA–TIFR, Pune
June 18, 2002.

Thermodynamics
A set of 2 lectures, International Physics Olympiad Training Camp – 2002,
Homi Bhabha Centre for Science Education, Mumbai
May 31, 2002.

Gravity and Light
Physics Department, Indian Institute of Science, Bangalore
March 12, 2003.

A. Praveen Kumar

Analog Fiber–Optic Links for GMRT
Electrical Engineering Department, California Institute of Technology,
April 23, 2002.

Subhashis Roy

The Galactic Centre Region - ongoing work at NCRA, Pune
Array Operations Centre, VLA, Socorro, USA,
November 12, 2002

The Galactic Centre Region - ongoing work at NCRA, Pune
Naval Research Laboratory, Washington
November 20, 2002.

D.J. Saikia

Nearby galaxies and clusters of galaxies
IUCAA–NCRA Summer School, IUCAA, June 2002.

M. Vivekanand

Rotation powered pulsars and isolated neutron stars
I ASTROSAT workshop on Pulsar Astrophysics, TIFR Mumbai
February 11–17, 2002.

Introduction to observational astronomy
Summer School, NCRA
May 20 – June 21, 2002.

Pulsar astronomy
Summer school for JAP, NCRA
May 17 – June 28, 2002.

Lectures by Visitors

Astronomy & Instrumentation Seminar

A.G. de Bruyn, *ASTRON, Dwingeloo & Kapteyn Institute, Groningen*:
Interstellar Scintillation and Ultra-Compact Radio AGN : The Case of J1819+3845
April 8, 2002

A.A. Deshpande, *Raman Research Institute, Bangalore:*
Vela, its X-ray Nebula and the Polarization of Pulsar Radiation
April 16, 2002

Robert Minchin, *Cardiff University, U.K.*:
A Deep HI Multibeam Survey
May 3, 2002

Crystal Brogan, *NRAO, Socorro:*
Low Frequency Survey of the Inner Galactic Plane
May 9, 2002

Tracy Clarke, *NRAO, Socorro:*
Low Frequency Observations of the Diffuse Emission in Abell 757
May 9, 2002

Francois Viallefond, *Observatoire de Paris*:
Atacama Large Millimetre Array (ALMA)
May 17, 2002

Ramana Athreya, *Pontificia Universidad Catolica, Chile And European Southern Observatory*:
Cluster Mass Distribution From Gravitational Weak Lensing Analysis
July 23, 2002

Emeric Le Floc'h, *Service d' Astrophysique, Cedex, France*:
A sample of high-redshift galaxies probed by GRBs : toward a new cosmic

window on galaxy evolution
August 9, 2002

Amitesh Omar, *Raman Research Institute, Bangalore:*
HI and OH Study of the Seyfert Galaxy Mrk 1
September 6, 2002

Rodney Smith, *University of Wales, Cardiff:*
How many galaxies are there?
September 18, 2002

Sandip Kumar Chakrabarti, *S.N. Bose National Centre for Basic Sciences, Kolkata:*
Advective Flow Paradigm of Black Hole astrophysics
October 1, 2002

Parijat D. Deshpande, *Chalmers University of Technology, Sweden:*
A 1.6 Gigabit/s, 25-85 kHz Underwater Ambient Noise Imaging Array
September 19, 2002

S. Jeyakumar, *Physikalisches Institut, Universitat zu Koln, Germany:*
Photon Dominated Regions, the dense Inter-Stellar Medium, at low metallicities
November 15, 2002

B.C. Joshi, *NCRA-TIFR, Pune:*
Coherent On-line Baseband Receiver for Astronomy
November 29, 2002

Anvar Shukurov, *School of Mathematics and Statistics, University of Newcastle, UK*:
Faraday ghosts: depolarization canals in the Galactic radio emission
December 31, 2002

Alastair Edge, *Department of Physics, University of Durham, UK:*
Cooling Flows: My Part in their Downsizing
January 6, 2003

Pankaj Jain, *Indian Institute of Technology,, Kanpur:*
Physical Origin of the Observed Large Scale Anisotropies in Radio and Optical Polarization from Distant AGNs
January 10, 2003

Katherine Blundell, Oxford University Astrophysics, Oxford, UK:
Two types of quasar – looks like carelessness?
January 22, 2003

Tiziana Venturi, *Istituto di Radioastronomia, CNR, Bologna, Italia:*
Extended radio emission in merging clusters of galaxies
February 20, 2003

Santimay Basu, *Space Vehicles Directorate, Hanscom AFB, USA &*
Sunanda Basu, *National Science Foundation, Arlington, VA 22230, USA*:
Impact of the low latitude ionosphere on transionospheric radio propagation
February 10, 2003

Paulo C. Freire, *Arecibo Observatory, Puerto Rico, USA*:
Timing of the PSR J2016+1947 binary pulsar at Arecibo: Testing the Strong Equivalence Principle
February 19, 2003

C.S. Stalin, *Visiting Fellow, NCRA-TIFR, Pune*:
A Comparative Study of Intra-night Optical Micro-variability of High Luminosity AGN Classes
March 21, 2003

Student Seminar

Ayesha Begum, *NCRA-TIFR, Pune:*
Dynamics of the Extreme Dwarf Galaxy Cam B
April 19, 2002

Urvashi Rau, *BITS, Pilani:*
Automatic RFI Identification And Flagging Solutions of Complex Antenna Gains – Algorithms & Simulations.
June 11, 2002

Kunal Bhattacharya, *Indian Institute of Technology, Kanpur*:
Study of Motion of Hydrogen Clouds in Dark Matter Halo
July 4, 2002

Nirmal Thyagu, *Indian Institute of Technology, Chennai:*
Simulation of Rotation Curves of Galaxies
July 4, 2002

Ganapati Sahoo, *Utkal University:*
Understanding the Imaging Processes
July 4, 2002

Samir Dhurde, *University of Pune, Pune*:
Are Hotspots of Radio Galaxies Sites of *In situ* Acceleration of Relativistic

Particles ?
July 4, 2002.

Ashrut Ambastha, *University of Pune, Pune:*
RFI Direction Finding
July 4, 2002

Seeby E.S., *Mahatma Gandhi University:*
The Introduction to Radio Interferometry and the imaging
July 4, 2002

Sarah Ruth Smolkin, *Queen's University, Canada:*
Double-Double Radio Galaxies
July 19, 2002

Jessy Kate Cowan Sharp, *Queen's University, Canada:*
Double-Double Radio Galaxies
July 19, 2002

Chiranjib Konar, *NCRA-TIFR, Pune:*
GMRT Imaging of Two Cluster Fields 0826+660(A665) at 1280 MHz & 0256+0006 at 610 MHz.
July 29, 2002

A. Srinivas Reddy, *Birla Institute of Technology and Science, Pilani:*
Phase Stability of GMRT
September 27, 2002

G. Prasanth, *Birla Institute of Technology and Science, Pilani:*
Development of Telephone Circuit of Telemetry System of GMRT Using FPGA/CPLD
September 27, 2002

Anupama Rai, *Birla Institute of Technology and Science, Pilani:*
Basics of Antenna And Study of Radiation of a Thick Folded Dipole
September 27, 2002

S. Janani, *Birla Institute of Technology and Science, Pilani:*
Holography of Dish Antennas
September 27, 2002

Jean Vernhes, *Visiting Engineer, NCRA-TIFR, Pune:*
Test Suit for the GMRT Correlator System
November 7, 2002

A. Srinivas Reddy, *Birla Institute of Technology and Science, Pilani:*
Phase Stability of GMRT
December 11, 2002

S. Janani, *Birla Institute of Technology and Science, Pilani:*
Holography : Diagnosing Antenna Aberrations from Far Field Measurements
December 11, 2002

G. Prasanth, *Birla Institute of Technology and Science, Pilani:*
Development of Telephone Circuit of Telemetry System of GMRT Using FPGA/CPLD
December 11, 2002

Anupama Rai, *Birla Institute of Technology and Science, Pilani:*
Basics of Antenna, Study of Radiation of Thick Folded Dipole and Design and Analysis of Wire Antenna using MOMIC/MININEC
December 11, 2002

C. Konar, *NCRA-TIFR, Pune:*
A study of giant radio galaxies

Informal Lecture

G. Swarup, *NCRA-TIFR, Pune:*
Frontiers of Radio Astronomy in Science and Engineering
June 7, 2002

Ashok Singal, *Physical Research Laboratory, Ahmedabad*:
Some Curious Phase Variations in the GMRT System
August 27, 2002

Dharam Vir Lal, *NCRA-TIFR, Pune*:
Spectral Index Maps and their Determination Methods
September 6, 2002

S.R. Jathar, *Gynecologist, Ameya Nursing Home, Pune:*
Common Health Problems of Working Women
December 21, 2002

Foundation Day Lecture

S. Ananthakrishnan, *NCRA-TIFR, Pune*
Understanding the Sun and its radiation effects on the earth-beings
October 30, 2002

Informal Discussions Group Meeting

Ranjeev Misra, *IUCAA, Pune:*
Ultra-Luminous X-ray Sources: A new kind of black hole systems
April 12, 2002

Subhashis Roy, *NCRA-TIFR, Pune*:
Detection of X-ray emission and flaring from the supermassive black hole at the Galactic Centre
April 12, 2002

Jayaram Chengalur, *NCRA-TIFR, Pune:*
The Milky Way's satellite population in a Λ CDM Universe
April 26, 2002

Prasad Subramanian, *IUCAA, Pune:*
X-ray/Gamma ray flares from hadronic jets in AGN
April 26, 2002

Gopal Krishna, *NCRA-TIFR, Pune*:
A Large-scale jet and FR I source in a spiral galaxy
May 10, 2002

S. Sridhar, *IUCAA, Pune:*
Stars and singularities: Stellar phenomena near a massive black hole
May 10, 2002

Ajit K. Kembhavi, *IUCAA, Pune*:
Chandra observations of X-ray jets
July 12, 2002

Dharam Vir Lal, *NCRA-TIFR, Pune:*
3C129 at 90 cm: Evidence for a Radio Relic?
July 12, 2002

A. Pramesh Rao, *NCRA-TIFR, Pune:*
Pulsar SNR Association — Case of the Duck
July 26, 2002

R. Srianand, *IUCAA, Pune:*
Oxygen Abundance in the Low Density IGM
July 26, 2002

Tarun Souradeep & Kandaswamy Subramanian, *IUCAA, Pune:*
Recent surprises from CMB anisotrophy data
August, 9, 2002

Tirthankar Roy Choudhury, *IUCAA, Pune:*
Constraints on reionization from thermal history of the IGM
August 23, 2002

C.H. Ishwara Chandra, *NCRA-TIFR, Pune:*
Observational Evidence for disk – jet connection in AGN
August, 23, 2002

S. Ananthakrishnan, *NCRA-TIFR, Pune:*
Coronal Mass Ejection or Solar Flare – Which comes first !
September 13, 2002

J.V. Sheth, *IUCAA, Pune:*
Hot bubbles from active galactic nuclei as a heat source in cooling-flow clusters
September 13, 2002

N.G. Kantharia, *NCRA-TIFR, Pune:*
The Large-scale Bipolar Wind in the Galactic Center
September 27, 2002

Rajesh Nayak, *IUCAA, Pune:*
Sensitivity of the Laser Interferometer Gravitational Wave Observatory to a stochastic background, and its dependence on the detector orientations
September 27, 2002

Ayesha Begum, *NCRA-TIFR, Pune:*
Faint stars in the Ursa Minor dwarf spheroidal galaxy: implication for the low-mass stellar initial mass function at high redshift
October 11, 2002

Rajaram Nityananda, *NCRA-TIFR, Pune:*
The strange world of negative refractive index
October 11, 2002

D.V. Ahluwalia, *Visiting Professor, IUCAA, Pune:*
Quantum Tower of Pisa
October 25, 2002

V. Sahni, *IUCAA, Pune:*
Braneworld Cosmology
October 25, 2002

Naresh Dadhich, *IUCAA, Pune:*
Homogeneous Collapse On The Brane
November 8, 2002

D.J. Saikia, *NCRA-TIFR, Pune:*
Radio-FIR correlations
November 8, 2002

Vasant Kulkarni, *NCRA-TIFR, Pune:*
Parsec-Scale Radio Structure and Broad Optical Emission Lines in a complete sample of 3CR Lobe-Dominated Quasars
November 22, 2002

Jayant Narlikar, *IUCAA, Pune:*
The Case for Non-Velocity Redshifts in Normal Galaxies
November 22, 2002

Bhal Chandra Joshi, *NCRA-TIFR, Pune:*
Twinkle twinkle neutron star
January 17, 2003

Prasad Subramanian, *IUCAA, Pune:*
Coronal Mass Ejections (CMEs) from the Sun: Energy budgets
January 17, 2003

Dharam Vir Lal, *NCRA-TIFR, Pune:*
Chandra Detection of a Type II Quasar at z = 3.288
January 31, 2003

M. Sami, *IUCAA, Pune*
Cosmology with Rolling Tachyon
January 31, 2003

Harvinder K. Jassal, *IUCAA, Pune:*
Tests of inflation: Next generation
February 7, 2003

R. Nityananda, *NCRA-TIFR, Pune:*
Quantum Interferometric Optical Lithography: Exploiting Entanglement to Beat the Diffraction Limit
February, 7, 2003

Parampreet Singh, *IUCAA, Pune:*
The Pre Big Bang Scenario in String Cosmology
February 21, 2003

G. Swarup, *NCRA-TIFR, Pune:*
Search for the Reionization Epoch
February 21, 2003

Sanjeev Dhurandhar, *IUCAA, Pune:*
Time delay Interferometry for LISA
March 7, 2003

A. Pramesh Rao, *NCRA-TIFR, Pune:*
1830-211 – the "Ooty" Lens revisited
March 7, 2003

C.H. Ishwara Chandra, *NCRA-TIFR, Pune:*
Inverse Compton X-rays from the radio galaxy 3C 219
March 21, 2003

Tarun Souradeep, *IUCAA, Pune:*
Cosmic Microwave Background anisotropy results from WMAP
March 21, 2003

Graduate Courses

J.N. Chengalur

The Interstellar Medium

Gopal Krishna

Extragalactic Astronomy II

R. Nityananda

Electrodynamics and Radiative Processes – I

D.J. Saikia

Galaxies and galactic dynamics

M. Vivekanand

High Energy Astrophysics (For Joint Astronomy Programme of the Indian Institute of Science, Bangalore)

Ph.D. Theses/ M.Sc. Theses

C.S. Stalin, State Observatory, Naini Tal: *Comparative intra-night optical micro-variability of high-luminosity AGN classes*, Kumaun University, 18-Oct-2002. **(Co-Guide: Gopal Krishna)**

VSRP / STP Projects/ Training of College Students

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D.J. Saikia

Samayar dharana aru bishwabrahmandar bayas (in Assamese)
AIR, Dibrugarh

Any other information.