



## Abstracts

### (A) Sun and solar system

#### **Modeling solar cycles using a variable meridional circulation in a flux transport dynamo model**

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**Abstract.** The sunspot number – a proxy of solar activity – varies roughly periodically with time. However the individual cycle durations and amplitudes are found to vary in an irregular way. An important feature of the solar cycle is the Maunder minimum during 1645-1715 when there were very few sunspots. We explore whether this irregular solar cycle can be modeled with the help of a flux transport dynamo model of the solar cycle. We model the periods of the last 23 sunspot cycles by varying the meridional circulation speed. We find that most of the cycle amplitudes also get modeled up to some extent when we model the periods. Moreover, under certain situations we are able to reproduce Maunder like grand minimum. However, we fail to reproduce these results if the value of turbulent diffusivity is reasonably low.

#### **Study of polarimetric properties of comet Levy 1990XX by mixture of compact and aggregate particles**

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**Abstract.** In the present work, the observed linear polarization data of comet Levy 1990XX are studied at wavelengths  $0.485 \mu\text{m}$ ,  $0.540 \mu\text{m}$  and  $0.670 \mu\text{m}$ . We propose a model which considers cometary dust as a mixture of compact and aggregate particles, with composition of silicate and organic material. Aggregates correspond to a mixture of Ballistic Cluster-Cluster Aggregate (BCCA) and Ballistic Agglomeration with Migration 2 (BAM2) with a suitable mixing ratio and compact particles correspond to polydisperse spheroids with different axial ratio ( $E = 0.08$  to  $1.2$ ) which includes prolate, spherical and oblate particles. It is found from our analysis that the observed polarization data of Comet Levy 1900XX at the above three wavelengths are successfully reproduced by using the proposed model.

### **Complex spectroscopic variations as observed from Norikura chronograph**

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**Abstract.** Spectroscopic observations of off-limb corona have been done using 25 cm chronograph of National Astronomical Observatory, Norikura, Japan. Raster scans were made using forbidden iron lines in optical regime, namely [Fe X] 6374 Å (red line), [Fe XI] 7892 Å, [Fe XIII] 10747 Å and [Fe XIV] 5303 Å (green line), with two lines simultaneously. Using those scans from mid-latitude to polar regions taken in September 2004, the variation of intensity ratios and spectral line widths with height and from structure to structure are studied. The results indicate that the line width of green line decreases with height whereas that of red line increases and the other two lines show intermediate behavior irrespective of the structure. Also, the intensity ratio of green line to red line decreases with height whereas that of other two increases with respect to red line. The possible explanation suggested for this complex behavior including the comparison of the gradients from structure to structure and also with the earlier equatorial region results will be discussed.

### **Polarimetric study of comet Halley using combined dust model**

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**Abstract.** In our present work, we study the observed polarization characteristics of comet Halley using a mixture of aggregates and compact spheroidal particles, with composition of silicate and organic material. Aggregates correspond to a mixture of Ballistic Cluster-Cluster Aggregate (BCCA) and Ballistic Agglomeration with migration 2 (BAM2) with some suitable mixing ratio. The compact solid particles correspond to spheroidal particles (prolate, oblate and spherical) with some size distribution. It is found from our work that the proposed model successfully reproduced the observed linear polarization data of comet Halley at wavelengths 0.365  $\mu\text{m}$ , 0.485  $\mu\text{m}$  and 0.684  $\mu\text{m}$ .

### **3D reconstruction and kinematics of eruptive prominences using STEREO observations**

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**Abstract.** We present observations of two large northern polar crown prominences that erupted on 2010 April 13 and 2010 August 1 on the Sun. For 3D studies of

these events, we developed a stereoscopic reconstruction technique for the images obtained from the SECCHI suite of instruments on board the twin Solar TERrestrial RELations Observatory (STEREO) spacecraft. This technique was applied to images obtained from the Extreme UltraViolet Imager to reconstruct several features along the prominences. The three-dimensional changes exhibited by the prominences can be explained as an interplay of two different motions, namely, the twist in the prominence spine, and the overall non-radial motion of the entire prominence structure. The sense of twist in both the prominences is determined from the changes in latitudes and longitudes of the reconstructed features. The study of kinematics of these features reveals crucial information of the early phase of eruptive prominences and initiation of the associated CMEs. Our results from 3D reconstruction of observations from two view points (STEREO) provide a better understanding of the physical mechanism in the lower corona as compared to previous results obtained using observation from a single vantage point, for e.g. SOHO.

### **Energy-dependent nature of thermal emission in solar flares**

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**Abstract.** Our study of 10 M - class solar flares observed by the SOXS mission reveals breakthrough nature of multi-thermal X-ray emission in 6-20 keV with temperatures of 15-50 MK. The multi-thermal power-law index ( $\gamma$ ) and the flare plasma cooling time vary between 2.7 – 4.3 and 22 – 310 s respectively. Further the break-energy point between thermal and non-thermal emission is found to vary between 17 and 22 keV.

### **Long-term variability of solar flare index**

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**Abstract.** We have studied the long-term variability of solar flare index during the solar cycle 21 to 23. We noticed that the yearly occurrence of flare index varies with 11-year sunspot cycle except under some circumstances. The occurrences of solar transient events are also following solar activity cycles i.e. varies with different phases of solar cycles. We observed that the occurrence of solar flares are in the increasing trend during the declining phase of solar cycle 21, whereas the overall occurrence of flares are higher during solar cycle 21 and 22 in comparison to solar cycle 23. This phenomenon is associated with Hale cycle. During solar cycle 21 and 22 northern hemisphere and southern hemisphere of the Sun was most active. After higher value of flare index in 22-year cycle, we find the overall value of

flare index is small for solar cycle 23 and we predict same condition for future solar cycle 24.

### **Filament eruption leading to two ribbon M-class flare in NOAA AR11093: Multi-wavelength study**

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**Abstract.** We present multi-wavelength study of two ribbon M-class flare in NOAA AR11093 observed on August 7, 2010 in the new solar cycle 24. We show observationally the evolution of this flare and the associated jet like ejection of material into corona in different wavelengths observed by different space borne and ground-based instruments. We also discuss the previous observational and theoretical model aspects related to this event.

### **Long term evolution of super active regions**

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**Abstract.** In the solar cycle 23, there were some active regions (ARs) which produced energetic events, e.g. flares, CMEs, of unprecedented magnitudes during their disc passes, termed as super active regions (SARs). For example, NOAA 10486 stood unrivaled as it produced flares of unprecedented magnitude, such as X17/4B, X10/2B and X28 in quick succession. Occurrence of flares of such magnitude at this rate evidently requires extremely rapid energy buildup mechanism. Therefore, from their energetic considerations, these SARs are expected to possess distinctly different sup-photospheric flows as compared to less productive ARs. Study of such SARs is expected to provide important insights in our understanding of flare productivity, characterization of ARs, and in space-weather predictions. We derived sup-photospheric flows beneath these SARs using ring diagram technique, one of the local helioseismic techniques. We found strong and largely twisted sub-photospheric flows in the interior of SARs as compared to ARs. We present maps of sub-photospheric flows beneath some SARs and their evolution from one to next Carrington rotation.

### **On the nature of propagating MHD waves in polar coronal hole**

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**Abstract.** Waves play an important role in the heating of the solar corona and in the acceleration of the fast solar wind from polar Coronal Holes (pCHs). Recently

using EIS/Hinode and SUMER/SOHO, we have reported the presence of accelerating waves in polar region (Gupta et al. 2010, ApJ, 718, 11). These waves appeared to be originating from a bright location on-disk, presumably the footprint of the coronal funnels. These waves were interpreted in terms of either propagating Alfvén waves or fast magneto-acoustic waves. The new sets of observations are obtained from the EIS/Hinode 2'' slit and imaging data from AIA/SDO in various filters over plume and inter-plume regions as HOP175 programme. The combination of spectroscopic and imaging data will provide further details on mode identification and properties of these waves and will help in the energy calculations. In this presentation, preliminary results obtained from these observations in terms of different nature of propagating waves in plume and inter-plume regions and energy carried by these waves will be presented.

### **Investigation of high energy solar energetic particle events of solar cycle 23 and their related Coronal Mass Ejections**

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**Abstract.** From the SEP events of cycle 23 we considered the events having  $\geq 1$  particle in 50 MeV range at the time of peak flux and computed their energy spectrum in the energy range of 30-100 MeV. Interplanetary Scintillation data from the Ooty Radio Telescope observations have been used to get the radial evolution of the CMEs in the inner heliosphere. We have compared the CMEs with the particle profile radial evolution.

### **Anomalously extended minima of solar cycle 23**

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**Abstract.** The new millennium extended solar minimum of solar cycle 23 (2007-2009) contains some distinct surprises and is anomalous in comparison to the past few solar cycles. In general, the level of solar activity goes through the cyclic changes lasting roughly 11 years. The last solar cycle 23 started in the year 1996 and was expected to last until 2006. Nevertheless, the solar activity minima continued beyond the year 2006 and lasted till 2009. In fact, anomalously, during the years 2007-09, a deep sunspot minima was observed at the end of the last solar cycle 23. It is observed that the sun had no sunspots continuously for over 50 days in July-August, 2009. More so, it is found that the solar cycle 23 has the longest quiet period as compared to the last many previous solar cycles. Anomalously low values of the geomagnetic disturbance Ap is observed during the whole quiet period (2007-09) of the sun, particularly in the month of January-September 2009, during which the high speed solar

wind streams are also not observed. As such, the past solar cycle 23 seems to have the very long period of about 14 years, which is anomalously distinct from previous four solar cycles, besides the obvious Ap correlation of very low activity. The low values of the sunspot numbers in years 2007-2009 also have a very distinct effect in producing lowest modulation in cosmic ray intensity, with highest values of neutron monitor counts observed in the year 2009, as compared to that observed so far in previous solar cycles. These results are discussed in the light of many associated solar-terrestrial phenomena.

### **On statistical study of acceleration of CMEs**

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**Abstract.** We present a statistical study on the acceleration of CMEs. This study is based on more than 8000 CME events observed by SOHO/ LASCO during January 1996 to December 2009, which observes the inner corona from 1.1 to 30  $R_S$ . In our study we distribute CMEs in three groups- Narrow, Normal and Halo CMEs. Our study shows that narrow CMEs are completely biased towards deceleration and normal and halo CMEs are almost equally distributed towards acceleration and deceleration. Our study shows that correlation between acceleration and speed of CMEs is high for halo CMEs.

### **Spatial damping of non-adiabatic slow magneto-acoustic waves in coronal loops**

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**Abstract.** It has been observed by various imaging and spectral instruments that wave and oscillatory phenomena frequently occur in different coronal magnetic structures. In coronal loops and solar prominences these oscillations are interpreted as slow magneto-acoustic waves. In this paper we study the spatial damping of linear non-adiabatic slow magnetoacoustic waves in a homogeneous, isothermal, and unbounded coronal plasma permeated by a uniform magnetic field, with physical properties akin to those of coronal loops. We consider an energy equation with optically thin radiative losses, thermal conduction, and heating, and linearize the MHD equations to obtain a fourth-order polynomial in the wavenumber  $k$ , which represents the dispersion relation for slow and thermal MHD waves. Since we are interested in the spatial damping, we have taken angular frequency as real and have numerically solved the dispersion relation to obtain complex solutions for the wavenumber  $k$  corresponding to slow and

thermal waves. It has been found that damping length of slow-mode waves exhibit varying behavior depending upon the physical parameters of the loop.

### **On the period ratio of slow mode in solar prominences**

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**Abstract.** The ground- and space-based missions detected the presence of small-amplitude periodic oscillations or waves in coronal structures. Observations of oscillations in prominences and in surrounding plasma suggest that they are of small amplitude and therefore can be interpreted in terms of linear MHD waves. Prominence seismology allows us to combine wave observations and theory to determine unknown parameters. The departure of period ratio  $P1/2P2$  (between the period of fundamental mode and twice that of its first overtone) from unity provides information about the structure of prominence. We consider analytically the effects of radiation, thermal conduction and compressive viscosity on the period ratio  $P1/2P2$  for a longitudinal propagating slow wave in solar prominence. We investigate the dependence of this ratio on the equilibrium parameters of prominence and its possible use as a diagnostic tool for prominence seismology.

### **Variation of thermodynamic stability of cyanoacetylene in different temperatures in Titan**

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**Abstract.** In order to make new prediction for thermodynamic stability of cyanoacetylene in different temperatures, quantum chemical calculations were performed. Cyanobreak acetylene is the product of neutral-radical reaction between cyanide radical and acetylene in Titan atmosphere. After optimizing the structure we investigated the variation of thermodynamic stability in different temperatures using B3LYP/6-31G\* basis set.

## **Long-term variability of interplanetary parameters and their impact on geomagnetic field**

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**Abstract.** The interplanetary parameters are used for the study of solar-terrestrial relationships. Both, hourly and daily values of these parameters have usually been employed to associate with parameters defining terrestrial effects. For the reported study, we have used the daily average values of the interplanetary indices (V, B, Bz, T, and N), as well as that of the Ap index, for the years 1965 to 2010. The averages have been calculated by choosing only those days for which simultaneous data is available for all these parameters (V, B, Bz, T, N and Ap). These include their yearly averages as well as the averages on the basis of the phases of the solar activity cycle. The statistical relationship between them has been investigated on these long-term averages, as well as on the day-to-day basis. (i) V vs Ap has always low values of correlation coefficient (r), (ii) on the contrary, B vs Ap has high values of r, (iii) the product of V and B vs Ap always yields much better correlations than for V or B alone, either on an average basis, or on a day-to-day basis, and (iv) even though, the long-term variations of V are not very significant, the variations of B follow solar activity cycle and has a continuously increasing trend during the solar cycles 20 and 21. The statistical results obtained here signify that VB is the most effective parameter in producing large scale geomagnetic disturbances. Our results indicate very clearly that mostly neither V nor B is significantly effective in producing geomagnetic disturbances. Rather, we note from the result presented here that it is competing effects of B and V together, which are quite effective in producing large-scale geomagnetic disturbances. Such a deduction also implies that during more disturbed geomagnetic conditions ( $Ap > 20$ ), either V is dominant (B moderate/low), or B is dominant (while V is moderate) besides both of them being dominant.

## **Temporal variations in the solar chromosphere-Ca K line profiles**

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**Abstract.** Previous studies show that there is a lack of information on the variation of network flux with solar cycle phase and also the center of solar disc was found to show no variation with solar cycle phase (White & Livingston, 1978, ApJ, 226, 679). A study on solar variability model (Skumanich et al. 1984, ApJ, 282, 776) shows that there is an excess component during the solar maximum phase. So the above mentioned studies, forms the basis for the development of new programme (Jagdev Singh 1989) at Kodaikanal tower telescope in 1986 to monitor Ca K line profiles as a function of latitude and integrated over the visible  $180^\circ$  longitude. The observations



have been taken from 1986 onwards. Thus the huge database will be used to study the various parameters of the Ca K line and to study the variation of network flux as a function of solar latitude with solar cycle phase. Activity related with sunspots has been studied widely but variations in the polar regions have not been observed systematically. Our data permits to study the changes in polar regions systematically and its implications to the magnetic cycle of the Sun. So the observations, methods, data analysis procedures, preliminary results will be discussed.

### **Damping of slow MHD waves in flowing plasma**

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**Abstract.** High-resolution observations show that oscillations and waves in the solar corona are common. Here we investigate numerically the effect of steady plasma flow on the dissipation of slow magnetoacoustic waves in solar coronal loops permeated by uniform magnetic field. Thermal conduction is taken into account as damping mechanism. The results of our numerical investigation reveal that the slow waves are strongly damped in the presence of steady flow.

### **North-South asymmetry in coronal rotation**

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**Abstract.** The solar images at 17 GHz by Nobeyama Radio Heliograph and in X-ray by soft X-ray telescope (SXT) on board Yohkoh satellite have been of particular interest for the estimation of solar coronal rotation using flux modulation approach. These studies established that the solar corona rotates differentially, as in the photosphere and chromosphere; but the gradient is significantly lower. The radio images estimate equatorial rotation period lower than those estimated by the X-ray images. The latitude profiles of the coronal rotation have temporal variability. The space-time plots of sidereal rotation period, obtained during 1999 – 2005 using radio images at 17 GHz and during 1992 – 2001 using X-ray images, interestingly, display clear North-South asymmetry. The asymmetry changes its sign in odd and even activity cycles of the Sun.

## **Long-term comparative study of large geomagnetic storms recorded during solar cycle 22 & 23**

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**Abstract.** A standard classical geomagnetic storm can be divided into three phases, namely initial phase, main phase and recovery phase. We have analyzed the best-fit initial, main and recovery phase duration for 190 large geomagnetic storm events. For the study of the initial phase duration, we have compiled such storm events whose initial phase duration varies in the time intervals of 0-2, 3-4, 5-6, 7-8 and > 8 hours. Similarly, for the main phase, time intervals of 0-6, 7-12, 13-18, 19-24 and > 24 hours have been selected. The recovery phase of storms takes more time, so the time intervals is selected in the varying range of 0-24, 25-48, 49-72, 73-96, 97-120 and > 120 hrs have been chosen. From this analysis, it is found that the maximum number of sudden commencement geomagnetic storms having their initial phase duration lies between 0-2 hours. The main phase duration for maximum number of large geomagnetic storms lies between 7-12 hours. The recovery rate depends on magnitude and main phase gradient of storms and best recovery phase duration lies between 73-96 hrs (3-4) days for maximum number of geomagnetic storms.

The occurrence rate of large geomagnetic storms displays a pronounced semi-annual variation. Here we have also studied the semi-annual variations of 190 storm events occurring during interval (1986-2007). This analysis indicates that in the first half of annual part (January-July), occurrence rate for large geomagnetic storms is maximum during March and April months. Similarly, in next half (July-December), occurrence rate is higher during October and November. These results show that the months March, April, October and November were more disturbed months and maximum solar activities occur during these months. It is also found that 49.5% of large storm events occur during these months. The semi-annual variation of large storm events shows near approximately a cyclic variation peaking around April and October months. The study of semi-annual variation of storms have an important role in space weather predications.

## **On cosmic ray and geomagnetic response to Coronal Mass Ejections (CMEs)**

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**Abstract.** A catalog of type II bursts and the associated coronal mass ejections (CMEs) observed by the solar and heliospheric observatory (SOHO) mission is used to select the twenty three CMEs events with CME speed equal to and less than 450

Km/Sec (i.e less than and equal to the average solar wind speed) during 1997-2008. Our observational results clearly indicate the even slow speed CMEs are capable of producing the cosmic ray and geomagnetic disturbances on day to day basis. The depression in cosmic ray intensity is larger three days after the arrival of the CMEs and is associated with the maximum disturbance in geomagnetic activity on the same day (i.e after three day from the arrival of CMEs). Fluctuations in cosmic ray intensity and the geomagnetic activity is also observed before the arrival of the CMEs.

### **Time-frequency analysis of solar electron flares during descending phase of solar cycle 23**

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**Abstract.** Short and intermediate-term periodicities in solar electron flares of two different energy bands ( $E > 0.6$  MeV and  $> 2$  MeV) during the last solar minimum of cycle 23 are reported here for the first time, using the 5.7 year data (June 1, 2003 to December 31, 2008) from the Geosynchronous Operational Environment Satellites (GOES). We find that the wavelet power spectrum analysis shows a number of quasi-periodic oscillations in both data sets. In the high frequency range, a prominent period of 22-35 days including 27 day oscillation is detected. Other quasi-periods in the range of 40-60 days, 90-100 days, 130-140 days, 180-190 days,  $\sim 250$  days, 350-370 days and  $\sim 1.3$  years are found in different phases of descending epoch of cycle 23. Possible explanations of the observed periodicities are given in light of previous results and solar r-mode oscillations.

### **Rotational temperatures of molecules**

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**Abstract.** Atoms and Molecules, particularly the latter are known to be sensitive to their physical environs. They have successfully been used to test/refine the available solar model atmospheres. In the present day scenario two sets of models are available viz., three dimensional models and single column homogeneous models. The former group which appears more realistic has led to a substantial reduction in abundances of certain atomic species whereas the latter is simple, easy to use and tested to explain such phenomenon as the C-L variation of continuum fluxes, line profiles of atomic lines, the rotational temperatures of molecular lines, estimates of abundances of several elements and the like.

Earlier the lines of the C2 Swan system of bands was utilized by us to determine whether the then available model atmospheres explained the center of the disc and a near limb observation of the rotational temperature. The conclusion was that the center of the disc temperature could well be reproduced but not the near limb one. A suggestion was made to revise the tested model atmospheres in the upper layers.

In the nineties when the controversy related to the solar abundance of Iron dominated the scene, after several exhaustive, detailed and careful scrutiny a simple solution was successfully employed to explain away and resolve the apparent controversy. This was related to the separate regions or layers of the solar atmosphere for the formation of lines due to neutral and ionized lines. A model was presented by the Belgian group of solar astronomers.

The aim of the present investigation is to report and examine in detail if the model by the Belgian group can reproduce the rotational temperatures of the C2 Swan system of bands and that of the vibration – rotation bands of the CO molecules formed in two very different regions of the photospheric spectrum. A variation on the accepted values of micro-turbulence is also considered. However, it must be noted that no attempt is made to suggest that the simplified and easy to use single column model atmospheres are to be used in place of the three dimensional model again by the Belgian group.

## (B) Stars and Galaxy

### **Non-Linear stability in generalized photogravitational restricted three body problem**

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**Abstract.** We have discussed the non-linear stability of triangular equilibrium point in generalized photogravitational restricted three body problem. Both primaries are taken as an oblate spheroid. We performed the first and second order normalization of the Hamiltonian of the problem. We have applied Arnold theorem to examine the condition of non-linear stability. We have found three critical mass ratios where this theorem fails.

### **Modeling interstellar extinction using a mixture of compact and aggregate particles**

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**Abstract.** The extinction generally occurs whenever electromagnetic radiation propagates through a medium containing small particles. The spectral dependence of extinction or extinction curve is a function of composition, structure and size of the particles. In the present work, we study the extinction efficiency ( $Q_{ext}$ ) of interstellar dust in the wavelength range 0.11 to 3.4  $\mu$ m. We propose a model which considers interstellar dust as a mixture of compact and aggregate particles, with composition of silicate and graphite. We consider compact particles as spheroidal particles and aggregates as Ballistic Cluster-Cluster Aggregate (BCCA) with some size distribution within a size range 0.004 to 0.31  $\mu$ m. We then generate the normalized average extinction curves in the wavelength range 0.11 to 3.4  $\mu$ m. It is found from our work that the proposed model can successfully reproduce the observed interstellar extinction curve.

### **Theoretical study of aminoacetonitrile, its ions and protonated forms in gas and astrophysical H<sub>2</sub>O ice**

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**Abstract.** The present study reports the theoretical infrared and electronic absorption spectra of aminoacetonitrile, its ions, cyanoprotonated and aminoprotonated forms in gas phase and astrophysical H<sub>2</sub>O ice using quantum chemical method. The second order Møller-Plesset perturbation (MP2) method with TZVP basis set is used

to obtain ground state geometries. An influence of ice on vibrational frequencies of neutral aminoacetonitrile was obtained using integral equation formalism model (IEFPCM). Significant shift in vibrational frequencies for neutral aminoacetonitrile when studied in H<sub>2</sub>O ice and upon ionization is observed. Electronic absorption spectra of aminoacetonitrile their ions, cyanoprotonated and aminoprotonated forms are obtained using time dependent density functional method (TDDFT). Vibrational frequencies, dipole moment, electron affinity, proton affinity and ionization potential of neutral aminoacetonitrile in gas phase are in good agreement with the available experimental frequencies at this level of theory. Rotational and centrifugal distortion constants are obtained at this same level of theory. The nature of electronic transitions is identified. We suggested lines especially good to be observed experimentally to detect these molecules in interstellar medium. Difference in spectroscopic signature of these molecules is obtained which will help in detecting and identifying these molecules in different astronomical environment.

### **Study of interstellar extinction by aggregate dust model**

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**Abstract.** Extinction generally occurs whenever electromagnetic radiation propagates through a medium containing small particles. The spectral dependence of extinction, or extinction curve, is a function of the composition, structure and size distribution of the particles. The study of interstellar extinction is important because they provide essential information for understanding the properties of the dust. In this work we have considered the aggregate dust model to interpret the extinction efficiency ( $Q_{\text{ext}}$ ) of interstellar dust in the wavelength range 0.11-3.4  $\mu\text{m}$ . Using Superposition T-matrix code with Ballistic Cluster-Cluster Aggregate (BCCA) aggregate having 64 number of monomers with graphite, astronomical silicates and amorphous carbon, the normalized extinction efficiency has been calculated for a well defined size distribution within a size range 0.001 to 0.077 micron of extinction near wavelength 2175 Å. The calculated normalized extinction efficiency curve is well matched with observed extinction efficiency.

### **Angular diameters of two miras and three semi-regular variables from near infrared lunar occultations at Mt Abu Observatory**

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**Abstract.** Uniform disk (UD) angular diameters of two Mira Variables and three semi-regular variables (SRVs), including a carbon star, derived from Lunar Occultation (LO) observations in the Near-Infrared (NIR) K-band at 2.2 microns are reported.

LO observations were made at the 1.2 m telescope of Mt. Abu observatory using two different Infrared detector systems – (a) A single channel InSb photometer and (b) A  $10 \times 10$  pixels subarray of NICMOS IR camera using a MCT detector array. The UD angular diameters derived from a detailed Modeling of the LO light curves are AW Aur (Mira):  $4.4 \pm 0.5$  mas; BS Aur (Mira):  $6.3 \pm 0.5$  mas; GP Tau (SRV):  $4.9 \pm 0.5$  mas, RS Cap (SRV):  $7.7 \pm 1.0$  mas and RT Cap (SRV, carbon):  $8.2 \pm 0.5$  mas. While the angular diameter values for RS Cap and RT Cap are in good agreement with earlier reported values, for the two Miras and GP Tau these are the first reported determinations of the angular diameter. Results derived from the angular diameters like the mode of pulsation of the two Miras and the effective temperatures, and possible circumstellar material of these sources will be presented.

### **Near-infrared study of fast nova KT Eridani**

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**Abstract.** We present near-infrared spectroscopic and photometric observations of the nova KT Eri taken during the first 100 days following its discovery on 2009 November 25.545 UT. The JHK spectra of the object have been taken from the Mount Abu Infrared Observatory using the Near-Infrared Imager/Spectrometer. The spectra, typical of the He/N class novae, show strong He I emission at 2.058 micron together with H I, O I and N I emission lines. The H I Paschen and Brackett spectral lines and the He I line at 2.058 micron show broad wings with a relatively narrow central component. The broad wings extend to  $\sim 3000$  km s<sup>-1</sup> while the central component has FWHM of  $\sim 1500$  km s<sup>-1</sup>. The optical light curve shows additional small amplitude outbursts near 38 and 70 days from the date of discovery. The distance of the nova is  $\sim 6.6$  kpc derived using MMRD relation and the estimated value of  $t_2 \sim 5.8$  days. The small value of  $t_2$  places KT Eri in the class of fast novae.

### **Trajectories of $L_4$ and Lyapunov characteristic exponents in the generalized photogravitational chemnykh-like problem**

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**Abstract.** Trajectories of the Lagrangian point  $L_4$  and the Lyapunov Characteristic Exponents (LCEs) are computed numerically. The dynamical behavior of near by trajectories is estimated by LCEs for various values of parameters. The values of LCEs remain positive for all the cases and depend on the initial deviation vector as well as the re-normalization time step. It is noticed that the trajectories are chaotic in nature and the  $L_4$  is asymptotically stable. The effect of radiation pressure, oblateness and mass of the belt are also examined in the present model

## A search for pulsations in chemically peculiar stars

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**Abstract.** Chemically Peculiar (CP) stars are hydrogen burning main sequence stars in the spectral range B8-F0. These stars have anomalous abundances, an over abundance of heavy elements up to a factor of  $10^5$  and under abundance of some light elements up to a factor  $10^{-2}$ . Among these stars, a group of stars have magnetic fields and this group is termed as A-peculiar (Ap) stars.

Pulsation is ubiquitous among chemically normal A-type stars, but comparatively rare among chemically peculiar Am and Ap stars of same spectral range. The conventional explanation for this is that diffusion produces the surface abundance anomalies in the chemically peculiar stars and also drains He from He II ionization zone, thus quenching the kappa - mechanism that drives the pulsation.

Using 104 cm telescope of Aryabhata Research Institute of Observational Sciences, we have observed 64 chemically stars between January 2006 to April 2009. From those observations, a total of four new pulsating variables (two roAp type variables and two Delta - Scuti type variables) have been discovered. Apart from these, in three other stars, we have also noted some variabilities. To confirm their variabilities, more observations are needed.

## Detecting modulations in NIR light curve of intermediate polar WX Pyx

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**Abstract.** We present near-infrared photometric study of the intermediate polar WX Pyx. J band light curve shows a modulation at  $\sim 26$  minutes. This period closely matches with the white dwarf spin period determined from previous X-ray and optical observations. A peak at period 5.3 hour is seen in the periodogram of NIR light curve and we attribute this with the orbital period of the system. Our analysis indicates that the secondary star is of M2 spectral type. The distance inferred from the surface brightness of M2 type secondary is 1.53 kpc. This suggests that the WX Pyx is one of the farthest IP known yet. The mass transfer rate and the magnetic moment of the white dwarf are estimated to be  $(0.95 - 1.6) \times 10^{-9} M_{\odot} yr^{-1}$  and  $(1.9 - 2.4) \times 10^{33} g cm^3$  respectively. Our analysis suggests that there is a steady partial disc present around the white dwarf and hence the mode of accretion in WX Pyx is disc-fed.



## **Anomalous absorption in a-type asymmetric top molecules in cosmic objects**

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**Abstract.** Since the detection of the first molecule OH in cosmic objects in 1963, scientists got interested in identification of molecules in the cosmic objects. By now more than 170 molecules have been identified. In order to know about the physical conditions prevailing in the cool cosmic objects and about the chemical reactions going on there, scientists are interested in identification of as many molecules as possible. In some molecular clouds, the kinetic temperature is very low, 10 - 20 K. For such objects, anomalous absorption, i.e., the absorption against the cosmic microwave background, may play an important role for identification of molecules. The transition 111 – 110 at 4.829 GHz of H<sub>2</sub>CO was the first one showing the anomalous absorption in the cosmic objects. The molecule H<sub>2</sub>CS also has been identified in the cosmic objects. We have discussed about the anomalous absorption of 111 – 110 transition in a-type asymmetric top molecules. For the investigation, the required parameters are the radiative and collisional transition probabilities. We can calculate radiative transition probabilities between the rotational levels. Calculation of collisional rates is a tedious job. In absence of accurate collisional rates, we can investigate the anomalous absorption in a qualitative manner by using the scaled values for collisional rates. We find that anomalous absorption of 111 – 110 transition is possible, provided collisional rates satisfy the required condition.

## **Lithium anomaly in K giants: Connection with RGB luminosity bump**

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**Abstract.** A few K giants are found to have anomalous high Li in their atmospheres. Adding to this anomaly, Li-rich K giants show far infrared excess and high rotation. Origin of overabundance of Li and associated peculiarities in Li-rich K giants are not well understood. To increase the sample size as well as to understand underlying physical process for excess Li, we have initiated spectroscopic survey of 2000 K giants along the red giant branch. This is the first major survey covering giants from RGB base to post luminosity bump in the HR diagram. Survey resulted in 14 new Li-rich K giants increasing the total number of Li-rich K giants by a factor of two. Importantly, all the Li-rich K giants occur at the luminosity bump suggesting their connection to internal changes in the star. We discuss the survey and the consequences

of the evidence that Li-rich phenomenon occurs only at a particular position on the HR diagram.

### **Large glitches, small glitches and timing noise**

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**Abstract.** Pulsars, generally, exhibit timing irregularities in the form of glitches and timing noise. Large glitches are characterized by a spectacular step change in rotation rate, usually accompanied by a change in spin-down rate. While these large glitches have a well-defined signature, small glitches exhibit all possible signatures. Some of these small glitches have been explained as mere timing noise, which is a fairly continuous erratic behaviour in phase, frequency or frequency derivative. To date, more than 500 glitches (large and small) have been reported in the conventional radio pulsars, binary pulsars, millisecond pulsars, AXPs, and other manifestations of neutron stars. Here, we present an analysis of glitches from these different manifestations of neutron stars and discuss the implications for the neutron star rotational stability.

### **A new principle of coherence in a synchrotron source**

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**Abstract.** A synchrotron source with a random distribution of velocity vectors for radiating charges will assumedly have no systematic phase relation between radiation fields from individual charges and would thereby give rise to an incoherent emission. It is known that synchrotron radiation mechanism does not allow a MASER type coherent emission. Here we show that a partial coherence due to antenna mechanism can be *inherently present in any compact synchrotron source*. Synchrotron radiation at an observing frequency selectively arises from relativistic electrons having a narrow range of Lorentz factors and moving in a cone of a narrow opening angle with respect to the line of sight to the observer, and thus having similar velocity vectors. As we show, even opposite charges moving within the cone augment each others radiation fields, contrary to what may be normally expected. The coherence volume grows with wavelength  $\lambda$  as  $\propto \lambda^3$ , giving rise to the possibility of coherence occurring at wavelengths larger than a certain value  $\lambda_p$  in a source. The coherence resolves many long standing astrophysical problems where theoretical predictions were not borne out by the observational data. For example, the spectrum gets enhanced by a factor  $\propto \lambda^3$  in the self-absorbed region. This resolves the observational puzzle of a flat spectrum instead of the theoretical steep slope - known in literature as a “cosmic conspiracy”. It further explains the brightness temperatures observed in space VLBI up to two orders

of magnitude higher than the theoretical incoherent synchrotron limit  $\sim 10^{11.5}$  K. A simple model for the variability, based on an injection of large number of particles resulting in coherence, explains the observed range of variability time scales (from less than a day to years) and the inferred extremely high brightness temperatures, up to  $\sim 10^{18-19}$  K, millions of time more than the theoretical limit. Coherence also explains the correlation observed in the optical/X-rays and the radio variabilities. In the case of a dense beam of monoenergetic electrons, e.g. in the case of synchrotron accelerators, the synchrotron spectrum may be that of an incoherent source at the peak near the characteristic frequency, but at sufficiently longer wavelengths coherence could be present, without the need of some specific mechanism for coherence.

### **Observational aspects of core collapse supernovae**

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**Abstract.** Core collapse supernovae are the end stages of most stars, more massive than  $8 M_{\odot}$ . As such, they provide a key test of stellar evolution. All subclasses of SNe, except for type Ia, are core collapse events. The differences in the observed properties of the various subclasses, and even within a single subclass, may be attributed to the progenitor mass, metallicity and environment. The light curve and the spectral development would enable obtaining certain critical parameters related to the progenitor. It is hence important to study individual SNe events. The aim of this work is to (a) study the individual objects in detail and obtain critical parameters such as the radioactive Nickel mass ejected during the explosion, the mass of the ejected material, velocity with which the material has been ejected, the explosion energy and the distance to the supernova; (b) estimate progenitor mass and radius and (c) group the individual events according to certain common properties and inter-compare the properties of the various groups to arrive at a possible evolutionary sequence of the progenitors.

### **Status update on double pulsar: Multi-frequency multi-epoch observations with GMRT**

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**Abstract.** The double pulsar system, J0737-3039, a highly relativistic binary system with two radio pulsars (periods  $\sim 23$  ms and 2.8 s), is an excellent system to study the gravity theories, processes in pulsar magnetosphere and the effects of geodetic precession on the observed pulse emission. It is a highly relativistic binary system with two radio pulsars in a tight edge-on mildly eccentric orbit with a significant advance of angle of periastron (orbital period 2.4 hr, orbital inclination angle  $87.7$  deg, eccentricity 0.09). PSR J0737-3039A exhibits a double peaked profile independent of

orbital phase with different spectral index for the two components, while PSR J0737-3039B exhibits a narrow profile, in two windows centered on orbital longitudes 210 and 280 deg (Lyne et al. 2004), called bright phase 1 and bright phase 2. Both profiles evolve significantly with observation frequency. The time-scale for geodetic precession is a factor of 4 shorter than that for Hulse-Taylor pulsar, PSR B1913+16, allowing these effects to be detected in a short time. Indeed, significant effects have been reported since the discovery of this system and in most recent observations with Giant Metrewave Radio Telescope (GMRT). A report on monitoring of this system at multiple frequencies and epochs with GMRT is presented and the implications of the results are discussed. An update on the current status of the research on this system is presented. In particular, the fading away of PSR J0737-3039B is reported.

### **A survey of nulling pulsars using GMRT**

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**Abstract.** Several pulsars show sudden cessation of pulsed emission, which is known as pulse nulling. In this paper, we are reporting nulling behaviour of 16 pulsars among which 6 were discovered recently in Parks Multibeam Survey and never reported any nulling behaviour. We are presenting some of the interesting nulling features of the few known nulling pulsars and also first time results on reduction in the pulsed energy during the null phase for all our samples. Fourier analysis has shown quasi-periodicity of nulling for few pulsars but no conclusive answer has been given till present date. To quantify the randomness of nulling pattern, we have applied few diehard randomness tests and compared obtained randomness with pulsar parameters to check for any correlations. We have also checked for any Hidden Markov Model (HMM) present in the null-burst length pattern.

### **Tracking the dispersion measure variation of millisecond pulsars using simultaneous dual frequency timing**

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**Abstract.** Dispersion Measure (DM) is one of the most important factors which can limit the accuracy with which one is able to time pulsars. The DM of a pulsar, in general, changes significantly with time due to reasons such as proper motion of the pulsar, plasma density changes in the binary orbit, drift of intervening inhomogeneous ISM, solar wind plasma. Hence, it becomes necessary to keep track of the changing

DM, especially for pulsar timing applications requiring very high timing precision, such as the various pulsar timing array projects which aim to detect gravitational waves. Drawing motivation from this as well as from an earlier work by Ahuja et al. (2005), who had achieved a DM accuracy of 1 part in  $10^4$  for long period pulsars, we initiated a project aimed to do regular simultaneous multi-frequency timing observation of a selected set of millisecond pulsars using the GMRT with the aim of studying (i) accurate DM variations of MSPs and their effects on timing accuracy and (ii) DM variations due to the solar corona and the solar wind. Preliminary results from the observations from previous three cycles are already demonstrating accuracies of DM measurements of a few parts in  $10^5$  for the MSP observations. With the further enhancements in observing modes of the GMRT software back-end that are planned, coupled with improved analysis techniques, it will soon be possible to get to our target of 1 part in  $10^5$  or better.

### **Self-similar flow behind a spherical shock wave generated by a piston moving in a gravitating or non-gravitating mixture of a non-ideal gas and small solid particles**

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**Abstract.** Self-similar solutions are obtained for one-dimensional isothermal and adiabatic unsteady flow behind a strong spherical shock wave propagating in a dusty gas with or without self-gravitational effects. The shock is assumed to be driven out by a moving piston and the dusty gas to be a mixture of non-ideal (or perfect) gas and small solid particles, in which solid particles are continuously distributed. It is assumed that the equilibrium flow-conditions are maintained and variable energy input is continuously supplied by the piston. The density of the ambient medium is assumed to be constant. The effects of an increase in the mass concentration of solid particles to the initial density of the gas, the parameter of non-idealness of the gas in the mixture, and the presence of self-gravitational field are investigated.

### **Suggestion for the search of H<sub>2</sub>CC in cool cosmic objects**

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**Abstract.** The transition 111-110 at 4.829 GHz of formaldehyde (H<sub>2</sub>CO) was the first one showing the anomalous absorption, i.e., the absorption against the cosmic microwave background. Anomalous absorption is an unusual phenomena. Structure of H<sub>2</sub>CC is very similar to that of H<sub>2</sub>CO and H<sub>2</sub>CS. Both H<sub>2</sub>CO and H<sub>2</sub>CS have already been identified in a number of cosmic objects. Though H<sub>2</sub>CC is not yet iden-

tified in the cosmic objects, we propose that H<sub>2</sub>CC may be identified in cool cosmic objects through its transition 111-110 at 4.85 GHz in anomalous absorption.

### **A suggestion for a search of the cyclic molecule c-C<sub>7</sub>H<sub>2</sub> in cool cosmic objects**

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**Abstract.** Cyclic molecules of the general series c-C<sub>n</sub>H<sub>2</sub> (*n* odd), where three of the carbon atoms form a triangle, have been supposed to be important species in cool cosmic objects. Here, we investigate the particular case of *n* = 7, i.e. c-C<sub>7</sub>H<sub>2</sub>, with the aim to obtain information about the rotational transitions by which the molecule could be identified in cool interstellar environments. Since this molecular species, to our knowledge, has not yet been fully studied experimentally we obtained the necessary structural parameters using a density functional theoretical approach employing the gradient corrected exchange-correlation functional B3LYP in conjunction with the extended cc-pVTZ basis set. The electronic structure calculations showed that c-C<sub>7</sub>H<sub>2</sub> has at least nine stable isomers, the two lowest of which being energetically equal. The first one has C<sub>2v</sub> and the other C<sub>s</sub> symmetry. Of these two structures we suggest the symmetric one for a search in cool cosmic objects. At the chosen level of electronic structure theory we obtained the rotational constants A = 7852.8326 MHz, B = 1565.0617 MHz, C = 1304.9804 MHz, and the electric dipole moment  $\mu = 3.853$  D. Though distortional effects might be significant they would not have a great influence on the qualitative behaviour of our investigation. We conclude that this molecule could be identified in cool interstellar environments by some of its rotational transitions 4<sub>23</sub> - 5<sub>14</sub>, 3<sub>22</sub> - 4<sub>13</sub>, 1<sub>11</sub> - 2<sub>02</sub>, and 3<sub>21</sub> - 4<sub>14</sub> at 3.0, 6.5, 0.5, and 9.1 GHz, respectively, in absorption against the CMB.

### **Arcturus stream : A case study**

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**Abstract.** Stellar streams are a group of gravitationally unbound stars which share same kinematic properties, and hence form coherent structures in the velocity space. Their origin is not clear. The concept of stellar streams or moving groups was in-

roduced much early (Eggen 1958) and were thought as dispersed cluster remnants retaining the original kinematics.

Subsequently, studies suggested that these are debris of accreted satellite galaxy in the Milkyway and belong to an old stellar population in the solar neighborhood. Kinematic studies reveal that the stream member stars are old and belong to thick disk of the Galaxy. Satellite accretion scenario is one front runner proposal for the thick disk formation in the Galactic disk.

In this study, we have explored one of the streams, known as Arcturus stream, through high resolution spectroscopy. Preliminary abundance results for a sample of Arcturus stream are obtained and compared with groups of stars that belong to thick disk and dwarf spheroidals. Alpha elements, that are known to be produced mainly in the massive but short lived SNII, seem to be enhanced relative to Fe, a dominant product in long lived SNIa. This suggests that the Arcturus stream stars are old and are mostly produced in the era where SNII was predominant.

Abundance results are very similar to the results of Galactic thick disk, which is a distinct component in the disk, both kinematically and chemically. It seems Arcturus is a subgroup within the thick disk but to establish whether the group is distinct from the thick disk, we have to determine differential age estimate for a sample of thick disk and Arcturus stars at the overlapping [Fe/H].

### **Abundance analysis of RV Tauri like stars**

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**Abstract.** We have done comprehensive abundance analysis using high resolution spectra for IRAS01427+4633, IRAS 06165+3158 and IRAS 19135+3937 which occupy the RV Tauri box in the IRAS two colour diagram. We have also analyzed RV Tauri stars SU Gem, V453 Oph and TX Per. We find abundance anomalies caused by selective depletion of refractive elements for SU Gem and IRAS 19135+3937, although the effect is less distinct for the later. This effect has been observed in some post-AGB stars and RV Tauri stars of spectroscopic class B. We have done a detailed abundance analysis for V453 Oph which is the only galactic RV Tauri star reported to exhibit s-process enhancement. We find relative enrichment of  $\alpha$  elements Mg, Si, Ca and Ti generally seen in old disk or halo objects and modest s-process enhancement [ $s/Fe = 0.6$ ]. We find very mild indication of s-processing in IRAS 06165+3158; a metal-poor object with RV Tauri like colours.

## Frequency analysis of systemic components of eight eclipsing binary systems

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**Abstract.** We present the photometric observations of 8 Algol-type eclipsing binary systems showing mass transfer activity to study the pulsations in their primary component. These are important targets for asteroseismology to explore their internal structure using pulsation frequencies. High-speed photometric observations of these stars were taken using three-channel fast photometer attached to the 1.04-m Sampurnanand telescope at ARIES during the year 2006-2008. We detect the delta-Scuti type pulsations in primary component of three binary systems viz. X Tri, RW Per and TV Cas. We do not find any new frequency in the known delta-Scuti systems like RZ Cas, AB Cas and AS Eri. Also delta-Scuti variability in the mass transfer systems RY Per and ST Per is not observed. We obtain an empirical relation between the orbital period and pulsation period of the primary. A longer orbital period of a binary component indicates a longer pulsation period. It is also found that larger force  $F$  (exerted by the secondary onto one gram of the primary) gives small pulsation period. However, the empirical relation discussed here needs more theoretical and observational confirmations.

## Space velocity of NGC 6121 (M4)

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**Abstract.** We present mean absolute proper motions of a globular cluster NGC 6121 (M4), determined by using the data from the UCAC2 Catalog. About 1500 stars brighter than 16.0 mag in J are measured in  $30'' \times 30''$  area. The space velocity component  $U = 10 \pm 5$ ,  $V = 10 \pm 5$  and  $W = 10 \pm 5$  km s<sup>-1</sup> are determined using absolute proper motion.



## J-band spectroscopy of classical Be stars

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**Abstract.** Classical Be stars (CBe) are rapidly rotating ( $V_{\text{sin}i} \sim 300 \text{ km s}^{-1}$ ) B-type stars with equatorial circumstellar decretion disks, the production of which is under debate. The Be phenomenon can be understood through the analysis of hydrogen recombination lines in the infrared spectral region. J-band spectroscopy of Be stars is one of the less studied fields in Be star research. We took J-band (11000 - 14000 Å) spectra of 34 CBe stars using the NICMOS instrument available with 1.2 m Mt. Abu infrared observatory. The spectra are interesting due to the presence of neutral oxygen (O I) lines, 11287 and 13165 Å, in addition to Paschen beta and Paschen gamma lines of hydrogen. The optical depth effects in the observed emission lines from the circumstellar disk have been deciphered through the line flux ratio analysis of the Paschen lines. The analysis of the O I lines has been used to understand the role of Lyman-beta fluorescence in the formation of these lines. Also, we used the spectra taken at different epochs separated over 1 year to study the variability in CBe stars.

## Infrared photometric study of the massive star forming region S235 using Spitzer-IRAC and Mt. Abu JHK observations

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**Abstract.** S235 complex is known to be a site of triggered star formation due to the expansion of H II regions. We present the Spitzer-IRAC images and IRAC ratio maps of the S235 star forming complex. In addition, we present the Mt. Abu near-infrared images of the two H II regions in the complex, called S235A and S235B. The IRAC photometry reveals on-going star formation, with 83 Class 0/I and 115 Class II YSOs in the entire S235 complex. We have identified a new young protostar “e2s3” in the region passing through its accretion phase. The IRAC ratio map of Ch2/Ch4 reveals that the source “e2s3” may be associated with shock-excited molecular hydrogen emission outflow. The Spectral Energy Distribution (SED) modeling of this new source indicates that it is a very young massive star that is not yet able to drive an H II region. A few young stellar objects (YSOs), possibly in an arc-like formation, are identified towards the south of S235A in the S235A-B region, which may be an evidence for magnetically super-critical collapse. One of the sources in the arc-like formation, namely S235AB-MIR, seems to be a young, massive star that is still accreting matter. The IRAC ratio map of Ch2/Ch4 traces clearly the Brackett alpha emission associated with the H II region of S235A within the horse-shoe envelope. Outside the horse-shoe structure, the ratio map indicates shock-excited molecular hydrogen emission.

## Optical follow-up of core-collapse supernovae 2010hq and 2010jl

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**Abstract.** We present the preliminary results from the optical photometric and low-resolution spectroscopic observations of the core-collapse type II supernovae 2010hq and 2010jl. With unfiltered discovery magnitudes of 14.7 and 12.9, these are the brightest type II events seen this year. Our first spectrum of SN 2010hq, taken nearly 30 days after discovery shows strong P-Cygni profiles of  $H_{\alpha}$ ,  $H_{\beta}$  and Na I D. It also shows various metallic absorption lines, mainly due to Fe II multiplets, Ca II, O I, and forbidden [Ca II] lines. This spectrum is typical of a type IIP event in its plateau phase. SN 2010jl is an energetic, rare type IIn burst, which has also been detected in the X-ray and UV bands. Proximity of this event, along with early discovery, allows us to conduct a detailed photometric and spectroscopic study of this object from the beginning. We also present the observationally derived parameters of these SNe and compare their properties with other core-collapse events of similar kind.

## UBVRI photometry of young Galactic cluster NGC2129, NGC1502 and King12

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**Abstract.** We present new optical photometry of open clusters NGC 2129, NGC1502 and King12 using data taken from the 104 cm Sampurnanand Telescope, Nainital. Our UBVRI CCD data reaches down to  $V \sim 21$  mag, covers about twice the apparent size of the clusters and for King 12, it is presented for the first time. The archival near-infrared data from 2MASS is used to study the fundamental parameters and mass function of the clusters. Accurate structural parameters for the clusters are derived using radial density profiles while the evolutionary parameters are derived comparing colour-colour and colour-magnitude diagrams with the theoretical models. The mean reddening  $E(B-V)$  towards the cluster is found to be 0.73 mag, 0.69 mag and 0.62 mag. All the three clusters have ages of about 10 Myr; distances (in kpc) of 2.2, 0.96 and 3.02 respectively. The sizes of cluster lie in the range 1pc to 3.5 pc. Mass function for all the clusters are found to be consistent with the Salpeter value for Galactic field stars. Cluster NGC 2129 is found to be a typical case of an overlapping double open cluster.

## Photometric and spectroscopic studies on barium stars

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**Abstract.** Barium stars are mostly G, K giants that are characterized by enhancement of heavy elements relative to Fe as well as enhanced CH, CN and C<sub>2</sub> molecular bands. Observed enhancement in abundances of heavy elements in these objects are generally explained to be a result of mass transfer from a companion star that has undergone its second ascent of the giant branch, becoming an AGB star. Results from photometric and spectroscopic analysis for a sample of barium stars will be presented.

## UBVRI CCD photometry of open clusters Haffner 9 and Waterloo 7

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**Abstract.** In the present work we have analyzed the CCD photometric data of two not-so-well studied open clusters Haffner 9 and Waterloo 7 in the UBVRI pass bands. This study is a part of the major project undertaken to provide a better picture of the stellar populations in the Galactic disk, with an aim to obtain the basic parameters of these clusters for the first time. They were observed on 12 November 2005 and 11 January 2006 respectively with the 2m Himalayan Chandra Telescope at Hanle. The colour excess  $E(B-V)$  is estimated to be 0.55 mag for Waterloo 7, whereas the cluster Haffner 9 shows differential reddening of 0.82 - 0.95 mag. By using the star count method we have estimated the cluster radius as 4 and 3.5 arcmin respectively for Haffner 9 and Waterloo 7. Further the clusters Haffner 9 and Waterloo 7 are estimated to be at a distance of  $3.63 \pm 0.5$  and  $2.512 \pm 0.5$  kpc respectively. The  $\log(\text{age})$  of Haffner 9 is estimated to be 8.20 and that of Waterloo 7 is 7.75.

## Fully automated period detection from variable stars' time series data

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**Abstract.** The exact period determination of a multiperiodic variable star based on its luminosity time series data is believed a task requiring skill and experience. Thus the majority of available time series analysis techniques require human intervention to some extent. Relying on the SigSpec technique (Reegen 2007), a fully automated method of period (or frequency) determination from the time series data of variable stars is developed. The SigSpec technique established here employs a statistically un-

biased treatment of frequency-domain noise and avoids spurious (i.e. noise induced) and alias peaks to the highest possible extent. We present tests on 386 stars taken from ASAS2 project database. From the output file produced by SigSpec, the frequency with maximum spectral significance is chosen as the genuine frequency. Out of 386 variable stars available in the ASAS2 database, our results contain 243 periods recovered correctly, 88 half periods, 42 different periods etc. Thus SigSpec has the potential to be effectively used for fully automated period detection from variable stars' time series data. The exact detection of periods helps us to identify the type of variability and classify the variable stars, which provides a crucial information on the physical processes effective in stellar atmospheres.

### **Optical studies of SN 2009jf: A type Ib supernova with an extremely slow decline and aspherical signature**

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**Abstract.** Optical *UBVRI* photometry and medium resolution spectroscopy of the type Ib supernova SN 2009jf, during the period  $\sim -15$  to  $+250$  days with respect to the *B* maximum are reported. The light curves are broad, with an extremely slow decline. The early post-maximum decline rate in the *V* band is similar to SN 2008D, however, the late phase decline rate is slower than other studied type Ib supernovae. With an absolute magnitude of  $M_V = -17.96 \pm 0.19$  magnitude at peak, SN 2009jf is a normally bright supernova. The peak bolometric luminosity and the energy deposition rate via  $^{56}\text{Ni} \rightarrow ^{56}\text{Co}$  chain indicate that  $\sim 0.20_{-0.03}^{+0.03} M_\odot$  of  $^{56}\text{Ni}$  was ejected during the explosion. He I 5876 Å line is clearly identified in the first spectrum of day  $\sim -15$ , at a velocity of  $\sim 16000 \text{ km s}^{-1}$ . The [O I] 6300-6364 Å line seen in the nebular spectrum has a multi-peaked and asymmetric emission profile, with the blue peak being stronger. The estimated flux in this line implies  $\geq 1.3 M_\odot$  oxygen was ejected. The slow evolution of the light curves of SN 2009jf indicates the presence of a massive ejecta. The high expansion velocity in the early phase and broader emission lines during the nebular phase suggest it to be an explosion with a large kinetic energy. A simple qualitative estimate leads to the ejecta mass of  $M_{\text{ej}} = 4 - 9 M_\odot$ , and kinetic energy  $E_K = 3 - 8 \times 10^{51} \text{ erg}$ . The ejected mass estimate is indicative of an initial main-sequence mass of  $\geq 20 - 25 M_\odot$ .

### Photometric variability of two BY Dra type stars

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**Abstract.** We present the analysis of the light curves of two BY Dra type variables V1147 Tau and V401 Vul. These two stars were observed from 104 cm Sampurnanand Telescope of Aries. For our analysis, we have also used the archival data from Hipparchus and All Sky Automated Survey(ASAS). Our period analysis shows the stars V1147 Tau and V401 Vul are periodic variable with the period of 1.5 days and 2.161 days respectively. Light curves observed at different epochs show change in minima, amplitude and shape. This indicates that the variability is due to the presence of dark spots.

### A CCD photometric study of the short period W Uma type eclipsing binary: FZ Orionis

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**Abstract.** We have carried out a new B, V, R and I broadband CCD time series photometry of a contact binary FZ Orionis. The light curves are analyzed by using Wilson-Devinney code. The present analysis shows that FZ Ori is a W-subtype of W Uma contact binary. The mass ratio and temperature difference are determined to be  $0.56 \pm 0.01$  and  $\Delta T = 65 \pm 59$ , respectively. However the radii of primary and secondary components are found to be  $R_1/R_\odot = 1.28$  and  $R_2/R_\odot = 0.98$ , respectively. The binary system shows small asymmetries in the light curve shape around the primary and secondary maxima. This could be due to the presence of hot spots on the primary component.

### Infrared emission modeling for vinyl PAHs

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**Abstract.** Polycyclic Aromatic Hydrocarbon (PAH) molecules are source of the infrared emission features at 3.3, 6.2, 7.7, 8.6, 11.2, 12.7 and 16.4 microns that are ubiquitously observed in diverse astrophysical objects. There are variations in the profile of these emission features between sources ranging from star forming regions to late type stars and also extra galactic sources. The profile variations point towards

the presence of a variety of PAHs in different population in different objects. In order to simulate the emission spectra from different sources the vibrational spectra of a wide variety of PAH molecules have been studied. The modeled emission spectra gives good match for some bands but simultaneous fit for all features is not obtained. In particular the 6.2 micron feature, assigned to C-C stretch mode, is not fitted well. We therefore also study PAHs with vinyl side groups. Quantum chemical calculations using DFT/B3LYP in conjugation with optimum basis are performed to obtain the IR spectra of vinyl PAHs. Modeling of emission is done assuming excitation by a UV photon and cascade emission through vibrational levels that are obtained theoretically. It is expected that due to the presence of C = C in vinyl group the aromatic C-C might shift closer to 6.2 micron. A closer match with the observed spectra will provide a better insight about the physical conditions and molecular evolution in the object.

### **Photometric and spectroscopic evolution of the type IIp supernova SN 2008in**

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**Abstract.** We present optical photometry and spectroscopy of the normal type IIp supernova SN 2008in which was discovered in the galaxy M61 (NGC 4303) about 10 days after the explosion. We calculated the distance to M61 of  $15.2(\pm 3)$  Mpc using Standard Candle Method (SCM) and Expanding Photosphere Method (EPM). The ejected nickel mass during the explosion is estimated to be  $0.025(\pm 0.01) M_{\odot}$ . The plateau luminosity, its duration (about 90 days) and the expansion velocity of the supernova ejecta at the middle of the plateau indicate an explosion energy of  $8.6(\pm 2.5) \times 10^{50}$  ergs, and the ejected envelope mass of  $16(\pm 4) M_{\odot}$  which gives the main sequence mass of  $20 M_{\odot}$ .

### **Clues to the origin of RCB Stars**

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**Abstract.** The R Coronae Borealis (RCB) stars are a group of H-deficient stars. The visual magnitude of these stars declines to several magnitudes at unpredictable times. The decline in their magnitude is caused by the formation of dust in the line of sight. The process that is responsible for the origin of these stars, which transforms a normal star into a H-poor RCB star, is still not clear. There are two proposed scenarios for their origin. One is the merger scenario, that involves merging of a He white dwarf with a C-O white dwarf, and the other is, the final He-shell flash that occurs at the late stages of a single star's evolution. The aim is to investigate the origin of these stars in the light of their observed spectroscopic signatures. One of the important features are

the presence of  $^{12}\text{C}^{13}\text{C}$  molecular bands in the spectra of these stars. The presence of  $^{13}\text{C}$  in their spectra is a clue to their origin.  $^{13}\text{C}$  is not expected in the merger scenario as most of the carbon content in the merged product has come from the C-O white dwarf, that is the triple alpha processed material  $^{12}\text{C}$ . Here, I will present the observed spectroscopic clues that can explain the origin of these stars.

### **Near-infrared studies of the recent (2008) outburst of V1647 Ori**

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**Abstract.** V1647 Ori, McNeil's object is a low mass young stellar object showing outburst activity possibly like Exors. Following the well documented 2004 outburst (e.g., Ojha et al. MNRAS, 2006, 368, 825) that lasted for nearly two years, V1647 Ori underwent another outburst episode in August 2008 (IAUC 8969). We have been making regular follow-up near-infrared observations at Mt. Abu observatory during the current outburst phase. Our observations showed that there were no significant changes in the infrared photometric magnitudes during this outburst phase so far, lasting for more than two years. However the H and K band spectra indicate variability in the spectral features (H I Brackett series, first and second CO overtone bands) on month scales, possibly due to variability in mass-accretion rate. Details of these observations and their implications will be presented.

### **Star formation history of some young open clusters**

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**Abstract.** Young open clusters have always been a platform for star formation studies. Irrespective of the previous assumption that all members in the cluster are coeval, recent studies show the presence of age range in young open clusters. Our study, based on multi-wavelength analysis of clusters younger than 40 Myr tries to identify any episodic formation of stars in young clusters. In this poster we present the results obtained for 5 young clusters; all less than 40 Myr. We used deep field optical UBVR photometry, spectroscopy, NIR data from 2MASS and Spitzer data at mid and far IR wavelengths. We have looked for episodic star formation in these clusters, giving rise to a range in age for the cluster stars and have attempted to model their star formation history.

## Exploring the disk accretion in DI Cep

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**Abstract.** The low mass young stellar objects of class-II, popularly known as classical T Tauri stars (CTTS) supposed to be surrounded by thick flared disk and accretes disk material through strong stellar dipolar magnetic field. The disk accretion rate and its variation with time is poorly know. DI Cep is an interesting object, found to have unexpected hump around 5300 Å in the continuum excess emission spectrum, which cannot be explained by current models of YSOs. Over the last six years this object is being spectroscopically as well as photometrically monitored using HCT. The data have been analyzed and modeled using a simple modeling technique developed by us. In this paper, we report for the first time our results related to the disk accretion phenomena in DI Cep.

## Magnetic field geometry in L1014: A dense core with a very low luminosity object

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**Abstract.** The small compact isolated dark clouds also known as Bok globules are believed to be ideal sites of low-mass star formation. Some of these clouds are undergoing gravitational collapse, and the ambient magnetic field plays a key role in collapse dynamics. A study of projected magnetic field geometry of molecular clouds in relation with their other properties, like the structure, kinematics, and alignment of any bipolar outflows that may be present in the cloud, can give us great insight into the role played by the magnetic field in shaping the structure and dynamics of these objects. The background star polarimetry is generally accepted as a useful tool to map the magnetic field geometry at the periphery of the clouds, which is responsible for the alignment of dichroic grains that produce polarization. We observed stars projected on L1014 to measure linear polarization using ARIES Imaging Polarimeter (AIMPOL) mounted on the 104 cm Sampurnanand telescope during the period of November–December, 2010. L1014 was previously thought as a starless dense core. Dense cores are considered to be starless if they do not contain an Infrared Astronomical Satellite (IRAS) point source to a sensitivity of  $L \sim 0.1L_{\odot} (d/140)^2$ . But Spitzer observations of L1014 as a part of Spitzer Legacy programme “From Molecular Cores to Planet Forming Disks” came as a surprise. L1014 was found to contain an embedded source, L1014IRS, with a very low luminosity of  $L \sim 0.09L_{\odot}$ . Furthermore, a compact low-mass bipolar molecular outflow was detected and confirmed to be associated with L1014. In this poster we will be presenting our preliminary results of a study conducted to investigate any possible relationship between the cloud magnetic



field orientation with other properties of the cloud and that of the embedded low-mass source.

### **Star formation activities in Sharpless 311 complex**

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**Abstract.** The H II region NGC 2467, also known as Sharpless 311, is located at a distance of 4.1 kpc. This region is dominated by one O6 Vn star, HD 64315. There are also two stellar clusters in the area, Haffner 19 (H19) and Haffner 18ab (H18ab). Hubble Space Telescope (HST) Advanced Camera for Survey (ACS) data shows a large number of brightened ridges and cloud fragments in NGC 2467 (De Macro et al. 2006). Recently, Sinder et al. (2009) found several YSO candidates at the edge of the H II region, indicating a possible site of induced star formation. We present the results of optical and near-infrared (NIR) observations with the KISO and CTIO telescope, to search for very low mass young stellar objects in this region. We construct JHK color-color and J - H / J to identify very low luminosity young stellar objects and to estimate their masses. Based on these color-color and color-magnitude diagrams, we identified a population of embedded YSO candidates with infrared excesses (Class I and Class II), associated with the region. Based on these observations, we will present the nature of these YSO candidates and associated cluster properties. We will also try to interpret the possible star formation scenario in this complex.

### **Star formation activity in W4 cloud complex**

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**Abstract.** W4 H II region, a part of large cloud complex W3/W4/W5 in the Perseus arm, is a good candidate to study the induced star formation at the peripheries due to the joint effect of several massive stars. We present the preliminary results of our optical and archival infrared (2MASS and Spitzer) photometry of the H II region. We identified several young stellar objects (YSOs; Class I and Class II) using near and mid-infrared colour-colour diagrams. The non-asymmetric distribution of the YSO candidates indicates triggered star formation in the bright-rimmed clouds associated with the H II region.

**A photometric survey for short-periodic variables in globular clusters NGC5024**

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**Abstract.** We are presenting the results of a commissioning campaign to observe Galactic globular clusters for the search of microlensing events. We have observed the cluster NGC5024 in March 2010. Light curves were obtained for 9,600 stars, out of which we identified 60 known variables and revised periods of some of short-periodic variables. We identify about at least half a dozen new variable sources, present their periods and light curves. We also present a candidate eclipsing binary, first ever found in this cluster.

**Young stellar population and triggered star formation in the star-forming complex SH2-252**

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**Abstract.** Sh2-252 is a large H II region ionized by the O6.5 star HD 42088, associated with the cluster NGC 2175 and is a part of the Gem OB association. The sub-H II regions Sh2-252 A, B and C of this complex are thought to be formed in the swept up cloud created due to the interaction of the ionization front of the massive star HD 42088 with the surrounding molecular cloud. Hence this complex is an ideal target to study the properties of the young stellar objects (YSOs) and initial mass function (IMF) in triggered star forming conditions. We have performed deep optical imaging survey of the region in the  $V$  and  $I_c$  bands over an area of  $\sim 1^\circ \times 1^\circ$  down to 23 magnitude in  $V$ . Using the Spitzer-IRAC observations,  $\sim 500$  candidate YSOs (Classes 0/I/II) have been identified indicating the richness of this complex with the young stellar population.  $H\alpha$  slitless spectroscopy survey of the region helps identifying over 60  $H\alpha$  emitting sources. Spatial distribution of these candidate YSOs shows number of sub clustering across the region and most of them are seen to be obscured in the optical observations. The location of these candidate YSOs on the  $(V - I)/V$  colour-magnitude diagram reveals that  $\sim 90\%$  of the YSOs have ages  $\leq 5$  Myr with a median age of  $\sim 2-3$  Myr and have masses in the range of  $0.3 - 2.5 M_\odot$ . The characteristics of the YSOs, evolutionary scenario of the sub-H II regions and IMF of the complex will be discussed in this presentation.

## Comprehensive abundance studies of four open clusters

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**Abstract.** Galactic open clusters are excellent tools to study the chemical evolution of Galaxy. They provide a sample of stars homogeneous in age and chemical composition and their distances are well determined. We have analyzed high resolution spectra (40,000) of red giant members for each cluster to derive abundances for a whole range of elements including light as well as heavy elements. We have measured equivalent widths for large number of lines for each species and have used model atmosphere grid developed by Kurucz and Castelli and 2009 version of spectrum synthesis code. For each cluster 4-5 red giants are analyzed. The membership to the cluster has been confirmed through their radial velocities and proper motions. The spread in temperatures and gravities being very small nearly the same stellar lines were employed thereby reducing the random errors. The errors of average abundance for the cluster were generally in 0.02 to 0.07 dex range.

Our present sample covers galactocentric distance range of 8.8 to 10.98 kpc. Most of these clusters are located in anti-center direction. NGC 752 exhibits near-solar [Fe/H] of  $-0.05$ , NGC 2360  $-0.11$ , NGC 1817  $-0.15$  and NGC 2506  $-0.32$ . The cluster to cluster variations are encountered for alpha elements, Fe-peak elements and for s and r-process elements. The present sample is quite modest and would be extended for a larger set of clusters. For each cluster the observed chemical abundance patterns, when sufficiently different in one or more elements, offer the possibility to reconstruct now dispersed stellar aggregates of the protogalactic disk and so improve our basic understanding of the disk formation process.

## Constraints on the formation of low-mass X-ray binaries

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**Abstract.** Standard formation scenarios for Low-mass X-ray Binaries (LMXBs) require careful fine-tuning of parameters at essentially every stage of the envisaged formation processes. This makes LMXB formation an extremely low-probability event. We here discuss various constraints on the parameters of the primordial binary system for the survival of the binary through formation stages like common envelope evolution and supernova explosion. The dependence of these constraints on the parameters affecting the above processes is demonstrated. The probability of formation of possible pre-LMXBs is then calculated for a given distribution function of primor-

dial binaries. An analytical method is suggested for the calculation of pre-LMXB distribution functions which can be used for LMXB population synthesis.

### **Distinguishing black hole and neutron star binaries through spectral evolution**

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**Abstract.** In this work, we have studied spectral evolution of several X-ray Binaries (XRBs) containing Neutron Star (NSXBs) and Black Hole (BHXBs) during outbursts. We find that during the rising phase of outbursts, transient BHXBs and persistent BHXBs trace entirely different trajectory in the Hardness Intensity Diagram (HID) but during the decay phase, they trace similar trajectory. The path traced by NSXBs is although closer to the path followed by the persistent BHXBs but there are subtle differences. The path followed by the NSXBs during the rising phase of the outburst lies above the path that is traced during the decay phase. However, in case of persistent BHXBs these two trajectories almost overlap. We have also carried out a detailed spectral analysis to understand the actual physical mechanisms driving the movement of the source in the HID. Spectral evolution of transient and persistent BHXBs show remarkable differences. X-ray spectral evolution of persistent BHXBs and NSXBs are also substantially different. We find that the Compton cooling is caused by enhanced disk emission during the rising phase. During the decay phase electron temperature is increased due to heating of the corona. Persistent BHXBs show entirely different spectral evolution than that seen in the NSXBs suggesting a different accretion disk geometry and radiative processes.

### **Quasi periodic oscillations in high magnetic field accretion powered pulsars**

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**Abstract.** We will present the discovery of Quasi Periodic Oscillations (QPOs) in several transient high magnetic field accretion powered pulsars using RXTE/PCA observations of few sources during their outbursts. Remarkably, in two of these sources, the QPOs have been detected only in a few observations near the end of the outbursts when the source intensity had decayed by more than two orders of magnitude from the peak of the outbursts. The QPO features are found to have significant energy and intensity dependence. These low frequency QPOs have so far been observed in 21 high magnetic field pulsars, a number comparable to or larger than any other class of

X-ray sources. We investigate if the measurements of the QPO frequency and X-ray luminosity can be used to estimate the magnetic field strength reliably.

### **Energy dependent pulse profiles and pulse phase resolved spectroscopy of transient HMXB pulsars**

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**Abstract.** We will discuss the complex energy and intensity dependence of the pulse profiles of a set of transient HMXB pulsars. We have detected strong energy dependence of the pulse profiles for these pulsars during outbursts. The pulse profiles are double peaked up to 10 keV and have a single peak at higher energy. We find that the energy spectra can be well fitted with a partial covering powerlaw model with high energy cut-off and an iron fluorescence line emission. The pulse phase resolved spectral analysis shows that the partial covering and high energy cut-off model parameters have significant changes with the pulse phase explaining the complex energy dependence of the pulse profiles.

### **Comparative study of black hole transients XTEJ1652-453 and XTEJ1752-223**

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**Abstract.** Transient sources are seen to undergo a sudden increase in flux to achieve its peak within very few days and then slowly decay over several days or months to the quiescent level. These are binary systems which can be either a LMXB or HMXB. Here we explain the characteristics of two transient sources XTE J1652-453 and XTE 1752-223, both first discovered by PCA on-board RXTE (Rossi X-ray Timing Explorer). XTE J1652-453 was detected during two PCA scans on 28th June, 2009 and 1st July 2009 and is located at an R.A of 16h52m20.33s and Dec of  $-45^{\circ}20'39.6''$  in the galactic centre region; while XTE J1752-223 was detected on 23-10-2009 in the galactic bulge region at R.A = 17h52m13.2s and Dec =  $-22^{\circ}18'30''$ . XTE J1652-453 is observed to have a faster rise to the peak, while XTE J1752-223 had a very slow rise along with a precursor. The spectral study suggests that both the sources do have thermal and non-thermal emissions and show different characteristic spectral state transitions. From the data analyzed, it is understood that XTE J1752-223 rises from its quiescence to the Low/Hard state, then into the High/Soft state via the intermediate state. Both XTE J1652-453 and XTE J1752-223 remain in the High/Soft state while in the peak, and during decay exhibit intermediate state for a long period of 2 months and enter the Low/Hard state before reaching the quiescence.

Spectral study of both the sources also shows the presence of a relativistic Fe  $K\alpha$  emission line. Type C QPO's are seen in the case of XTE J1752-223 while in the intermediate state, but no characteristic features or QPO's are seen in XTE J1652-453. An estimation of the innermost radius of the accretion disc and equivalent mass proves that both the sources are LMXB's and black hole candidates. We would like to present a comparison of both these sources by spectral and timing analysis.

### **Broadening of pulse frequency peak in accretion powered pulsars**

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**Abstract.** In many X-ray pulsars, a broadening is seen in the wings of the pulse frequency peak which is understood to be a coupling between the periodic variability and the low frequency aperiodic variability. In a transient X-ray pulsar 4U 1901+03, we have found intensity dependent changes in the pulse profile at very short timescales. We attribute the broadening of the pulse frequency peak in this source to these systematic changes in the pulse shape. Similar analysis has been done for several other pulsars to investigate if in all sources the pulse peak broadening takes place due to pulse shape changes. We will present here a summary of our investigation of this phenomenon of pulse frequency peak broadening.

### **Stable X-ray states in X-ray black hole binaries**

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**Abstract.** We suggest that the low hard state (LH), high soft state (HS) and steep power low state (SPL) are stable X-ray states and all other X-ray states are intermediate states seen when source travels between any two stable states during the evolution of outbursts in black hole X-ray binaries (BHXBs). The SPL state represents highest accretion rate region during an outburst. During the rising phase of outbursts, source follows one of the two opposite routes to the SPL (1) source may follow anti-clockwise path in the hardness intensity diagram (HID). In this case, the accretion disk is initially cold and truncated at large radii, and (2) it may follow clockwise path in the HID. In this case, the accretion disk is hot and extended up to the innermost stable circular orbit (ISCO). During the decay phase of all outbursts, source always follows anti-clockwise path. The accretion disk is hot and extended up to the ISCO.

## Dips in the pulse profiles of accretion powered pulsars

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**Abstract.** We report detection of sharp dips in the pulse profiles of several persistent and transient accretion powered X-ray pulsars using RXTE observations. The pulse profiles of accretion powered pulsars carry a lot of information regarding the radiative processes near the surface of the star, magnetic fields that channel the accretion flow etc. The dips in the pulse profiles can be due to the interaction of accretion column with the emitting radiation as it passes through the line of sight. We have also investigated the energy and intensity dependence and phase width of these dips to have a better understanding of the nature of the absorbing material. Any intensity dependence of the pulse phase of the dips will also reveal the nature of the absorbing structure in relation to the neutron star.

## VHE pulsar observations with HAGAR telescope array

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**Abstract.** Few pulsars including Crab and Geminga have been observed by the HAGAR telescope array since its commissioning phase. We have collected almost 76 and 49 hours of data from sky regions containing Crab and Geminga pulsar. Preliminary analysis indicates that there is no pulsed emission from these sources. In this work we report our analysis regarding search for gamma ray emissions in pulsed mode and set upper limits from time averaged fluxes.

## Near-Infrared observations of Be X-ray binary pulsar A0535+265

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**Abstract.** We present results obtained from the near-infrared spectroscopic observations of the Be X-ray binary pulsar A0535+262 at different phases of its  $\sim 111$  day orbital period. The binary companion of the pulsar HDE 245770 is an O9.7-B0 IIIe star in a relatively wide eccentric orbit. The pulsar shows regular X-ray outbursts with the orbital periodicity during which, the X-ray luminosity increases up to as high as three orders of magnitude. To investigate the effect of the X-ray outbursts on the optical/infrared emission from the binary companion, observations of the Be star

were carried out using the 1.2 m telescope at Mt. Abu IR observatory. Near-IR spectroscopy of the object shows that the JHK spectra are dominated by the emission lines of hydrogen Brackett and Paschen series and He I. The strengths of these (prominent) lines are enhanced during the X-ray outburst phase compared to that of the X-ray quiescent phase. The He I lines at 1.0830 micron and 2.0585 micron are found to be very strong during the X-ray outburst phase. Along with these He I lines, we also detected an emission He I line at 1.7002 micron. This He I line is found to be present only during the X-ray outburst and vanishes during the X-ray quiescent phase. The details of the near-IR observations will be discussed.

### **X-ray spectroscopy of the high mass X-ray binary pulsar Centaurus X-3 over its orbit**

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**Abstract.** Dipping activity in the X-ray intensity in binary systems is believed to be caused by the obscuration of X-rays from the compact object by structures located in the outer regions of the accretion disk. As dips are very rarely seen in the High Mass X-ray Binaries (HMXB) which is rather common in case low mass X-ray binaries, it is interesting to investigate the properties of the pulsar in HMXB systems showing dips. Here, we present a detailed and comprehensive spectral analysis of the of Suzaku observation of Centaurus X-3 covering the eclipse, out-of-eclipse, and dips in the light curve. The broadband energy spectra of the pulsar, during the eclipse, out-of-eclipse, and dips are found to be well described by a model consisting of a partial covering power-law with high energy cut-off and three Gaussian functions for 6.4 keV, 6.7 keV, and 6.9 keV iron emission lines. The dip in the X-ray light curve can be explained by the presence of an additional absorption component with high column density and covering fraction the values of which are not very significant during the rest of the orbital phases. The parameters of the three iron emission lines are also significantly different compared to those during the rest of the observation. The flux variations of the three iron line components are used to investigate the emission regions. The details of the results will be presented.

### **Timing and spectral properties of transient X-ray pulsar GRO J1008-57**

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**Abstract.** We present the timing and spectral properties of the Be transient high



mass X-ray binary pulsar GRO J1008-57 using Suzaku observation in the declining phase of its 2007 outburst. Pulsations with a period of 93.737s were clearly detected in the light curves of the pulsar up to energy of  $\sim 100$  keV. The pulse profile was found to be strongly energy dependent, a double peaked profile at soft X-ray energy bands ( $< 8$  keV) and a single peaked smooth profile at hard X-rays. The broadband energy spectrum of the pulsar is well described with three different continuum models viz. (i) a high energy cut-off power-law, (ii) a Negative and Positive power-law with Exponential cut-off (NPEX), and (iii) a partial covering power-law with high energy cut-off. In spite of large value of absorption column density in the direction of the pulsar, a blackbody component of temperature  $\sim 0.17$  keV for the soft excess was required for the first two continuum models. A narrow iron  $K_{\alpha}$  emission line was detected in the pulsar spectrum. The partial covering model, however, is found to explain the phase averaged and phase resolved spectra well. The dip like feature in the pulse profile can be explained by the presence of an additional absorption component with high column density and covering fraction at the same pulse phase. The details of the results will be presented.

### **Timing and spectral analysis of the X-ray binary pulsar XTE J1829-098**

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**Abstract.** We have used the archival RXTE PCA data to investigate timing and spectral characteristics of the Pulsar XTE J1829-098. Spectral analysis confirmed the present discovery of Cyclotron line at  $\sim 18$  keV and detection of Iron line at around 6.4 keV. We have performed multi-wavelength studies to study the properties of the source.

## (C) Extragalactic Astronomy and Cosmology

### Hyperfine transition of Helium-3 as a probe of the high redshift universe

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**Abstract.** I will describe salient properties of the hyperfine transition of singly ionised Helium-3. I will discuss results of simulation and analytical studies to make a case for use of this transition as a probe of the high redshift universe.

### The giant radio galaxy DA240 in slingshot model

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**Abstract.** We attempt a slingshot model interpretation of the unusual association of some 1 and 1/3 dozen nonstellar galaxian objects around the parent optical galaxy of the giant radio galaxy DA 240 (also known as 0748.6+55.8 (J2000)). Similar interpretation may be possible for another large radio galaxy 3C 31 (also known as NGC 383; 0104.6+32.1 (1950.0)).

### Reionization constraints using principal component analysis

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**Abstract.** Using a semi-analytical model developed by Choudhury and Ferrara (2005) we study the observational constraints on reionization via a principal component analysis (PCA). Assuming that reionization at  $z > 6$  is primarily driven by stellar sources, we decompose the unknown function  $N_{ion}(z)$ , representing the number of photons in the IGM per baryon in collapsed objects, into its principal components and constrain the latter using the photoionization rate obtained from Ly-alpha forest Gunn-Peterson optical depth, the WMAP7 electron scattering optical depth and the redshift distribution of Lyman-limit systems at  $z \sim 3.5$ . The main findings of our analysis are: (i) It is sufficient to model  $N_{ion}(z)$  over the redshift range  $2 < z < 14$  using 5 parameters to extract the maximum information contained within the data, (ii) All quantities related to reionization can be severely constrained for  $z < 6$  because of a large number of data points whereas constraints at  $z > 6$  are relatively loose, (iii) The weak constraints on  $N_{ion}(z)$  at  $z > 6$  do not allow to disentangle different feed-

back models with present data. There is a clear indication that  $N_{ion}(z)$  must increase at  $z > 6$ , thus ruling out reionization by a single stellar population with non-evolving IMF, and/or star-forming efficiency, and/or photon escape fraction. The data allows for non-monotonic  $N_{ion}(z)$  which may contain sharp features around  $z \sim 7$  and (iv) The PCA implies that reionization must be 99% completed between  $5.8 < z < 10.3$  (95% confidence level) and is expected to be 50% complete at  $z \approx 9.5-12$ . With future data sets, like those obtained by Planck, the  $z > 6$  constraints will be significantly improved.

### Dark energy perturbations and the ISW effect

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**Abstract.** Dark energy perturbation effects the growth of matter perturbations even in scenarios with noninteracting dark energy. I will describe this effect in the context of scalar field models of dark energy. I will also discuss observability of dark energy perturbations and their effect on matter perturbations via the Integrated Sachs Wolfe (ISW) effect.

### Physics of rotating and expanding black hole universe (PREBHU)

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**Abstract.** Throughout its journey universe follows strong gravity. By unifying general theory of relativity and quantum mechanics a simple derivation is given for rotating black hole's temperature. It is shown that when the rotation speed approaches light speed temperature approaches Hawking's black hole temperature. Applying this idea to the cosmic black hole it is noticed that there is "no cosmic temperature" if there is "no cosmic rotation". Starting from the Planck scale it is assumed that - universe is a rotating and expanding black hole. Another key assumption is that at any time cosmic black hole rotates with light speed. For this cosmic sphere as a whole while in light speed rotation "rate of decrease" in temperature or "rate of increase" in cosmic redshift is a measure of "rate of cosmic expansion". Since 1992, measured CMBR data indicates that, present CMB is same in all directions equal to 2.7260 kelvin smooth to 1 part in 100000 and there is no continuous decrease! This directly indicates that, at present rate of decrease in temperature is practically zero and rate of expansion is practically zero. Universe is isotropic and hence static and is rotating as a rigid sphere with light speed. At present galaxies are revolving with speeds proportional to their distances from the cosmic axis of rotation. If present CMBR temperature is 2.7260 kelvin, present value of obtained angular velocity is  $2.17 \times 10^{-18}$  rad/sec = 67 Km/sec/Mpc. Present cosmic mass density and cosmic time are fitted with nat-

ural logarithmic ratio of cosmic volume and planck particle's volume. Finally it can be suggested that dark matter and dark energy are ad-hoc and misleading concepts. (Planck particle can be considered as the baby universe).

### **Primordial black hole formation in matter-dominated era using Brans-Dicke theory**

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**Abstract.** In the context of Brans-Dicke theory, we have found that primordial black holes can be formed in the matter-dominated era. Considering an early matter-dominated era between inflation and reheating, we show that the primordial black holes formed during that era evaporate quicker than those of early radiation-dominated era. Thus, in comparison with latter case, less number of primordial black holes could exist today. Again the constraints on primordial black hole formation become stronger than their radiation-dominated era counterparts indicating a significant enhancement in the formation of primordial black holes during the matter-dominated era.

### **Deep GMRT 150 MHz observations of the DEEP2 fields: Searching for high redshift radio galaxies revisited**

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**Abstract.** The well established correlation that shows radio sources exhibiting ultra-steep spectrum are normally at higher redshift. This correlation ensured exploitation of the potential high redshift candidates from the last three decades. In order to continue the search for high redshift radio galaxies, we have extracted the ultra-steep spectrum samples from 150 MHz radio observations of the well-studied DEEP2 deep fields at higher frequencies centered on 1652+3455, 2330+0000 and 0230+000, which were carried out using the Giant Metrewave Radio Telescope (GMRT). We present here one of the observed deep-fields centered on 2330+0000 whose deep 150 MHz GMRT image has an rms noise of  $\sim 0.9$  mJy/beam. The source catalog of this deep field contain around 389 sources within 20% peak primary beam response. After careful estimation of spectral indices by cross-correlating each source in our catalog to the already available radio catalogs from NVSS and FIRST surveys at 1400 MHz, we found about 140 steep spectrum radio sources with spectra steeper than 1. We will further study these steep spectrum sources through SDSS and DEEP2 optical catalogs to search potential high redshift candidates.

## Recent star formation history of the Magellanic Clouds

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**Abstract.** The details of recent interactions between the Large and the Small Magellanic Clouds (LMC and SMC) can be understood by studying their recent star formation history. This study aims to detect any directional or propagating star formation in the last 100 Myrs in the Clouds. We traced the age of the last star formation event (LSFE) in the inner LMC/SMC using the photometric data in V and I pass bands from the Optical Gravitational Lensing Experiment (OGLE-III) and the Magellanic Cloud Photometric Survey (MCPS). The age of the LSFE in a given sub-region corresponds to the main-sequence turn off point in the colour-magnitude diagram (CMD). After correcting for extinction, the obtained turn off magnitude is converted to age, which represents the (LSFE) in a region. In this study, we do not see any signature of directional propagation of star formation, but we find a radially inward propagation of star formation in both the Clouds. The recent star formation is more in the northern LMC, when compared to the southern LMC, suggestive of gas available in this region for star formation.

We have estimated the density distribution of main sequence stars in the LMC, with different age cut-offs. The centroid of each of the distributions is also calculated. We find a shift of center towards the north-east of LMC. The above two features are probably due to tidal effect of the Galaxy on the gas present in the LMC.

## Variability in low broad absorption line quasar outflows

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**Abstract.** Quasar outflows have a huge impact on the evolution of central super-massive black holes, their host galaxies and the surrounding intergalactic medium. Studying the variability in these Broad Absorption Lines (BALs) can help us understand the structure, evolution, and basic physical properties of these outflows. Using the 2m telescope in IUCAA Girawali observatory we are conducting a repeated Low ionization BAL monitoring programme with 27 LoBALs (five of them are Fe LoBALs) at  $z \sim 0.3-2.1$  covering timescales from 3.22 to 7.69 years in the quasar rest frame. We see a variety of phenomena, including some BALs that either appeared or disappeared completely and some BALs which do not vary over the observation period. In one case, the excited fine structure lines have changed dramatically. One

source shows signatures of radiative acceleration. Here we present the results from this ongoing programme.

### **Observations of far ultraviolet diffuse emission from the Small Magellanic Cloud**

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**Abstract.** We present the first estimation of far ultraviolet (FUV: 1000 – 1150 Å) diffuse radiation from the Small Magellanic Cloud (SMC) based on observations made with the *Far Ultraviolet Spectroscopic Explorer (FUSE)*. We have adopted the data analysis method of Murthy and Sahnou (2004) for extraction of diffuse surface brightnesses from the *FUSE* spectra. The diffuse radiation is primarily due to light from hot stars scattered by the interstellar dust grains. The FUV diffuse surface brightness in the SMC ranges from around  $10^3$  photons  $\text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{Å}^{-1}$  to as high as  $2.5 \times 10^5$  photons  $\text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{Å}^{-1}$ . We have estimated the fraction of the total radiation in the field emitted as diffuse radiation which is about 40% – 50%. We found that much less light is scattered in the FUV than at longer wavelengths with the stellar radiation going into heating the interstellar dust. The FUV diffuse fraction from the SMC is much higher than the Large Magellanic Cloud (LMC; Pradhan et al. 2010) due to less number of young hot stars in the SMC compared to the LMC.

### **The 3D structure of the Small Magellanic Cloud**

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**Abstract.** The 3D structure of the inner Small Magellanic Cloud (SMC) is investigated using the red clump (RC) stars and the RR Lyrae stars (RRLs), which represent the intermediate-age and old stellar populations of a galaxy. The V and I bands photometric data of the Optical Gravitational Lensing Experiment (OGLE III) catalog is used for our study. The mean dereddened I magnitude of both the RRLs and RC stars are used to study the relative positions of the different regions in the SMC with respect to the mean SMC distance. This shows that the north eastern part of the SMC is closer to us. The line of sight depth of the sub-regions in the SMC are estimated from the dispersions in the mean  $I_0$  magnitudes of both the RC stars and the RRLs. A large line-of-sight depth (front to back distance) is obtained from the analysis of both the populations. The similarity in their depth distribution suggest that both these populations occupy a similar volume of the SMC. From these above results the SMC is approximated as a triaxial ellipsoid in which both the RC stars and RRLs are distributed. The parameters of the ellipsoid are obtained using the inertia tensor analysis. An axes ratio of 1:1.3:6.2 with a 1 degree inclination of the longest axis with the line-

of-sight is obtained from the analysis of RRLS. The position angle of the projection of the ellipsoid on the sky obtained is 74.5 degrees. The analysis of the RC stars with the assumption that they are extended up to a depth of 2.5 sigma, provided an axes ratio of 1:1.48:6.8 with the longest axis inclined with an angle of 1.3 degree with the line-of-sight. The position angle of the projection of the ellipsoid on the sky obtained is 55.3. The axes ratio and the inclination values match well for both the populations. The possible reasons for the difference in the position angle is discussed. The implications of this study are also discussed.

### **Analytical triaxial model with varying axial ratios**

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**Abstract.** A family of triaxial mass models is presented which is projected analytically. The contours of constant projected density are approximately ellipses with ellipticity variation and position angle twist. An application to a real galaxy is presented.

### **Star formation in blue compact dwarf (BCD) galaxies**

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**Abstract.** I present the optical photometry, spectroscopy using HCT of Blue compact dwarf (BCD) galaxies. The BCDs are observed through UBVRI filters. The colour-colour diagram (CCD) of U-B vs V-I and U-B vs B-V are created from integrated magnitudes. We have for the first time employed the mixed population technique using CCDs to find out ages of the underlying population intermixed with the starburst regions. A combination of few Gyr population, few hundred million years population and an young burst of age 5-15 Myr is detected for most of these galaxies. The structure of BCDs is a smooth background of low surface brightness (LSB) old stellar population and intermixed with the clumps of H II regions. The spectra of BCDs are typical H II region kind of spectra. The electron densities are  $< 100 \text{ cm}^{-3}$  and temperatures are in the range 6000-15000 K. The oxygen abundance is calculated using the standard bright line methods. The oxygen abundance ( $\log[\text{O}/\text{H}] + 12$ ) of the sample of BCDs varies from as low as 7.9 to as high as 8.5. So these galaxies are (1/5 – 1/2.5) times metal poor when compared to solar. The BCDs are observed through  $\text{H}_\alpha$  filters installed in the HFOSC system. The  $\text{H}_\alpha$  fluxes and luminosities are used to calculate star formation rates (SFR) that are in the range 0.01 to 0.1  $\text{M}_\odot/\text{yr}$  for individual H II regions and ranges between 0.1 to 1.0  $\text{M}_\odot/\text{yr}$  for the whole galaxy. The archival data from 2MASS is used to obtain the integrated colour-colour diagrams of (J-H) vs (V-K). NIR colours are less affected by reddening and are better signatures

of old stellar population. The results are compared with optical CCD, the interesting dichotomy are presented.

### **Study of intragroup medium in Holmberg 124 group**

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**Abstract.** Quantifying the importance of complex interplay between galaxies and their environment requires the detailed tracking of galaxy properties over a broad range of environment and look-back time. Groups are vital to obtaining a complete understanding of galaxy evolution and environmental processes. In this poster paper, we attempt to interpret the observed distribution of the atomic H I and radio continuum observed using GMRT in the poor group of galaxies, Holmberg 124. We combine our radio data with data at other wavebands from literature and try to construct a model of this spiral-rich group. This group of galaxies is interesting in that all the member galaxies show signatures of interaction in their morphology and kinematics. NGC 2820 and NGC 2805 are the massive spiral galaxies whereas NGC 2814 and Mrk 108 are smaller late type galaxies in the group. In this poster, we use our empirical results to examine the feasibility of various physical mechanisms such as tidal interactions, ram pressure stripping, turbulent viscous stripping on shaping the evolution of the galaxies in this group and compare it with other groups of late type galaxies.

### **Semi analytic models of galaxy formation - A few applications**

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**Abstract.** We introduce a new method for following the formation and evolution of galaxies in the cosmological N-Body simulations. Dissipationless simulations are used to track the formation and merging of dark matter haloes as a function of redshift. Simple prescriptions, taken from semi analytic models of galaxy formation are adapted for gas cooling, star formation and various feedbacks. This scheme enables us to explore clustering properties of galaxies, and to study how the selection by luminosity, colour and type influence the results. We plan to apply this model to the reionization study of the Universe at high redshift.



## Disk galaxy rotation curves

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**Abstract.** We show that simple axisymmetric Newtonian calculation suffices to consistently connect disk galaxy rotation curves to underlying mass distribution and vice versa, without need for any dark matter. To this end, we connect mass density profiles of five galaxies of varying sizes with observed galaxy rotation curves. The five galaxies are: NGC6822 (4.8 kpc), Large Magellanic Cloud (9 kpc), The Milky Way (17 kpc), NGC3198 (30 kpc) and UGC9133 (102.5 kpc). The mass and mass density profiles of these galaxies have been computed using the scientific computing s/w package MATLAB taking the already available velocity profiles of the galaxies as the input, and without considering any dark matter contribution. We have plotted these profiles after computing them according to three different theories of gravity (and dynamics): Newtonian, Modified Newtonian Dynamics (MOND) and Vacuum Modified Gravity. We also consider how the profile due to the Newtonian theory would modify if we use a cosmological constant  $= 5 \times 10^{-56} \text{ cm}^{-2}$ . Comparing these mass and mass density profiles, we try to form an idea regarding what could be a realistic theory of gravity and whether we need dark matter to explain the results.

## Luminosity volume method to directly get galaxy number density to past cosmic epochs

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**Abstract.** Use of the differential distribution  $p(V/V_m)$  of the  $V/V_m$ -variable rather than just the mean leads directly to the cosmological number density without any need for assumptions about the cosmological evolution of the underlying (quasar) population. Calculation of this number density  $n(z)$  from  $p(V/V_m)$  is illustrated using the best sample that was available in 1981, when this method was developed. This sample of 76 quasars is clearly too small for any meaningful results. So the method is applied to a much larger cosmological sample of over 300 quasars to infer the cosmological number density  $n(z)$  as a function of the depth  $z$ .

## A multi-frequency study of five large radio galaxies

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**Abstract.** Studies of large radio galaxies are important for understanding the late stages of evolution of radio sources and constraining their evolutionary models. These sources could also be used as probes of the intergalactic medium at different redshifts. The larger ones of these are over a Mpc in size and are referred to as giant radio sources. We present a multi-frequency study of five such large radio galaxies, J0318+684, J0949+732, J1211+743, J1918+742 and J2042+751, whose projected linear sizes range from about 0.8 to 1.5 Mpc. Their redshifts range from about 0.05 to 0.2. The low-frequency observations were made with the Giant Metrewave Radio Telescope (GMRT), while the high-frequency ones were made with the Very Large Array (VLA). We present the structure and spectra of these sources over a large frequency range, estimate their spectral ages and compare these results with model expectations.

## 3C321: an H I absorber with relic radio emission

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**Abstract.** We report the results of Giant Metrewave Radio Telescope (GMRT) observations of H I absorption towards the FR II radio galaxy 3C321 (J1531+2404), which is associated with an optical galaxy interacting with a companion. The absorption profile which is seen towards the radio core is well resolved and consists of three components which appear redshifted relative to the optical systemic velocity. We estimate the column density and optical depth of H I gas from these observations. We also present radio continuum observations of the source with both the GMRT and the VLA in order to understand the properties of a plume of emission at an angle with the source axis. This feature could be relic emission due to an earlier cycle of activity. If so, this would be consistent with a trend for detection of H I absorption and rejuvenation of radio activity suggested earlier.

## Multiphase ISM in a starburst galaxy NGC 1482

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**Abstract.** We present the multi-wavelength study of a starburst galaxy NGC 1482. Optical broadband imaging analysis reveals a prominent dust lane well aligned along its major axis with dust extinction properties identical to those in the Milky Way. Ionized gas map derived from the deep H-alpha imaging analysis shows a physical association with the dust in this galaxy. The star formation rate estimated from H alpha flux value is  $\sim 1 M_{\odot}/\text{yr}$  while that derived from the IRAS flux density is  $11.87 M_{\odot}/\text{yr}$ . X-ray emission map of NGC 1482 was derived from the analysis of 28 ks Chandra X-ray archival data. X-ray emission maps thus derived in different energy bands show asymmetric distribution of hot gas well beyond the optical D25 region in this galaxy and have an extension orthogonal to orientation of the dust lane. We do not find any point source in this galaxy; however, double nuclei are evident in hard band emission map of this galaxy. The X-ray spectrum extracted for this galaxy was fitted with the VMEKAL and a simple power law component. Temperature profile of the diffuse X-ray component reveals a systematic gradient.

## High frequency study of few large size radio galaxies

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**Abstract.** We present the high frequency study of a sample of ten large size radio galaxies selected from NRAO VLA Sky Survey (NVSS), Westerbork Northern Sky Survey (WENSS) and 3CR survey. The radio sources with angular size larger than  $2'$  have been selected which have been observed with Very Large Array (VLA) from 1.4 GHz to 8 GHz. We present the radio maps of these sources and estimate their spectral indices, the radio power and the flux at different frequencies. We also discuss some of the properties of the jets of these sources.

## **GMRT H I imaging of Wolf-Rayet galaxies**

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**Abstract.** The results from the H I 21 cm-line imaging of a few isolated Wolf-Rayet (WR) galaxies using GMRT will be presented. WR galaxies have substantial population of very massive young stars therefore tracing very recent ( $\sim 10^6$  yr) star formation event in a galaxy. The WR galaxies can provide clues on mechanisms related to star formation trigger in galaxies. The selected WR galaxies in the present study do not have known optical companion or any remarkable optical distortion. We find that in most of the cases H I tidal tails can be traced in these galaxies indicating tidal origin of WR phase. The main results and GMRT images will be presented.

## **Spectroscopic study of candidate Be stars in the Magellanic Clouds**

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**Abstract.** The Magellanic Clouds (MCs) are known to be abundant in Be stars. Since the MCs are metal poor than in our Galaxy, it will be interesting to understand the properties of Be stars in these galaxies. Mennickent et al. (2002) and Sabogal et al. (2005) have identified many Be star-like variables showing light curves similar to those of Galactic Be stars (called type-4 stars) and also others presenting different kinds of light curves (called type-1, type-2, type-3 stars). We report the results of spectral analysis of a subset of the above Be candidate stars in the SMC and the LMC. Spectra were obtained for 68 candidate stars in the SMC and 38 candidate stars in the LMC. Observations were made using the 1.5 m CTIO Telescope and 2.5 m LCO Telescope. Our sample includes stars of type 1, 2 and 3 of the LMC and the SMC. The spectral features are used to identify their spectral class and to see whether they show some properties of Be stars.

## Measurement of time-delay in the gravitationally-lensed quasar SDSS J0806+2006

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**Abstract.** We report new measurement of the time-delay between the photometric flux variations of the quasar images in the (double-image) gravitationally lensed quasar SDSS J0806+2006 at a redshift of 1.537. A total of 97 epochs (amounting to 504 image frames) of observations were acquired on this quasar in R-band using the 2-m Himalayan Chandra Telescope in Hanle between the period October 2007 and May 2010. The observed image frames were reduced using the MCS deconvolution technique (Magain, Courbin & Sohy 1998, ApJ, 494, 472) to obtain the light curves of the quasar images. The light curves are then subjected to curve shifting procedures to get an estimate of the time delay in this lensed system as part of a larger collaboration called COSMOGRAIL (Cosmological MONitoring of GRAvItational Lenses).

## Star formation in blue compact dwarf galaxies of the local volume

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**Abstract.** We determine the total GALEX fluxes (FUV 1350 – 1750 Å) of twenty one Blue Compact Dwarf Galaxies (BCDG's) of the Local Volume (LV). We also make a study of the location of the sites of star formation in these galaxies, as delineated by UV light, with respect to other components of the galaxy, like H I, old stars, optical light etc.

## Study of the EoS parameter for a cosmological model with Fermionic field and power-law potential

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**Abstract.** In the present work, we explore how a Fermionic interaction potential having the form of a power-law affects the EoS parameter in the cosmological model with Fermionic field, proposed by us earlier. It is found that, for a range of model parameter values, the EoS parameter of the dark energy field is practically constant, with a value nearly equal to -1. This value is consistent with what we expect from observations. From the nature of the behavior of the EoS parameter, it is concluded

that the current model can be treated like a cosmological constant for a range of model parameter values.

### **Multi-wavelength variability of NGC 3516**

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**Abstract.** Active galactic nuclei (AGN) show flux variations over the entire electromagnetic spectrum and this flux variability is an important characteristic of all AGNs. It is possible that the flux variations in different spectral regions are either connected or driven by a single mechanism. We present results on the multi-wavelength variability of the AGN NGC 3516.

### **Fast optical variability in blazar S5 0716+714**

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**Abstract.** Blazars are the subclass of AGNs showing very fast variations in all the wavebands (ranging from radio to VHE gamma rays). We have monitored this source during five nights in March 2010. Almost all the five nights are showing the bright state of source as well as significant variation ( $\sim 0.1$  mag during  $\sim 3$  hours). During two out of five nights we can see very rapid rise and decay in intensity (approx 0.07 mag during 15 min). Several models are proposed to explain such kind of fast variability. The shock acceleration in the jet seems to be better to explain the observed behavior during the monitoring period.

### **Intrinsic shapes and orientations of the elliptical galaxies, NGC 3379 and NGC 7619 using photometric data**

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**Abstract.** Determination of the intrinsic shape and the orientation of individual elliptical galaxies is an important problem. The statistical method to determine the shape and orientation was developed by Statler and his coworkers. These authors use the photometric, as well as, the kinematical data of the galaxies. As the numbers of galaxies with good photometry are many more as compared to those with good kinematics, we attempt the shape estimates using photometric data alone. We determine the intrinsic shapes and orientations of the light distribution of galaxies by combining

the proles of photometric data from the literature with triaxial models. The intrinsic shapes and orientations are given by a Bayesian probability distribution. The likelihood of obtaining the data from a model is a function of the parameters describing intrinsic shape and orientation. We apply the method to infer the shape and orientation of a galaxy, using the ellipticities and the difference in the position angles at two suitably chosen points from the proles of the photometric data. The expectation values ( $\langle q_0 \rangle$ ,  $\langle q_\infty \rangle$ ,  $\langle |T_d| \rangle$ ) and most probable values ( $\langle q_{0P} \rangle$ ,  $\langle q_{\infty P} \rangle$ ,  $\langle |T_{dP}| \rangle$ ) constitute a summary of the shape of NGC 3379, we nd  $\langle q_{0P} \rangle = 0.93$ ,  $\langle q_{\infty P} \rangle = 0.78$ ,  $\langle |T_{dP}| \rangle = 0.03$ ,  $\langle q_0 \rangle = 0.88$ ,  $q_\infty = 0.72$  and  $\langle |T_d| \rangle = 0.29$ . These can be compared with the values  $\langle cL \rangle = 0.75$ ,  $|T_{dP}| = 0.03$ ,  $cLP = 0.87$ ,  $TmP = 0.0$ , reported in Statler (1994, ApJ, 425, 500; hereafter S 94). The expected as well as the most probable values of the short to long axial ratios of our calculation agree extremely well with the values in S94. This agreement establishes our methodology, quite rmly. We also nd that the orientation of NGC 3379 is not well constrained. This is again in agreement with the results obtained by Statler (1994, Astr.J., 108, 111) We nd that the position angle difference plays the crucial role in orientation estimates. Orientation of the elliptical galaxies with position angle difference  $\geq 40.0$  are well constrained. The results of shapes and orientations of other galaxies can also be compared with the values reported by other workers.

### Multi-wavelength investigation of some dusty E/SO galaxies

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**Abstract.** We report the study of dust extinction properties in some early type galaxies, using optical deep broadband images. Wavelength dependence of dust extinction was studied by obtaining extinction map and extinction curves for these galaxies. The extinction curves of these galaxies run parallel to that of the Milky way, suggesting that the properties of dust in these galaxies are similar to that of our Galaxy. The value of  $R_v$ , the ratio of total extinction in V band to selective extinction  $E(B-V)$  between B and V band, for these galaxies, lies in the range 2.06 – 3.56, while its canonical value is 3.1 for the Milky way. Total dust content for these galaxies obtained using dust extinction and is found to be in the range of  $10^3$  to  $10^4 M_\odot$ , which is an order of magnitude smaller than those derived using IRAS flux density, suggesting that a significant amount of diffusely distributed dust remains undetected in the optical bands. Distribution of dust is compared with those of hot and ionized gas, to look for the possible physical association between different forms of interstellar medium.

## Photometric and spectroscopic study of the S0 galaxy, NGC 1266

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**Abstract.** We present the results from a photometric and spectroscopic study of the S0 galaxy, NGC 1266, in the optical wavelengths. This project was carried out as part of the IGO observational training school, held during 20 December, 2010 to 15 January, 2011, at IUCAA (Pune).

Surface photometry was performed in the BVR wide band and H-alpha narrow band filters. We used ellipse fitting to the isophotes, to measure the surface-brightness profile, the radial variation of position angle, ellipticity, and the B4 (boxyness/diskyness) parameter. We created colour maps and H-alpha emission line maps to identify the spatial distribution of dust features and ionized gas.

We report the identification of extended cone of ionized gas outflow in the central 2 kiloparsec region of NGC 1266. Follow-up spectroscopy shows that the narrow-band emission is dominated by the [N II] emission, which is stronger than H-alpha emission. We detect outflow velocity of approximately  $500 \text{ km s}^{-1}$  from the wavelength shifts of the emission lines. Our results from the spectroscopic study include emission line identification, flux measurements of the emission lines, and physical parameters of the ionized gas.

## Analysis of Fermi-LAT data on Mrk-421 during its high state in February 2010

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**Abstract.** With the launch of Fermi in June 2008, which has the sensitivity to measure the emission from bright TeV blazars on daily to weekly time scales, it is now possible to put together high quality data to build simultaneous and well sampled spectral energy distribution of blazars in their flaring state. With the aim of obtaining a broad spectral energy distribution of Mrk-421 during its high state, a detailed analysis of the Fermi-LAT and RXTE/ASM data recorded between 12th Feb. 2010 to 25th Feb 2010 has been performed to study the daily flux/spectral variability of the source. The analysis involves studying the daily flux/spectral variability of the source in 100 MeV - 100 GeV and 1 GeV - 100 GeV energy bands by using the Fermi-LAT data. The light curves of the source in the above mentioned energy bands reveal flux variability by a factor of  $\sim 2$  with  $TS > 25$  (i.e.  $\sim 5\sigma$  detection) on several nights with peak flux values of  $\sim 5 \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-2}$  and  $\sim 1 \times 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$  in the above two mentioned energy bands. Apart from presenting the light curves of the source as recorded by the



Fermi-LAT in 100 MeV-100 GeV energy band and by the RXTE/ASM in X-rays, we will also discuss aspects like correlation coefficient and variability index in the paper.

### **Investigations of TeV high states of Bl Lac object Markarian 421**

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**Abstract.** Markarian 421 ( $z \sim 0.031$ ) emits non-thermal radiation from radio to TeV gamma-ray energies. It falls under the blazar subclass of Active Galactic Nuclei (AGN) which are the most extreme and powerful variable sources of photons of above said energies and are believed to have their jets more aligned toward the Earth as compared to any other class of radio loud AGN. They display high luminosity, irregular amplitude variability in all accessible spectral bands and have a core-dominated radio morphology with radio spectra join smoothly to the infrared (IR), optical and ultra-violet spectra. This object has been extensively studied in TeV domain of gamma-rays using TACTIC gamma-ray telescope at Mt. Abu. It was found to be in High Emission States (HES) during 2006 and 2008 observations. In this paper, we investigate these two HES in terms of possible correlation studies between the source light curves at TeV and X-ray energies. In addition, in the scenario of leptonic single zone Synchrotron Self Compton (SSC) model, HES related source parameters like magnetic field, electron energy spectrum, size of the emission region etc. have also been estimated. Preliminary results pertaining to these studies will be presented.

### **Compatibility of various EBL models with recent ground-based sub-TeV observations of extragalactic sources**

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**Abstract.** While an enormous amount of new data at UV-optical and IR-mm wavelengths have been recently obtained, presence of intensive foreground emission makes any direct measurements of extragalactic background light (EBL) extremely difficult. Since it is well known that very high energy photons from extragalactic sources are expected to suffer absorption from interactions ( $\gamma_{VHE} + \gamma_{EBL} \Rightarrow e^+ + e^-$ ) with extragalactic background light (EBL), the energy and redshift dependent opacity causes a deformation of the observed VHE spectrum, which depends on the spectral energy distribution (SED) of the EBL. In this work, we present estimates of optical depth as a function of redshift and primary photon energy for various EBL models. Compatibility of the EBL models with sub-TeV observations of extragalactic sources using Cherenkov imaging telescopes, will also be presented here. The observational data of 3C279 from the MAGIC collaboration, collected during 22-23 February 2006, will

also be critically examined for constraining the intergalactic low energy photon spectra.

### **Long term variability of optical counterparts of X-ray sources in NGC 1399**

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**Abstract.** We present the optical variability studies of X-ray sources in NGC 1399 with the HST ACS observations. NGC 1399 is a giant elliptical galaxy in the center of Fornax cluster, 36 X-ray point sources have been identified by Chandra. We searched for the optical counterparts to these sources in HST archival images. Out of 36, twenty six of them falling in the HST field of view and 22 of them having potential counterparts within an error circle of few arcsec. Two of them show significant variability of  $\sim 0.4$  magnitude between two F475W observations separated by 23 months, while the others have a variation less than 0.1. The X-ray luminosity of these optically varying sources is less compared to ultra-luminous X-ray sources (less than  $10^{39}$  erg s<sup>-1</sup>). The optical variability indicates they may be background AGNs.

### **Spectral and timing study of Mrk110**

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**Abstract.** Narrow-line Seyfert 1 galaxies are identified by the unusual narrowness of their H $\beta$  lines. They are believed to be powered by supermassive black holes (SMBH) of relatively small masses, with high accretion rates, possibly close to the Eddington limit. Furthermore, NLS1 have long been known to be characterized by extreme properties of their X-ray emission: a strong soft excess in the ROSAT soft band 0.1 – 2.4 keV, unusually steep X-ray spectra in the hard X-ray band 2 – 10 keV, and very rapid and large variability. We undertake the spectral and temporal study of Mrk 110 which is a low redshift ( $z = 0.03529$ ) X-ray bright NLS1s. The analysis will be carried out on the XMM-Newton and Suzaku observations of this source. Study of cross-correlation between different energy bands will further help us to understand the underlying physical process.

### **VHE gamma- ray observations of Markarian 501 and 1ES2344+514 with TACTIC during 2009-10**

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**Abstract.** We have observed two AGNs Markarian 501 ( $z=0.034$ ) and 1ES2344+514 ( $z=0.044$ ) in Very High Energy (VHE)  $\gamma$ -ray region with the TACTIC telescope located at Mt. Abu, Rajasthan. The observations on these two extragalactic sources were made during March 2010 May 2010 and November 2009 - December 2009 for 77.9 and 47.6 hours respectively. Preliminary analysis of the data does not indicate presence of a statistically significant VHE gamma-ray signal from either source direction. Further, data of three satellite based experiments FERMI (30 MeV-300 GeV), RXTE (ASM 2-12 keV) and Swift (10-50 keV) on these two AGN were also analyzed to obtain respective contemporaneous source light curves in order to investigate states of these objects at lower energies as well. Details of these results will be presented in the meeting.

### **Mrk 421 in a high TeV emission state during 2010: TACTIC observations**

Ramesh Chand Rannot, P. Chandra, K. K. Yadav, A. K. Tickoo, K. Chanchalani, M. Kothari, K. K. Singh, N. K. Agarwal, A. Goyal, H. C. Goyal, S. Kotwal, N. Kumar, P. Marandi, K. Venugopal, C. K. Bhat, N. Bhatt, S. Bhattacharya, N. Chouhan, V. K. Dhar, S. R. Kaul, S. K. Koul, M. K. Koul, R. Koul, A. K. Mitra, S. Sahayanathan and M. Sharma  
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**Abstract.** We have observed the extragalactic TeV gamma-ray source Mrk421 ( $z = 0.030$ ) in the Very High Energy (VHE) domain of gamma-rays with the TACTIC telescope. The observations were made in the tracking mode of TACTIC operation from 22nd November 2009 to 15th May 2010 and a total of 265.5 hours of the data were recorded from this source direction. Preliminary analysis of the data indicates detection of a significant TeV gamma-ray signal with a statistical significance of  $9.3\sigma$ . Further, these preliminary results also indicate a variability in signal strength on a day to day basis particularly during March 2010 observations. In order to study the source at lower energies, we also compare the TACTIC TeV light curves with those of the RXTE ASM (2-12 keV), FERMI (1 GeV-300 GeV) and SWIFT(15-50 keV) obtained

for the same period. Details of these preliminary results will be presented in the meeting.

### **Origin of the soft excess emission from Narrow Line Seyfert 1 (NLS1) galaxies**

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**Abstract.** We present results derived from the analysis of XMM-NEWTON archive data of some NLS1 galaxies with an objective to investigate the nature of soft excess in the X-ray band below 2.5 keV. The spectrum in the energy range between 2.5 - 10 keV can be easily represented by a single power law with photon index  $\sim 2.5$ , however, an excess emission of soft component is clearly evident if its lower energy limit is extended to 0.3 keV. This excess emission at soft energy is perhaps due to the inverse Comptonization of low energy photons by relativistic electrons in the accretion disk. The issue regarding origin of this excess emission is addressed by fitting different models to the X-ray data.

### **Investigation of X-ray cavities in the cooling flow cluster galaxies**

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**Abstract.** We present results based on the detailed analysis of deep XMM-Newton and Chandra observations of some clusters galaxies focusing on the investigation of cavities and discontinuities in the X-ray emission maps derived from their surface brightness study. Feedback from the AGN is believed to be the most promising mechanism for the formation and evolution of such cavities. We employed the contour binning, unsharp masking as well as 2D smooth model generation techniques for the investigation of such cavities and other hidden features in the selected targets. These cavities are of elliptical shapes, exist in pairs, and show a surface brightness decrement of several tens of percent. Spectroscopic analysis of X-ray emission extracted from different regions enabled us to examine the variations in derived parameters like X-ray luminosity, electron density, entropy, metal abundance, temperature, enthalpy, etc.

Using the X-ray image deprojection technique we estimate the temperature and abundance gradient in the cavities of target clusters. Our results imply that these cav-

ities are originated due to the AGN outflows associated with cluster cooling flow. We also derive various cavity properties like age, power, size and pressure which in turn enabled us to understand the mechanism of such cavity formation. Their association with radio jets implies that the heating and cooling in the clusters are coupled by feedback process.

### **Study of VHE gamma ray emission from AGN using HAGAR**

Amit Shukla and HAGAR collaboration

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**Abstract.** Blazars are a sub-class of Active galactic nuclei (AGN) whose narrow radiation beams, generated in relativistic jets, are pointed directly towards us. It is believed that this radiation is a result of accretion onto the supermassive black hole at the center of the host galaxy. This radiation often extends from radio to gamma-rays. The radiation mechanism of very high energy gamma ray emission from blazars and other crucial parameters like magnetic field, size of the emitting region are not well understood yet. To understand above mentioned properties of the blazars, we observed five nearby TeV gamma ray emitting blazars (Mrk421, Mrk501, 1ES2344+514, 1ES1218+304 and 3C454.3) and one radio galaxy (M87) using High Altitude GAMMA Ray (HAGAR) telescopes. HAGAR is an array of seven telescopes located at Hanle to detect Cherenkov light caused by extensive air showers initiated by gamma rays. Measuring relative arrival time delays and densities of Cherenkov photons at individual telescopes, the arrival direction and energy of incident gamma rays can be reconstructed. HAGAR telescope array has collected more than 180 hrs of AGN data in last two years. A detailed analysis procedure to extract gamma ray signal from HAGAR data will be discussed and preliminary results on these AGN will be presented.

### **Multi-wavelength study of TeV Blazar Mrk421 during giant flare**

Amit Shukla and HAGAR collaboration

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**Abstract.** We present results of a multi-wavelength study of nearby ( $z = 0.03$ ) TeV Blazar Mrk421. Mrk421 is in the high state of activity since November 2009 and has shown flaring behaviour in X-ray and gamma ray bands in February 2010. One of the brightest flaring episodes of this source was observed by various experiments on 17th February 2010. We have observed this source in bright state using High Altitude GAMMA Ray (HAGAR) telescope array at energies above 200 GeV during 13 - 20 February 2010. HAGAR has detected Mrk421 at the flux level of about 6 Crab units on 17th February and this is consistent with detections reported by other very high energy experiments. We present the spectral energy distribution of the source during

this flaring episode. Also using soft X-ray data from ASM on board RXTE, hard X-ray data from BAT on board Swift and gamma ray data from LAT on board Fermi in association with HAGAR data, we have investigated the correlated variability.

### **Intracluster medium of a merging cluster Abell 3395**

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**Abstract.** We present a study of the merging environments of the bimodal merging cluster Abell 3395 using XMM-Newton EPIC and ATCA radio observations. We have discovered the presence of a new subcluster in addition to the previously known two main subclusters. The radio morphology reveals the presence of interesting radio sources in the cluster. The cluster does not show any signs of cooling flows for which we have tried finding an explanation.

## (D) Instrumentation

### **Gamma/hadron segregation using random forest method for ground based gamma ray telescope TACTIC**

Mradul Sharma<sup>1</sup>, M. K. Koul<sup>1</sup>, S. Bose<sup>2</sup>, J. Nayak<sup>2</sup>, N. Bhatt<sup>1</sup>,  
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**Abstract.** Statistical techniques are quite frequently used in the data analysis of present day high-energy and astrophysics experiments. Generally these methods are employed because of the lack of knowledge about the mathematical dependence of the parameter of interest on the relevant measured variables. A tree-based classification method “Random Forest” has been employed to segregate Gamma-ray and hadron initiated atmospheric Cherenkov events detected by ground based gamma-ray telescopes. The basic concepts of Random Forest method and its application for TACTIC telescope will be discussed.

### **Monte Carlo simulations for performance parameters of HAGAR**

Lab Saha and HAGAR collaboration

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**Abstract.** High Altitude GAMMA Ray (HAGAR) telescope is an experiment for detection of very high energy gamma rays from astronomical sources. This telescope array located at an altitude of 4270 m at Hanle, is the highest altitude atmospheric Cherenkov telescope in the world. This experiment indirectly detects gamma ray primaries through detection of Cherenkov light from extensive air showers. Performance of this experiment can be understood only through Monte Carlo simulations of extensive air showers and modeling of HAGAR telescope response. Details of these simulations are presented along with the comparison with experimental data.

### **New analysis of Crab nebula and OFF source data at VHE with HAGAR in the Himalayas**

Richard Joseph Britto and HAGAR collaboration

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**Abstract.** The High Altitude GAMMA-Ray (HAGAR) array is a wavefront sampling array of 7 telescopes, using the atmospheric Cherenkov technique, set up at Hanle, at 4270 m above mean sea level, in the Ladakh region of the Himalayas. It constitutes

the first phase of the Himalayan Gamma-Ray Observatory (HIGRO) project, and is sensitive to gamma rays from  $\sim 200$  GeV. Regular source observations are on since September 2008. We have collected more than 80 hrs of data from Crab nebula, standard candle source of TeV gamma-ray astronomy, and present preliminary results on selected data sets. We have also collected more than 60 hrs of data from OFF-source regions at a similar declination, for estimation of statistical fluctuations and systematics in our data/analysis. We present these studies and discuss our analysis procedures.

### **Weather monitoring at GOALS observatory Mt. Abu from 1999 to 2010**

Ramesh Chand Rannot, A. H. Goyal, P. Chandra, M. K. Kothari,  
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**Abstract.** The TACTIC telescope is operational for more than ten years at GOALS observatory, Mt. Abu (24.6N, 72.7 E, 1300m AMSL). It is an imaging gamma-ray telescope based on the atmospheric Cherenkov technique, wherein a large light collector and a fine cluster of PMTs (camera) along with the relevant instrumentation are used to record images of Atmospheric Cherenkov Flashes (ACF), during clear and moonless nights. The ACF based very high energy gamma-ray telescopes require a suitable site characterized particularly by the maximum annual number of cloudless clear nights, with no artificial background light and low dust levels. In our earlier site characterization study before the TACTIC installation, it was found that the Mt Abu site offered more than 60% clear nights for TeV observations in a year. We have continued this study since 1999, using an automatic weather station, which was installed during the same year to collect data on various meteorological parameters. Results of the analysis of recorded data for atmospheric parameters like temperature, wind speed, dust load (Total Suspended Particulate Matter TSPM) and number of clear nights from 1999 to 2010 will be presented at the meeting.

### **Implementation of disp analysis procedure for the TACTIC telescope**

Ramesh Chand Rannot, K. K. Yadav, K. K. Singh, M. K. Koul,  
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**Abstract.** Data recorded on potential gamma ray sources using Imaging Atmospheric Cherenkov Telescopes is usually dominated by the background of cosmic rays with a typical ratio of 1:1000 events. In order to obtain a sensitive measurement of a gamma ray source, an effective background suppression in the data is necessary by



retaining a large fraction of gamma ray events. A set of image parameters called Hillas parameters are usually applied for gamma and cosmic ray separation using both source dependent and source independent information in the camera. The Disp analysis procedure uses the information of the shower image shape to reconstruct the position of the source on an event-by-event basis assuming that the source position lies on the major axis of the image. However, this procedure provides two source positions along the major axis of the image but does not provide information on which side of the shower image the arrival direction lies. The asymmetry charge distribution in the image contains the head and tail information of the recorded shower in the camera plane. The implementation details of Disp analysis procedure using TACTIC simulated data will be discussed in this meeting.

### **Simulation studies on GEM Based soft X-ray polarimeter**

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**Abstract.** A significant degree of the astrophysical X-ray sources are expected to emit linearly polarized radiation. Measurement of the angle and degree of polarization can provide information of emission processes, geometry and magnetic field of the observed source. The standard techniques used to measure polarization are Bragg Diffraction and Thomson Scattering which have limitations such as narrow energy band sensitivity, high background etc. The technique discussed here is based on Photoelectric Effect which makes use of the emission direction of the photoelectron to measure the polarization angle. This is experimentally done by using GEM (Gas Electron Multiplication) detector. GEM amplifies the primary ionization leading to easier read out of the track of the photoelectron and hence the reconstruction. Operating parameters of GEM detector such as gas-mixture, pressure, absorption thickness and electric field decide the track length and the diffusion of secondary electrons which in turn defines the accuracy of the reconstruction. In addition, these parameters also decide the sensitivity and the detection efficiency of the detector. Garfield, a simulation tool is used in the present work to optimize these parameters of the GEM detector. Here we discuss the results pertaining to the photoelectron track length w.r.t gas mixture and pressure. These results will also be discussed in perspective of diffusion and sensitivity.

### **Charged particle detection using swept charge devices**

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**Abstract.** Airless planetary bodies like the Moon allow us to remotely sense their surface elemental composition using the technique of X-Ray Fluorescence (XRF)

spectroscopy. An array of twenty four Swept Charge Devices (SCDs) will form the Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS) to be flown on Chandrayaan-2 for XRF studies of the lunar surface. The innovative SCD can provide better X-ray spectroscopic performance at higher operating temperatures compared to X-ray CCDs. However the fluorescent spectra produced by X-rays from the sun can also be contaminated by Particle Induced X-ray Emissions (PIXE). In order to estimate the PIXE contribution to the observed X-ray spectrum, it is required to have a simultaneous measurement of charged particle flux in the lunar orbit. Tests are being conducted in this regard to test the feasibility of using one of the SCDs of CLASS for charged particle detection. Experiments have been carried out where a scintillator of suitable thickness is placed over an SCD to convert it into a particle detector. Preliminary results of these experiments will be presented in this work.

### **Simulation studies for optimizing the trigger field of view of the TACTIC telescope**

Maharaj Krishen Koul, A. K. Tickoo, V. K. Dhar, K. Venugopal,  
K. Chanchalani, R. C. Rannot, K. K. Yadav, P. Chandra, M. Kothari  
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**Abstract.** A crucial issue in the operation of Imaging Atmospheric Cerenkov Telescopes is the optimization of the trigger condition, which is based on the discriminated signals of the individual pixels. The telescope should accept gamma-ray images at the lowest possible energies and also suppress background proton-induced showers as much as possible. Using the CORSIKA air shower code we have carried out detailed Monte-Carlo simulation studies with regard to optimizing the trigger field of view (FoV) of the TACTIC telescope. The results of this study suggest that, a trigger FoV corresponding to the innermost (11×11) pixels is quite optimum for accepting most of the events from a point gamma-ray source. This optimized FoV not only reduces the triggers generated due to chance coincidence but also the triggers from the cosmic ray background leading to improved sensitivity for TACTIC telescope. The results of the Monte-Carlo simulation studies on the performance of the TACTIC telescope at several zenith angles for various trigger FoV will be presented.

### **Simulation of night sky background for HAGAR**

Lab Saha and HAGAR collaboration

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**Abstract.** For experiments like HAGAR, based on atmospheric Cherenkov technique, performance of the experiment depends strongly on the level of night sky background (NSB) at the observation site. Proper modeling of NSB in simulations is important to

get the realistic estimate of the performance parameters. Here we present the Monte Carlo simulation of NSB and its comparison with experimental data. Effect of after-pulsing in photo-multiplier tubes is also modeled in present simulations.

### **Thomson X-ray polarimeter for a small satellite mission**

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G. Rajagopala<sup>1</sup>, H. N. Nagaraja<sup>1</sup>, M. S. Ezhilarasi<sup>1</sup>, P. Sandhya<sup>1</sup>,  
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**Abstract.** X-ray polarimetry is an unexplored area in high energy astrophysics. We describe a Thomson X-ray polarimeter developed for a small satellite mission. The instrument works in the 5-30 keV energy band and will be suitable for X-ray polarization measurement in about 50 hard X-ray sources. Currently, a laboratory model has been made and tested successfully and the design and fabrication of an engineering model is in progress. Different aspects related to mission specifications, instrument design, test results, and sensitivity for polarization measurement are discussed.

### **A new programmable receiver for the Ooty Radio Telescope**

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**Abstract.** Ooty Radio Telescope (ORT) is being upgraded with a new programmable receiver by digitizing RF and transporting data via optical fibre to a software correlator and beamformer. In Phase 1, all 40 half modules (11m section, BW = 18 MHz) are digitized, providing a field of view of 4.6°. Phase 2 aims at a 27° field of view with 6' resolution, which will result in a vast enhancement of ORT's potential for largescale surveys, sky monitoring for transient events and space weather monitoring. We present the design, current status and initial results.

### **Development of an automated extinction monitor for the NLOT site survey**

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**Abstract.** In order to search a few potential sites for the National Large Optical Telescope (NLOT) project, we have initiated a site survey programme. Since, most of instruments used for the site survey are custom made, we also started developing our own site characterization instruments. The Automated Extinction Monitor which is a small wide field telescope, will be dedicated to record atmospheric extinction in one or more photometric bands. It will give very accurate statistics of distribution of photometric nights and hours. In addition to this it will provide the measurement of sky brightness. In this poster, we briefly describe overall design of the proposed instrument and also report the status of the progress made so far.

### **Performance of the 130-cm optical telescope at Devasthal**

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**Abstract.** The F/4 130-cm optical telescope has been installed at Devasthal in October 2010. The Devasthal site at an altitude of  $\sim 2450$  m near Nainital has advantages of having best astronomical seeing and dark sky in the country. The first results from the telescope have provided seeing in between  $1'' - 1.5''$  most of the time. The first results comprising deep observations of galaxies, galaxy clusters, supernova and transients, star forming regions etc. will be presented. The results on the ongoing effort to obtain sub-arcsec seeing using Lucky Imaging method will also be presented.

### **Report on VHE Gamma Ray observatories in India**

Varsha Chitnis, on behalf of HiGRO collaboration

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**Abstract.** Past decade has seen considerable increase in number of sources detected in GeV-TeV band because of ground-based experiments like HESS, MAGIC, VERITAS. Recently Fermi has also contributed significantly to this field with several exciting discoveries up to the energies of few GeVs. Since large number of sources show cutoffs in their spectra in the range of 10-100 GeV, it is important to lower energy thresholds of ground-based experiments and have overlap with Fermi to study this band. High Altitude GAMMA Ray (HAGAR) experiment was designed to achieve lower energy threshold exploiting advantage of its location at higher altitude. This experiment,

which is the first stage of Himalayan Gamma Ray Observatory (HiGRO) collaboration between BARC, IIA, TIFR and SINP, will be soon be followed by another large experiment called Major Atmospheric Cherenkov Experiment (MACE). Taking advantage of high altitude in addition to very large mirror area of 21 m, MACE is expected to reach lower energy threshold in the neighbourhood of 20-30 GeV. Status of HiGRO will be reviewed followed by some discussion about proposed international collaborative experiment called Cherenkov Telescopes Array (CTA) of which Indian groups intend to become part.

### **A report on upcoming observatory of MPCST at Dongla, Ujjain**

Bhupesh Saxena<sup>1</sup>, Padmakar Singh Parihar<sup>2</sup> and Rajesh Sharma<sup>1</sup>

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**Abstract.** The M.P. Council of Science and Technology (MPCST), Bhopal has initiated a project to establish an astronomical observatory at Dongla, Ujjain. This place is situated exactly on the tropic of cancer (longitude  $75^{\circ}45'45.5''E$  and latitude  $23^{\circ}26'43.2''N$ ), and was the center of ancient Indian astronomy over several hundreds of years. The place is relatively dark, having moderate seeing and is found to have a large number of clear nights during September-April months. The proposed observatory will have mid-size robotic Optical Telescope equipped with large format CCD imaging camera. The science driver for the observatory is to continuously monitor a variety of variable stars and the transient objects. The telescope is primarily expected to be used by astronomers from the Indian universities, however, one quarter of the telescope time would be available to astronomers from other national institutes. The project work has already started and the observatory is supposed to see the first light some time during June 2011. In this poster we report the progress made so far.

## **(E) Teaching of Astronomy & Astrophysics**

### **Some innovative programmes in Astronomy education**

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**Abstract.** In order to inculcate a systematic scientific awareness of the subject of Astronomy among the students and to motivate them to pursue careers in Astronomy and Astrophysics, various innovative educational programmes have been designed at MPBIFR. Among them, the main programme is termed as the “100-hour Certificate Course in Astronomy and Astrophysics” which has been designed basically for the students of the undergraduate level of B.Sc. and B.E. streams. The time duration of the 100 hours in this course is partitioned as 36 hours of classroom lectures, 34 hours of practicals and field trips and the remaining 30 hours being dedicated to dissertation writing and seminar presentations by the students. In addition, after the 100-hour course, the students have the option to take up specialized advance courses in the topics of Astrobiology, Astrochemistry, Radio Astronomy, Solar Astronomy and Cosmology as week-end classes. These courses are at the post graduate level and are covered in a span of 18 to 20 hours spread over a period of 9 to 10 weeks. As a preparatory programme, short-term introductory courses in the same subject are conducted for the high school students during the summer vacation period. Along with this, a three-week programme in basic Astronomy is also designed as an educational package for the general public. The students of these courses have the opportunity of being taken on field trips to various astronomical centers as well as the Radio, Solar and the Optical Observatories as part of their curriculum. The guided trips to the ISROs Satellite Centre at Bangalore and the Satellite Launching Station at SHAR provide high degree of motivation apart from giving thrilling experiences to the students. Further, the motivated students are encouraged to involve themselves in regular research programmes in Astronomy at MPBIFR for publishing research papers in national and international journals. The teaching and mentoring faculty for all these programmes includes the visiting Scientists and Professors from various Research Organizations located in and around Bangalore as well as the in-house Scientific staff. It is gratifying to note that several students, after going through one or more of these courses, have indeed made commitments to pursue Astronomy as their career, some of them even obtaining admissions in to the institutes and universities in India and abroad for further studies in this field.

## Examples from Astrophysics in undergraduate teaching

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**Abstract.** Physics teaching requires frequent alluding to examples and real situation where a certain concept is applicable. Astrophysics provides a variety and range of phenomena that can be recalled and explained during teaching of nearly all undergraduate branches. Sometimes these examples are the only relevant examples. To make astrophysics more accessible and attractive as a future study option, incorporating examples from astronomy and astrophysics in undergraduate Physics syllabus could be of importance. Besides common examples from mechanics and gravitation some relevant examples are enumerated that can easily be used in the classroom to both explain a concept and simultaneously introduce some astrophysical phenomenon. Some examples that could be explained or outlined are Expanding Universe in Doppler effect; stellar temperature-luminosity in blackbody radiation; gravitational lensing in image formation by converging lens; Faraday effect in polarization; Auroras and Pulsars in cyclotron; Sahas ionization theory; Chandrasekhars mass Limit; Fraunhofer absorption lines; Forbidden spectral lines etc. The existing curriculum need not be modified - almost some tutorials may be added. Few of these are already mentioned in the syllabus of few universities.

## Astrophysics teaching at Assam University, Silchar

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**Abstract.** The Department of Physics is established in 1996 and since, then, thirteen batches of students have completed their Masters programmes in the subject. The Department introduced in the year 2001 Astrophysics as one special paper in PG level (in the second year). The syllabus of Astrophysics is designed to include courses from observational Astronomy to Theoretical Astrophysics and Cosmology. There are two theory papers (in third and fourth semesters), one practical paper (in third semester) and one project or dissertation paper (in fourth semester), each one carries 100 marks. The major instruments available in the department for carrying out the experimental work are Meade-16 inch telescope, Celestron-8 inch inches Telescope, Meade refracting telescopes (4 inches, 2 number), SSP-5, SSP-3 photometer, Sivo Fibre-fed Spectrometer, CCD (Meade 416 XT, ST-6), Goniometer, Limb darkening apparatus etc. The practical paper includes study of the variation of sunspots; measurement of the parallax of distant objects, on moon and on planets like Jupiter and Saturn, measurement of the magnitude of different stars, study of the light scattering properties of rough surfaces, analysis of the image by image processing software (IRAF) etc. The project papers are based on research oriented topics which covers

latest trends in Astrophysics including solar system studies, Interstellar medium and star formation studies and some problems in gravito-optics. There are altogether 6 scholars who have been awarded PhD and 10 are registered for PhD in Astrophysics. Besides these, 8 scholars have been awarded M. Phil. in Astrophysics. The broad research area of Astrophysics includes light scattering properties of cosmic dust, star formation, gravito optics, polarization study of comets etc. The Astrophysics group is currently doing research in different fields and have very good publications in several peer reviewed journals of international status.

### **Teaching Astronomy at CUSAT**

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**Abstract.** The Department offers a one semester course in Astronomy for PG students. The paper is titled as 'Relativity and Astrophysics and content of the course is: Tensor Analysis, General Relativity, Cosmology and Astrophysics. From 2009-10 academic year onwards, two experiments: (1) Determination of apparent mass of a star and (2) Measurements of lunar topography are included in the M. Sc. practicals. Students are also given training in sky watching. Since 2006 onwards the department is conducting a summer programme for school children for 10 days during vacation and two days are set apart for Astronomy related topics. We give training to students to make small telescopes and they are also introduced to wonders of the sky. This is now an annual programme of the department. From last year onwards we visit schools especially in villages and students were given training in making small telescopes and a sky watching programme is also held for the benefit of the students. We also conduct sky watching programme in the campus for the benefit of students and the public.

### **Teaching Astronomy at SRTM University, Nanded**

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**Abstract.** School of Physical Sciences of SRTM University, Nanded, Maharashtra offers Astronomy & Astrophysics as one of the specializations at postgraduate (M. Sc) level. With a view to provide training in astronomical observations, data analysis and interpretation of the data; the school has incorporated a set of observational as well as data analysis exercises as a part of this course. The school at present is having observing facilities like, two 8 inch aperture Meade optical telescopes equipped with SSP-3 and SSP-3A photometers, 416-XT CCD camera and is in the process of procurement of Advanced Coma Free 16 inch (40cm) aperture Meade LX-200 optical telescope along with ST-10XME CCD camera and SBIG spectrograph. In addition to these facilities, with an objective of spreading the joy and excitement of radio as-



tronomy among the postgraduate and research students, the school is procuring one 10-foot diameter dish antenna and 1420 MHz Hydrogen Line Spectrometer (radio observation setup). For the solar irradiance measurement, the school is also procuring one StellarNetUV-VIS-NIR Spectro-Radiometer. These facilities are quite suitable for continuous monitoring of a variety of variable stars, carrying out spectroscopic observations of a variety of objects, 21-cm observations of star-forming regions, solar irradiance measurement etc. This presentation is aimed to give a brief summary of various activities that are conducted at M Sc. level using the facilities available in our university department.

### **Teaching of Astronomy and Astrophysics in University of Delhi and the under-graduate projects in IRC**

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**Abstract.** We have two courses in General Relativity and Cosmology, two in Astronomy and Astrophysics and one in observational Astronomy. In addition to this, B Sc. and M Sc. students do projects both formal and informal basis. The IUCAA Resource Centre, is a place where students from different colleges come to use the library, discuss with people working in Astronomy & Astrophysics as well as to do projects in Astronomy & Astrophysics. The recent addition on the telescope facility as well as the upgradation of the IRC as a data centre has enhanced the interest among students in this area.