Modern Engineering Trends in Astronomy - 2019

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INDIAN INSTITUTE OF ASTROPHYSICS

Bengaluru

Book of Abstracts

Contents

1. Wide Field Optical Spectrograph for Thirty Meter Telescope – India's contribution in the design and development

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Wide Field Optical Spectrograph (WFOS) is one of the first light instrument for the Thirty Meter Telescope. It is a seeing limited, multi - object instrument that covers a wavelength range between 310nm to 1000nm and field of view of 8.3x3.5arcmin. Current 2-channel spectrograph concept is a slit mask design with a vertically mounted-on-axis layout, on the Nasmyth platform. The entire instrument rotate vertically to compensate for the field rotation during observations. The grating and camera are designed to have motion in a fixed horizontal plane to avoid varing gravity vector during observations. The instrument requires to have a stability of less than 1pixel (15microns) at the detector over 24 hours, so that the day time calibrations can be used during the night. Rotating camera and articulation sample user-desired wavelength range. Different filters and gratings will be used for different observing modes,(imaging, low-res R~1500, med-res R~3500, and high-res R~5000 modes). India made significant contribution towards the optical design analysis, flexure modelling and currently pursuing the mechanical design of the grating exchange system, camera mounts and articulation system. India will also contribute to the calibration system and will lead the instrument control software. We will present an overview of the instrument concept evolution and highlight some of the contributions from India.

2. INVESTIGATING SINGLE PHOTON INTERACTION PRODUCED BY TYPE II SPDC

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SPDC is a nonlinear instant optical process that converts one photon of higher energy (namely, a pump photon), into a pair of photons (namely, a signal photon, and an idler photon) of lower energy, in accordance with the law of conservation of energy and law of conservation of momentum. It is an important process in quantum optics, for the generation of entangled photon pairs, and of single photons.

The main goal of photon interaction experiment is to collide two photons at specific point in space and time exploring the particle nature of light and to reveal new information about the very nature of photons. The goal of photon collision is accomplished using β barium borate crystal which produces a pair of entangled photons using spontaneous parametric down-conversion (SPDC) process which are to be collided.

3. Sky Watch Array Network (SWAN): Wide-band Receiver Instrumentation development and Current Status

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The Indian SWAN (Sky Watch Array Network) initiative aims to significantly enhance Indian observing capabilities in radio, and importantly, also to sustainably build & nurture future generations of talented radio astronomers in India to take up the challenges and lead in exciting research in astronomy. The SWAN focus is to design, develop and use a wide-band interferometric array of antenna across different parts of India to facilitate and conduct deep searches & studies of fast and slow transient radio radiation from astronomical sources, also enabling high angular resolution (VLBI) imaging of discrete galactic & extragalactic sources at low radio frequencies. It also facili- tates hands-on experience to a large number of undergraduate/postgraduate students through their direct & active participation, starting from the design stage to competitive research using the array network. The proposed competitive network, with nominally 1000 sq. m array area at each location and operation spanning a decade in frequency (50-500 MHz), is being developed in three phases. As a proof-of-concept/demonstrator setup, a 7-station narrow-band system, using small tiles (based on MWA design) and receiver hardware from RRI-GBT Multiband system, is successfully configured and tested in array mode. In addition to the above, a broad-band receiver system capable of simulta- neously catering to eight input signals (each of width 175 MHz) is being developed to operate in the frequency range 50MHz – 400MHz, having low noise amplifiers with FM band rejection, high-gain amplifier modules, a set of band shaping microstrip based filters, as well as a high-speed ADC and Virtex-6 FPGA based digital back-end receiver. The evaluation of this system in the laboratory is in progress.
In this talk, we discuss the technical aspects related to the design, development, and the laboratory test results obtained from the broad-band RF receiver system.

4. The Infrared Astronomy Group (IR group) of TIFR,

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The Infrared Astronomy Group (IR group) of TIFR has been developing near-infrared (NIR) instru- ments for ground based Indian telescopes, far-infrared instruments for TIFR 100-cm balloon borne telescope and has recently developed space platforms via IRSIS & other projects. This talk will present an overview of NIR astronomical cameras developed by the IR group which have been commissioned / used at various observatories in India (e.g. IGO, IUCAA,Pune; MIRO, PRL, Mt Abu; HCT, IIA, Hanle, Ladakh and DOT, ARIES, Devasthal, Uttarakhand). TANSPEC Optical-NIR spectrograph is recently (April 2019) installed and commissioned at DOT 3.6 meter telescope. TIRSPEC NIR imager and spectrometer was commissioned at 2 meter HCT, Hanle in 2014 and is currently being used for science observations. TIRCAM2 NIR imager has been used at MIRO, IGO and is currently installed at the side port of DOT 3.6 meter telescope. Talk will also cover a briefoverview of the IRSIS related work.

5. Low cost - 21cm observation on Sun from Kodaikanal Solar Observatory

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Traditionally 1420 MHz line emission is used to study the Doppler Spectrum of the 21-cm hyper fine line of interstellar atomic hydrogen.This radiation comes from the transition between the two levels of the hydrogen 1s ground state, slightly split by the interaction between the electron spin and the nuclear spin. We have modified the old dish antenna and the receiver system to study the radiation from Sun at 21 cm at Kodaikanal. The result is compared with the available online resources to compute the thermal emission from Sun (Quiet Sun) at this wavelength. The radio instrumentation and interesting results will be presented.

6. Low cost Characterisation of Sun and Nadir Sensors for Attitude Control of Nano Satellites

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Nanosatellites based experiments are having an exponential growth in recent times. These satellites use miniaturised components that consumes less power. Attitude control of Nanosatellites depends upon various sensors such as sun sensor, nadir sensor, inertial measurement unit and others. All these sensors need to be qualified/characterised before the actual flight. Academic institutions and small companies don't have access to equipment that are dedicated for precise testing of these sensors. This paper discusses about two different low cost testing methodologies of sun and nadir sensors in the laboratory requirement. These sensors are based CMOS camera technology that takes the image of the sun and earth to estimate the satellite attitude. First method uses direct sun as the light source with readings obtained for different azimuth and elevation. Second method uses xenon-arc lamp in a laminar flow chamber that closely resembles the sun spectrum. Third method uses multi-spectrum light source for the testing.

A separate setup was made for the nadir sensor testing in which an aerobics ball with light source from behind placed inside a dark chamber was used to simulate earth. Camera images of the aerobic ball (earth simulator) were taken from the sensor for different positions and attitude was estimated. The experimental setup, comparisons, pros and cons for each of the methods are discussed in detail.

7. Engineering challenges in realization of Visible Emission Line Coronagraph on-board Aditya L1

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Visible Emission Line Coronagraph (VELC) on board India's first space solar mission Aditya-L1 is an internally occulted reflective coronagraph designed for solar coronal studies. VELC is capable performing the observations in imaging, spectroscopic and spectro-polarimetric modes closer to the solar limb (50arcsec). Super polished off-axis parabolic mirror is chosen as primary mirror (M1). Due to the off-axis primary, the payload structure deviates from the cylindrical structure. VELC consists of 21optical assemblies, 4 detectors and 4 baffles. The payload volume is 1.71m (L) x 1.07m (W) x 0.540m (H). All the payload components should be aligned to tight tolerances (<20 arcsec) in order to meet the performance requirements. Payload global stiffness has to be > 100 Hz to withstand the launch loads. The in-orbit thermo-structural (check) stresses should be minimal such that the payload performance is not compromised. Thermal gradient in the optical cavity is around 6˚C (22±3˚C), this gradient should not affect the inter separation between the optical elements. The optical components are spread out over the optical bench of size 1.6m x 1m and to keep the interface stress to minimum, the flatness demanded is ~10 microns. The overall mass budget of the payload is about ~172 kg. The results of the optical tolerance analysis calls for the CTE of the optical bench to be < 8ppm.

VELC includes three sCMOS (visible channels) and one InGaAs (IR channel) detector systems. Each of the detectors has four packages consisting of Detector Head Assembly (DHA), Control and Data Processing Electronics (CDPE), Power Supply Electronics (PSE) and Interface to BMU (CERT). The sensor, Detector Proximity Electronics (DPE) and interface with payload thermal control system constitute the DHA. Considerable efforts are made in the selection of sensors (to meet the proposed science goals), configuring electronics design and interface, mechanical interface, thermal interface, optimizing camera electronics, on-board data processing protocols, etc.

All of these systems have to be integrated, tested and calibrated to achieve the designed system performance. Sub-system level tests and calibrations are being developed. Stringent contamination control protocols have been evolved and implemented to minimize the scatter due to particulate and molecular contaminants. Sub-system level tests and payload integration will be carried out in class- 10 clean facility. Vacuum calibration of VELC is critical and hence its final performance test will be carried out in vacuum environment. Several system-level calibration protocols such as PSF/MTF measurements, spectroscopic, radiometric/photometric, polarization calibrations, etc. are planned and also being implemented.

The science goals, overall instrumentation, criticalities and challenges faced in each domain will be presented across various sessions by the concerned authors.

8. Design and development of mechanical systems of SUIT Payload onboard Aditya L1

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The Solar ultraviolet imaging telescope (SUIT) onboard Aditya L1 is an upcoming space telescope to study the Sun in near UV (200nm - 400nm) range and will be placed in a halo orbit around Sun-Earth L1 point. The mechanical systems design of SUIT involved considering crucial factors of structural integrity to withstand launch loads, meeting temperature specifications within the payload, light- weighting of components, assembly and alignment sequence to meet the optical requirements.The instrument can reach high temperatures due to exposure to 1450W/m2 solar intensity at L1, while the CCD imaging device will need to operate at a temperature of -55 degrees Celsius. Moreover, the payload components include moving mechanisms, optics, and electronics, which have specific vibration qualification values. Therefore, the design of the mechanical housing for these items needs to ensure that the thermal deformation is within allowed limits and the components will survive launch loads. In the presentation, we will be discussing the procedure to develop the mechanical design of the instrument and the various techniques used to validate the design.

We used the design software Solidworks and NX Nastran for the CAD modeling and FEM studies for designing these components. This included features such as grid structures, thin-walled structures, honeycomb panels, flexures based mounts, to meet the final optical, structural and thermal specifications. The presentation will include the methods and results of thermal distortion studies, vibration simulation studies, and a brief report on manufacturability, optomechanical assembly procedure of the instrument so as to meet the design requirements. The overall impact of this study is that it can be an additional guideline for facilitating the mechanical systems design of space telescopes and will be useful in similar future projects.

9. Brush arrangement for dome of 3.6m Devasthal optical telescope at ARIES

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ARIES 3.6 m optical telescope at Devasthal is enclosed in steel building with rotating dome. Dome comprises of upper rotating cylindrical steel structure and lower fixed dome support structure. Ro- tating dome being a fabricated structure of about 16.5m mean diameter involved lot of welding and a clearance of about 150 mm was kept between fixed dome structure outer wall and rotating dome outer plate. Flexible sheets were fixed between fixed and rotating structure to avoid entry of rain water and dust etc. Requirement for better arrangement to solve the problems posed by rain water, dust, insects and fog etc. was felt at ARIES. Arrangement of brushes with polyethylene terephtha- late (PET) bristles has been prepared for the purpose of filling the gap between fixed and rotating structure. A sliding mechanism has been developed for changing of bristles during their wear and tear. Material for the bristles was selected using various economical, ecological, physical and chem- ical parameters. Certain necessary tests on prototype were also performed to check that bristles meet the required conditions. ARIES is planning to put the brush arrangement for dome of 3.6m Devasthal optical telescope.

10. Design and Development of stress relieving support system for TMT primary glass blanks

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The Thirty Meter Telescope (TMT) adopts a recently developed technology known as Stressed Mir- ror Polishing (SMP) for the polishing of its 492 glass blanks. In this process, first the meniscus type spherical shape glass blanks are converted in to the conjugate of desired aspheric shape by the ap- plication of forces around the edges using warping arms. This is followed by spherical polishing in the stressed condition to obtain the required surface figure. The stress accumulated in the glass blank needs to be released before the metrology to measure the asphericity of the surface. Hence it is essential to remove the stress by keeping the glass blank in a free floating condition. To achieve this, the glass blanks need to be kept over a platform or a support system which will provide a zero gravity condition.
As a part of this, we designed and simulated a passive support system which works using the whiffle- tree mechanism to produce a floating condition. This is achieved by sensing the reaction force at each support point and nullifies the gravity effect by giving equal and opposite counter acting forces. This stress relieving support system which additionally gives optimized support for the glass blank and helps to minimize the surface deformation due to its self weight sagging. This paper discusses about the design and analysis of the support system and it also discusses about the sensitivity, tolerance on position and force and alignment sensitivity of the glass blank over the support system.

11. Design and Development of Telescope Cover Structure for 3.6m Telescope at ARIES

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The 3.6 m optical telescope of ARIES is installed at Devasthal site for astronomical observations. Need for additional protection of telescope apart from that provided by its dome was felt to avoid any minute water leaks from dome roof, accumulation of dust on the mirrors and also to minimize effect of humidity on telescope during rainy season. A telescope cover structure has been designed to cover the telescope inside its dome. It was designed as a permanent structure that will be integrated with dome's existing structure. Structure will allow movement of two 10 MT under slung cranes in dome as well as periodic health run of the telescope during rainy season. Prototype of telescope cover structure was prepared and its assembly was tested with dome structure. Components for manual version of the telescope cover structure were fabricated in-house, assembled with dome and tested successfully at site with plastic covers. Presently further work on up-gradation of telescope cover structure with retractable water proof and fire resistant fabric is under progress.

12. Radio Frequency Interference and its mitigation at upgraded GMRT

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Giant Meterwave Radio Telescope (GMRT) is an array telescope of 30 antennas each of 45 meter in di- ameter located at Khodad, Pune. The upgraded GMRT have a seamless coverage over the frequency band (120 MHz – 1450 MHz) with high dynamic radio receivers. The Radio frequency interfer- ence to a radio telescope is a permanent threat and needs continuous monitoring and mitigation to protect the operation of radio telescope. Intentional transmissions like mobile communication, TV transmission, wireless service, Air traffic control signals, FM radio stations, satellite services and un-intentional radio interference from power lines, CATV, Industries, Wind power generating sta- tions, computers, computer network components, UPS, SMPS, AC units, Lights etc. are the common sources of radio interference to a Radio Telescope. This paper presents RFI monitoring, characteriza- tion of various types of RFI, RFI shielding solutions and various other mitigation techniques adopted at upgraded GMRT for the control of radio frequency interference and maintain a RFI free ambience.

13. Testing a Multi-element, Multi-beam, FPA Beamformer in Free- space Test Range

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The Expanded GMRT (eGMRT) is a proposal to look at three expansions to the GMRT - increasing the field of view, increasing angular resolution and improving the sensitivity to the extended radio emission. In this talk, we would focus on the testing of multi-element, multi-beam beamformer using the 144-element Focal Plane Array (FPA) procured from ASTRON. The preliminary tests for the beamformer are being carried out with FPA as an aperture array. A free-space test range, meeting the far-field requirements at L-band, has been developed at the GMRT site. The narrow beamwidth transmitting antenna (a 3m diameter parabolic dish and a cross-dipole feed at the prime-focus) required for beampattern measurement and beamsteering experiments was fabricated at NCRA. Beamsteering measurements have been carried out by radiating continuous wave and broadband noise in this test range. Tests have also been carried out to observe navigational satellites in the L-band with the transmitting antenna used for “phasing” the array. The test methodology, details of the experiments and the results would be described. The test results from the beamsteering experiments show a close match with the theoretically expected outcome. The entire process of testing from setup to data acquisition and analysis is automated to allow for a speedy understanding of the data and efficient debugging.
Currently, we are working to test multiple beams in the field-of-view (FoV) by applying optimal beamforming weights.

14. Development of tools and methods to characterize low noise power supplies for the purpose of Astronomical instrumentation

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Reducing power supply noise is one of the essential steps in order to implement precision and reliable instrumentation. However, commercial power supplies are usually insufficient for the purpose of astronomical instrumentation. They usually lack noise characterization over a range of frequencies and also over a range of applied load. In this regard, we have defined a method of estimating toler- able noise limits along with specific bandwidth and load limit requirements for various electronic components. We have developed tools such as DC constant current loads and active RC filters to test and measure the noise performance of off-the-shelf power supply modules. Finally, We have fabricated a range of old and modern voltage regulator architectures and compared their measured noise figures for the purpose of realizing a low noise (< 50 microVolt RMS) power supply. We will discuss the various methods of noise measurement using a modern digital oscilloscope and various techniques to reduce power supply noise.

15. Accelerated Tile Processor

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Modern FPGAs are revolutionizing the digital system designs with built-in analog to digital convert- ers (RFSoC), floating point DSP processors and with high-level programming tools. We have planned to build a versatile digital receiver, namely the accelerated tile processor, by exploiting these FPGA features. We will present here the salients features of the digital processing architecture considered and discuss the advantages arising from such a design for a multi element radio telescope application.

16. An overview of Analog Receiver System for Detection of Global EoR Signal

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SARAS is an ongoing experiment aiming to detect the redshifted global 21-cm signal expected from Cosmic Dawn (CD) and the Epoch of Reionization (EoR). Standard cosmological models predict the signal to be present in the redshift range z ~6-30 corresponding to a frequency range of 40-200 MHz, and as a spectral distortion of amplitude 20-200 mK to the cosmic microwave background. Design of a radiometer for detection of this weak signal is a challenging task, owing to the fact that this frequency range is dominated by astrophysical foregrounds of Galactic and Extragalactic origin, with several orders of magnitude greater brightness temperature and strong terrestrial Radio Frequency Interference (RFI). It is critical that the instrumental systematics do not preclude the measurement of the weak 21-cm signal via additive or multiplicative confusing structures in the measured sky spectrum.
Here, we present the system design of the SARAS 3 version of the receiver, emphasising on the re- ceiver configuration and the signal flow from the antenna to the digital backend. We touch upon the aspects on the system design and laboratory measurements. New features in the evolved de- sign include Dicke switching, double differencing and implementation of optical isolation and op- tical switching for improved accuracy in calibration and rejection of additive systematics leave no confusing systematic structures at a level of a few mK. We review the design and engineering chal- lenges involved in the deployment of the system in field for sky observations with future plan of action.

17. FPGA-based Focal Plane Array Beamformer Architectures for the Expanded GMRT

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The Expanded GMRT (eGMRT) is a proposal to look at three expansions to the GMRT - increasing the field of view, increasing angular resolution and improving the sensitivity to the extended radio emission. In this talk, we would focus on increasing the field-of-view using Focal Plane Array (FPA) and the ongoing development of the FPGA-based prototype FPA beamformer. A prototype is being developed to understand the challenges in building real-time beamformer with multiple inputs and multiple beams. As part of this project, we have calculated the computational complexity of implementing FPA beamformer in real-time and the various tradeoffs at the architectural level. This tradeoff analysis helped in arriving at an optimal number of inputs, spectral channels, and beams for Virtex-5 FPGA.

In case of an FPA system, the computation of beamformer weights through the correlation operation is only needed at distinct time intervals. This led to a further increase in the number of inputs for the same hardware setup, by separating the correlation and beamforming designs, and exploring FPGA reconfigurability. An alternate approach through a fully offline correlation design using recorded raw voltages would also be described. The current version of the multi-element, multi-beam design of the narrowband (32 MHz bandwidth, 16-input, 4-beam) and wideband (300 MHz bandwidth) beamformers have been developed using the CASPER (Collaboration for Astronomy Signal Processing and Electronics Research) methodology. The recent test results from the above- mentioned beamformer designs conducted in a free-space test range (at the GMRT site) would be described. As a step towards migration to contemporary signal processing platforms and the final prototype beamformer, we have started beamformer development using Xilinx RFSoC (RF System-on-Chip).

Engineer's Day Talk

18. Ultra-Precision Engineering Enabling human's fundamental quest to decode the COSMOS

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Every step in the direction of our fundamental understanding of the Cosmos had required pushing the limits of existing technology to build more precise and more sensitive instruments which in-turn requires development of new techniques for ultra precision fabrication. The Laser Interferometer Gravitational Wave Observatory or LIGO as it is popularly know, is a 4 km arm length laser interferometer designed and developed for detecting the minuscule contraction and expansion of space due to a passing gravitational waves and are arguably the most complex and precise instrument that humankind had ever built to understand the universe. The talk will provide a brief overview of the Advanced LIGO detector, the ultra-precision technologies that needed to be developed, the engineering challenges and complexities that went into achieving the required sensitivity to be able to detect and measure Gravitational Waves.

19. INSIST: A Proposed Wide-Field, UV-Optical, Imaging and Spectroscopic Space Telescope

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Optical imaging has been the driving force of astrophysical research, historically driven by the ground based telescopes, which still drives the ground based astronomy, with the recent surveys like the SDSS, PANSTARRS as well as the upcoming LSST. IR and UV wavelengths obtained from space are complimentary to the ground facilities. With the upcoming JSWT to compliment the IR wavelength range in the near future, a deep photometric survey in the complementary UV range is lacking for the international astronomical community. India reached a major milestone in the area of space astronomy with the successful launch and post launch operations of its first space obser- vatory, ASTROSAT and has achieved in securing a firm foot print for Indian in the international astronomy scene. The success of this space observatory and the lessons learned has motivated to enlarge the footprint of Indian space astronomy in the international scene.

The high resolution optical/UV images have so far been provided by the Hubble Space telescope (HST) since 1990s. The high spatial resolution imaging of the HST is limited to very small fields. As the mission is approaching the end of its life time, it is unlikely to be available for a very long period. As the 2030s will produce deep sky images in the optical and IR regions, a similar coverage in the Ultraviolet are not addressed by any of the planned mission. This is where India with its capacity to launch and operate space observatories, can fill the gap. The UVIT was a capability demonstration and it is important to take this strength to create the next generation UV-¬optical observatory class space telescope in the next decade, to fill the gap in the international scene.

In order to fill the gap in the UV space astronomy, Indian astronomical community has submitted a proposal, Indian Spectroscopy and Imaging Space Telescope (INSIST), to ISRO. INSIST is an obser- vatory class mission aims to do imaging with high spatial resolution (0.2") covers 0.25square degree FOV with the sensitivity of 28th magnitude in the UV for an exposure of 1ksec and a multi object spectroscopy feasibility with a spectral resolution of R~2000 in UV. During the design phase, various optical configurations have been considered and the merits and demerits of each design has been studied. Optical design and design challenges of INSIST will be discussed in details here.

20. Adaptive Optics Program at IIA

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Adaptive optics is an inevitable technology in any modern large ground-based telescope. It involves use of corrective optical elements within the telescope to compensate for the deleterious effects of the Earth's atmospheric turbulence on the image quality. Indian Institute of Astrophysics is deliberating on building a 2 m class large solar telescope (The National Large Solar Telescope) and a 10 m class stellar telescope (The National Large Optical Telescope). In view of this, an adaptive optics program has been initiated at IIA to generate necessary expertise by demonstrating adaptive optics on existing small telescopes. In this talk, I will present the progress made in last two years in this initiative and discuss the future prospects.

21. Non-spherical representation of optical surfaces - an advanced study

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In general, a majority of optical system used conventional spherical surfaces as it is easy to make and characterize. Though advantages of using non-conventional surfaces such as aspheric, freeform are being well known since primitive era of geometric optics. The recent progress in high precision engineering technology continuously demanding these surfaces in order to meet stringent optical design requirements. However the right choice of representation of these surfaces is not easy and sometimes may lead to fabrication and metrology criticality which directly push the cost of the optics. In this document different type of non-conventional surface representation with their advantages and disadvantages is being covered.

22. FE analysis for the mechanical structure of Prototype Segmented Mirror Telescope

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To keep in pace with the emerging trends in scientific research and cater to the need of growing Indian astronomical community, a need is strongly felt for realising an 8-10 meter size optical tele- scope in India. Construction of such a large optical telescope size is possible only when the primary mirror is made of large number of small mirror segments. In segmented mirror technology, smaller mirror segments are aligned with respect to each other so that it acts like a single, monolithic large aperture telescope.

Before embarking on such a large and expensive segmented mirror telescope project, it is necessary to understand the complexities of the segmented mirror technology by thoroughly working on the design, development, analysis, fabrication, realisation and laboratory experimentation by making a full-fledged prototype segmented mirror telescope (PSMT) of a smaller size. It is planned to realise a 1.5m aperture PSMT at IIA, with 7 segments for this purpose. The design and analysis of this PSMT is in advanced stage.

23. Mirror Segment Error Budget Development for 10 meter class Telescope; NLOT/MSE

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The proposed India's National Large Optical Telescope and the Mauna Kea Spectroscopic Explorer are optically designed to have nearly identical hyperbolic primary of 60 segments of size 1.44m, de- livering a circumscribed 11.25 meter aperture. In order to get the best image quality, all the segments in the primary mirror need to be aligned in the telescope for a monolithic profile. Any deviation from the monolithic profile would degrade the Image Quality(IQ). The possible error contributions from M1 which could cause the image degradation are categorized into seven major groups: (i) Segment Residual Figure Error (SRFE), (ii) Segment Thermal Distortion (STD), (iii) Segment Support Print Through (SSPT), (iv) Segment Drift Errors (SDE), (v) Segment In-plane Displacement (SIPD), (vi) Segment Out-of-plane Displacement (SOPD) and (vii) Segment Dynamic Displacement Residuals (SDDR).
The primary error components in each of the above-mentioned group is represented as the lower order Zernike term (4th order) except the 1g gravity effect where the higher order Zernike terms are significant. Most of the lower order surface deformation on each of the segment will be corrected by warping harness in the segment support system but eventually introduces high frequency residuals. In order to achieve the M1 system-level top-down IQ allocation, we have developed M1 shape error budget which includes lower and higher order surface deformation. The Image quality is character- ized by the 80% Encircled Energy (EE80) in error budget. Details about the technique used for the development of the mirror segment error budget and the sensitivity of each lower order term and gravity effects on M1 for telescope Zenith angle 0 and 30 degree for on-axis as well off-axis fields will be discussed here.

24. Conceptual Design of Primary Mirror Cover for the proposed 2m class National Large Solar Telescope

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The National Large Solar Telescope (NLST) is proposed to be built in India which will be one of the most powerful telescopes to study the Sun. It will have a 2m size primary mirror. The primary mirror needs a removable cover to carryout two important functions: first one is to protect primary mirror from environmental conditions when the telescope is not in operation and second one is to prevent dangerous concentrated solar radiation from primary mirror arriving directly to secondary mirror or any part of the telescope structure without passing through the heat rejecter when the telescope points to an unintended direction due to some malfunctioning of the drive control system.
Few design concepts worked out for this primary mirror cover along with their drive mechanisms for the 2m NLST are presented in this paper.

25. Conceptual design for TMT High Resolution Optical Spectrograph (HROS)

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High Resolution Optical Spectrograph (HROS) is one of the proposed second generation instruments for Thirty Meter Telescope (TMT). It is expected to be a seeing limited workhorse instrument for TMT. We present a conceptual design of a high resolution optical spectrograph for TMT. The design uses strategies of successful spectrographs (e.g. UVES, ESPRESSO) and incorporates constraints on the maximum available sizes of large optical components. The design offers large flexibility to choose several observing modes to meet the ambitious science goals of extremely large telescopes. HROS has spectral resolutions of R ~ 25000-100000 combined with a multi-object capability. The instrument design consists of two separate echelle spectrographs to cover the blue and red wavelengths. The combined red and blue spectrographs provide simultaneous wavelength coverage between 310 nm and 1100 nm. Both slit and fiber inputs are available to meet the high throughput and high stability requirements. Here, we will present a detail design of the spectrograph, the focal plane optics, telescope interface and pre-slit optics.

26.Telescope Control Software and Communication server for 30 inch Telescope, VBO - an Overview / Software aspects of 2.4 M mirror coating plant, VBO

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27. The 3.6 m DOT electronics: Maintenance and future upgradation strategies

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We describe here the electronics aspects of the 3.6 m Devasthal Optical Telescope (DOT) and discuss the strategic approach adopted by the ARIES electronics engineering team for maintaining and up- grading the telescope. The construction of the 3.6 m DOT was completed at the AMOS Factory in Belgium in the year 2012 and the telescope was partially disassembled into its sub-systems and trans- ported to ARIES Devasthal site and reassembled and commissioned in 2016. The critical electronic parts of the telescope consist of both the customized systems like local realtime control computers running customized software for controlling the active optics enabled primary and secondary mirror support systems, wavefront sensor, azimuth and altitude motors and the standard industrial compo- nents like Delta Tau motion controllers, B&R programmable logic controllers, Kollmorgen and LTI drives, Kollmorgen motors and Heidenhain and Renishaw encoders. The control components are programmed and interfaced to implement suitable control law to deliver the stringent performances. Owing to large size of the telescope the control components are distributed over different realtime network. Additionally, these components require constant monitoring, preventive and scheduled maintenance and upgradation for their smooth and reliable functioning.

28. RF over fibre optic backplane for phased array antennas

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RFoF technology enables a path for low loss signal transmission over longer distances, carry huge bandwidth of data, and is also immune to electrical noise. The paper discusses the technology, design, and methods for implementing it for phased array antennas application. The RFoF backplane is very much compact and suitable for phased array antennas, these replace the need for bulky RF cables, which is capable of carrying the output of the only single element. MPO (multi-fiber push- on) developed to provide multi-fiber connectivity in one connector to support higher bandwidth and higher density applications. The purpose of the project is to design RF over fiber-optic backplane for the focal plane array, it consists of 144 Vivaldi antenna elements with frontend electronics (LNA) behind it. The low cost, high dynamic range signal transport system is designed and implemented with multi-fiber push on technology. The laser transmitter section is directly connected to the RF output of elements, so this is made very lighter in weight keeping the overall weight of feed to be minimum, making it suitable to be mounted over the prime focus of dish antenna. The designed system supports the frequency range from 500 to 2000 MHz and has an optical budget of 8 dB which will support an additional distance of 32 km at 1310 nm wavelength.

29. RASCAL (Reflector Antenna Sensitivity Calculator) Software

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G/Tsys defines the sensitivity of a radio telescope and is an important figure of merit. It is important to know the overall antenna efficiency and system noise temperature of the telescope in order to calculate the G/Tsys. In order to calculate the G/Tsys for uGMRT bands, a Software was developed in-house at GMRT-NCRA, named as RASCAL (Reflective Antenna Sensitivity CALculator). This paper presents the G/Tsys calculation of any single-dish radio telescope (Prime Focus feed/ Cassegrain Feed) using it is a software and can be used for any other Reflector antenna. Some basic inputs like primary Dish dimensions (F/D, Dish diameters, angle of quadruped, feed house area, etc), Radiation pattern of the feed, LNA noise temperature and receiver losses are required to compute antenna overall efficiency, system noise temperature and finally G/Tsys and secondary Radiation pattern of single dish. The program was also used to calculate the G/Tsys of other radio telescopes in order to cross verify the results and the results were found to match closely.

30. Antenna and RF

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Design considerations and challenges of integrating on-chip antennas in nanoscale CMOS technology at millimeter-wave (mm-wave) to achieve a compact front-end receiver for 5G communication systems. Solutions to overcome these challenges are offered and realized in digital 28-nm CMOS. A monolithic on-chip antenna is designed and optimized in the presence of rigorous metal density rules and other back-end-of-the-line (BEoL) challenges of the nanoscale technology. The proposed antenna structure further exploits ground metallization on a PCB board acting as a reflector to in- crease its radiation efficiency and power gain by 37.3% and 9.8 dB, respectively, while decreasing the silicon area up to 30% compared to previous works. The antenna is directly matched to a 2-stage LNA in a synergetic way as to give rise to an active integrated antenna (AIA) in order to avoid ad- ditional matching or interconnect losses. The LNA is followed by a double-balanced folded Gilbert cell mixer, which produces a lower intermediate frequency (IF) such that no probing is required for measurements. The measured total gain of the AIA is 14 dBi. Its total core area is 0.83 mm² while the total chip area, including the pad frame, is 1.55×0.85 mm².

31. Dual polarized broadband dipole antenna feed with conical reflector for uGMRT

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The Giant Metrewave Radio Telescope (GMRT) is an international facility for Radio Astronomy, op- erational since 2002. It consists of 30 fully steerable prime focus feed parabolic antennas, each of 45 m. diameter, spread over an area with an effective radius of nearly 15 km, and covering frequencies in the range of 150 MHz to 1420 MHz. Though meant primarily as an aperture synthesis instrument, antenna arrays can be formed out of the 30 dishes, where separate sub-arrays can work on different frequency bands concurrently.

To meet the requirement of seamless frequency coverage from about 50 MHz to 1500 MHz, we have designed and developed wide-band feeds of an octave or more bandwidth, to efficiently cover the following bands: 120-240 MHz (Band-2), 250-500 MHz (Band-3), 550-850 MHz (Band-4) and 1000- 1500 MHz (Band-5).

This paper describes the broadband dipole antenna feed with conical reflector design for L-band (1000-1500 MHz). This feed has been designed and prototype model was implemented at GMRT observatory. This future cone-dipole design for 900-1500 MHz, provides very good return loss per- formance (<-10 dB) and with uniform edgetaper ~ 12 dB throughout the band.

Dipole Design Concept: Any λ/2 dipole is resonant to particular frequency and narrow band in nature. When the dipole is loaded with plates/sleeves either on the top or bottom of the dipole, it will nullify the effect of Inductive reactance and improves the electrical bandwidth. λ/2 Dipoles for Band-2, -3, -4 & -5 have been designed and optimized the sleeve configuration to achieve required band width.

Cone Design Concept: Dipole and dipole with flat reflector will have asymmetric radiation pattern. If dipole arms are bent to achieve symmetry in radiation pattern, it will affect antenna impedance and power handling capabilities. To solve the above mentioned, dipole has to keep in the standard form and the flat reflector has to be bent to improve the radiation pattern symmetry. For Band-3, -4 & -5, cone-angle has been adjusted to 70 deg to optimize spill over and illumination losses for 45 meter dia. GMRT parabolic dish.

Successful completion and deployment of this wideband feed on all 30 antennas will make the GMRT a very sensitive and versatile instrument for a variety of new science in astronomy.

32. DESIGN OF DRIVE CIRCUIT FOR PIEZO WALKER FOR CONFIGURABLE SLIT UNIT

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We at TIFR, have initiated the development of a Multi-Object Infrared Spectrometer (MOIS) using a configurable multi-slit arrangement for a large aperture Indian optical/infrared telescope. In order to retain flexibility, avoid design and operational issues involved in using focal plane masks for multi-object spectroscopy we present here the first design concepts for the Configurable Slit Unit (CSU) that will be used to place multiple slits at different positions on the sky. The CSU simultaneously displaces bars across the FoV of the telescope to mask unwanted light so that a rectangular slit is formed at any desired position in the focal plane by positioning two opposing bars. The two opposite bars need to be independently controllable from either side so as to achieve any slit width opening as required during observation so that any slit width right from fully closed to fully open imaging field can be achieved. For infrared observations the entire mechanism has to be operational at cryogenic temperatures. We are currently working on a preliminary design for the CSU based on piezo-walkers to achieve the linear movement of the slits. In this talk I will present an overview of the CSU and specifically the microcontroller based drive circuit that we have designed to control the motion of the piezo-walkers accurate to 2.5 micron.

33. Evolution of GMRT Servo Computer with RTAI: Status and Updates

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Now a days General Purpose GNU Linux Operating Systems employed in variety of applications from digital gadgets to avionics, flight navigation systems and nuclear power plant control applica- tions. Monolithic kernel architecture of Linux OS makes it not suitable for safety and time critical applications. In such cases, to convert the GPOS into strict timing constraints, several approaches were followed in embedded system industry (ex: RTAI, RT-Patch and Xenomai etc). In this paper we are going to present, one such technique which converts the General Purpose Linux Operating System (GPOS) into Time critical system based on Real Time Application Interface (RTAI). In ad- dition with, we present minimal embedded system building techniques with Buildroot, and how it was used to develop the complete RTAI patched RTOS with different Linux kernel releases and RTAI versions. Also we presented performance measures of RTAI and debugging tools which helped us to tune and implement the RTAI based embedded software for GMRT Servo application.

34. Developmental status of X-ray polarization sensitive mirrors

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We have developed multilayer mirrors which can reflect X-rays are Brewster angle (~45^{o}) and hence are sensitive to X-ray polarization. We have fabricated several W/B_4C multilayer mirrors using magnetron sputtering technique with different parameters, optimizing the performance and sensitivity at soft X-ray region (photon energy < 1 keV). We have developed a conceptual design for a broad-band X-ray polarimeter using X-ray optics and multilayer mirrors. These mirrors have polarization sensitivity for soft X-rays. In order to improve the overall performance of the instrument, these mirrors are made transparent to hard X-rays by etching out the substrate. These type of mir- rors acts as polarimeters for soft X-rays while transmitters for hard X-rays simultaneously which has tremendous applications for astronomical X-ray polarimetry. I will present the design of an X-ray polarimeter instrument along with the developmental and test results of substrate etched multilayer mirrors.

35. An overview of Analog Receiver System for Detection of Global EoR Signal

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SARAS is an ongoing experiment aiming to detect the redshifted global 21-cm signal expected from Cosmic Dawn (CD) and the Epoch of Reionization (EoR). Standard cosmological models predict the signal to be present in the redshift range z ~6-30 corresponding to a frequency range of 40-200 MHz, and as a spectral distortion of amplitude 20-200 mK to the cosmic microwave background. Design of a radiometer for detection of this weak signal is a challenging task, owing to the fact that this frequency range is dominated by astrophysical foregrounds of Galactic and Extragalactic origin, with several orders of magnitude greater brightness temperature and strong terrestrial Radio Frequency Interference (RFI). It is critical that the instrumental systematics do not preclude the measurement of the weak 21-cm signal via additive or multiplicative confusing structures in the measured sky spectrum.
Here, we present the system design of the SARAS 3 version of the receiver, emphasising on the re- ceiver configuration and the signal flow from the antenna to the digital backend. We touch upon the aspects on the system design and laboratory measurements. New features in the evolved de- sign include Dicke switching, double differencing and implementation of optical isolation and op- tical switching for improved accuracy in calibration and rejection of additive systematics leave no confusing systematic structures at a level of a few mK. We review the design and engineering chal- lenges involved in the deployment of the system in field for sky observations with future plan of action.

36. Feasibility Study of Early Digitization implementation at GMRT

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In the existing GMRT receiver chain analog RF signals are transporated from antenna to centre station via optical fibre. The signals are then converted to baseband and digitized for further processing. The Early Digitization (ED) scheme is a part of ongoing GMRT development where broad-band RF signals will be digitized and packetized at antenna base and then sent to centre station through fiber optic instead of digitizing it at centre station.
The main benefits of early RF sampling are a simpler RF signal chain, decreased cost per channel and less channel density. With fewer analog components, instruments featuring a direct RF architecture are typically smaller and more power efficient. Building high channel count systems such as fully active phased-array radar, direct RF sampling can decrease the footprint and cost of systems. In addition to the size, weight, and power (SWaP) reduction, the simplified architecture removes potential sources of noise, images, and other errors, such as LO leakage and quadrature impairments, within the RF instrument itself. Direct RF sampling architectures also simplifies synchronization as focus is only on clock and trigger synchronization.
A PPS acts as a trigger signal marking start of data acquisition boundary. Hence 1PPS at each antenna needs to be generated very precisely with minimum jitter. For this various schemes were proposed and tested. The receiver system was developed to process boradband RF and a comparison study with existing GMRT chain was done. Theoretical and practical results from both receiver chain were summarised to show improvements in system parameters. In this poster we will present design details of the developed system and various test results on astronomical sources.