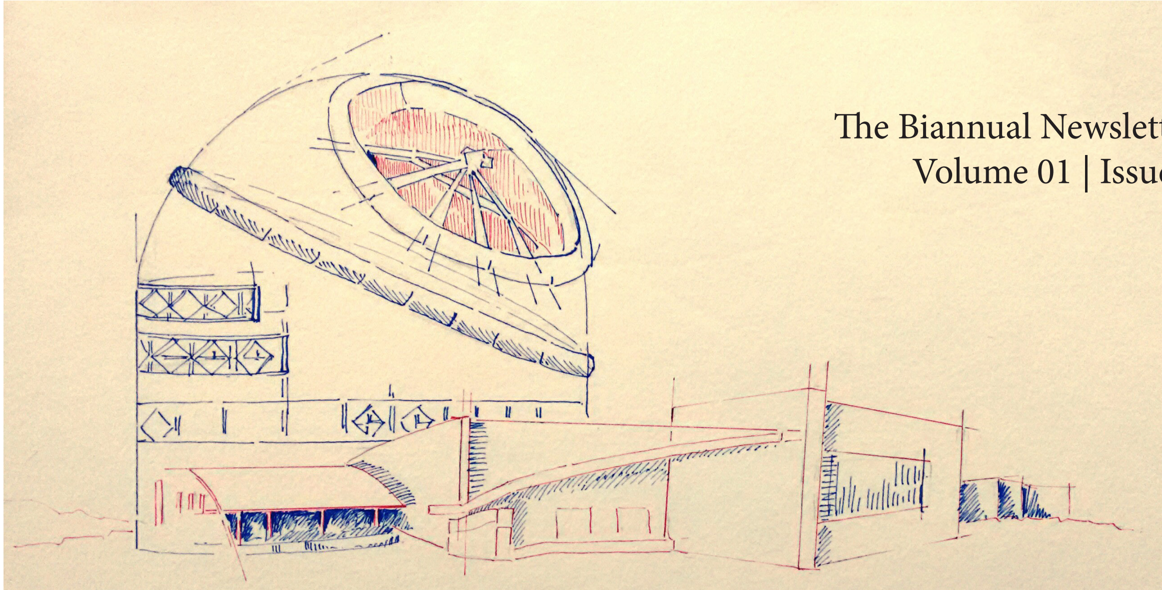

Dhruv

The Biannual Newsletter of *Aakashganga*
Volume 01 | Issue 01 | January 2015

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Aakashganga is the students' Astronomy and Astrophysics club at the Indian Institute of Science Education and Research (IISER), Pune. It aims to create an interest in Astronomy among the students of IISER Pune and at the same time provide a platform for students who wish to pursue Astronomy or Astrophysics as a research career. We also realise the need for Science to reach out to everyone and are thus determined to exercise efforts in this direction. *Dhruv* is the biannual newsletter of *Aakashganga* and we are proud to present this first issue. *Dhruv* has been started in keeping with the aforementioned aims of the club.

UNESCO has declared 2015 as the International Year of Light and Light-based Technologies (IYL2015). Light lies at the heart of observational astronomy. It has helped us see and better understand the universe. We hope that this declaration will help fuel further advances in the field of Astronomy and Astrophysics.

A hundred years ago, in 1915, Albert Einstein presented the General Theory of Relativity to the Prussian Academy of Sciences. It is to date the most elegant and the most complete description of the phenomenon of gravity, previously described by Sir Isaac Newton. Gravity is intimately connected to Astrophysics, Astronomy and Cosmology; it being the force that holds the Universe together. The science of Astrophysics motivated this theory and has also benefitted greatly from it. We at *Aakashganga* remember this great feat fondly.

In the annals of time, 2014 will forever be remembered as the year when Indian space technology took several leaps forward. The Mars Orbiter Mission, affectionately christened *Mangalyaan*, successfully entered into orbit around Mars on September 24, 2014, making the Indian Space Research Organisation (ISRO) only the fourth space agency in the world to reach Mars, and also the first to do so on the first attempt. Closely following the success of *Mangalyaan*, ISRO went one better, and on December 18, 2014, successfully launched the Geosynchronous Satellite Launch Vehicle Mark 3. The GSLV 3 offers a higher payload than the currently functional launch systems. It is India's heaviest ever rocket and is widely seen as the next step forward towards sending humans into space. The consecutive success of these two missions is a matter of great pride for all of us and the expertise gained will surely prove valuable as we aim towards being a superpower in the field of Science and Technology.

From the Faculty Coordinator

Greetings on the occasion of the first issue of *Dhruv*, the newsletter of *Aakashganga*, the Astronomy and Astrophysics club at IISER Pune. I am glad to be serving as a faculty coordinator of this vibrant group. We have started the academic year with guest lectures by eminent astronomers, rooftop sky watching sessions and have plans to participate in the astronomy outreach activities associated with the forthcoming meeting of the Astronomical Society of India in mid-February at NCRA-TIFR, Pune. There are also plans for setting up a basic radio telescope for observing the Sun and a night-time optical telescope in due course. I am impressed with the enthusiasm of the members of this group, and look forward to further engaging with them as we go along.

With best wishes,
Prasad Subramanian

Dr. Prasad Subramanian is an Associate Professor at the Indian Institute of Science Education and Research (IISER), Pune. He is also the Faculty Coordinator of Aakashganga, the IISER Pune Astro Club.

Dhruv is Sanskrit for Polaris, the pole star. Probably the most important star in the Northern Celestial Hemisphere, Polaris for long has been used in navigation and Astrometry because of its apparent motionlessness in the sky. Hence, the name of the newsletter; an inspiration to guide us all along.

The logo of the newsletter recognizes the contributions of Radio Astronomy towards the advancement in the fields of Astronomy and Astrophysics and hence in improving our understanding of the universe.

Logo Design: Anup Anand Singh

Events - Fall 2014

- *Saturday Night Sky Watching Sessions*

- *International Observe the Moon Night*
September 06, 2014

- *Bombs in the Universe - Talk by Dr. Poonam Chandra (NCRA, Pune)*
September 08, 2014

- *Around the Universe in Thirty Minutes – The Astro Quiz*
September 15, 2014

- *The Amazing World of Astronomy - Talk by Prof. Jayant Narlikar (IUCAA, Pune)*
October 10, 2014

- *The Mysterious Sun - Talk by Dr. Durgesh Tripathi (IUCAA, Pune)*
October 16, 2014

- *The Mysterious Magnetic Personality of Our Sun - Talk by Prof. Arnab Rai Choudhuri (IISc, Bangalore)*
November 12, 2014

Celebrating the Cosmos

03

Anup Anand Singh

Standing under the night sky, humans for long have been staring at stars; thinking about and questioning the vast expanse of universe that surrounds them. This curiosity, innate to all of us, has been the driving force behind the evolution of human knowledge.

Astronomy, the oldest of the natural sciences, owes its origins to the curiosity of our ancestors over the ages. This curiosity eventually facilitated the foundations of other branches of Physics, famously exemplified by the formulation of the Universal Law of Gravitation by Sir Isaac Newton.

Physics and Astronomy are probably the two most highly intertwined components of the natural sciences. Both emphasize on the formulation of relevant questions, the testing of alternative hypotheses by the careful analysis of data and rigorous logical and analytical thinking. Astronomy has further led to the development of Astrophysics and Cosmology; and at present the boundaries between these three realms of Science- Astronomy, Astrophysics and Cosmology, have blurred to such an extent that it is as if these boundaries never existed. Although, the theoretical and observational divisions do exist, owing to slightly different approaches- very often one paves the way for the other. The prediction of the existence of the planet Neptune by French mathematician Urbain Le Verrier in 1864, and its subsequent discovery by astronomers, was very aptly termed by Francois Arago, another French scientist, as “discovering a planet with the point of his pen”.

The night sky has always been a part of human lives. It has served as a storybook for young kids. And on numerous occasions, these stories have led to new insights about our universe. Young and amateur astronomers are now substantially contributing to ongoing research. Their contributions are no longer limited to the naming of planets and asteroids; discoveries of comets and supernovae have joined the list of credits.

Today we are in perhaps one of the most exciting times to be working in the field of Astrophysics and Cosmology. Technological innovations have accelerated the development in these fields. The Thirty Meter Telescope (TMT) being constructed in Hawaii promises to enable astronomers to study the universe with details never achieved before. Apart from being the world’s most capable ground-based optical, near-infrared, and mid-infrared observatory, TMT will also be special in the aspect that it will be built and operated by institutions from five different nations: Canada, China, India, Japan and USA. It will stand as an exemplar of the demolition of narrow domestic walls for satisfying the human quest for knowledge; an exemplar of Science being a unifying force.

The mysteries of the cosmos will continue to intrigue the generations to come. They will also continue to inspire humans to improve their understanding of the universe and eventually, their place in the grand design.

Anup Anand Singh is a second year BS-MS student at the Indian Institute of Science Education and Research (IISER), Pune. He is also the Student Coordinator of Aakashganga, the IISER Pune Astro Club.

The image on the cover page is a rendering of the Thirty Meter Telescope (TMT) being built in Hawaii.
Illustration: Swastik Mishra

04

International Observe the Moon Night

September 06, 2014

Organised worldwide by the National Aeronautics and Space Administration (NASA), the Lunar and Planetary Institute and the Lunar Reconnaissance Orbiter, International Observe the Moon Night (InOMN) is an annual event that is dedicated to encouraging people to ‘look up’ and take notice of our nearest neighbour, the Moon. From looking at the Moon with a naked eye to using the most sensitive telescope, every year on the same day, people from around the world hold events and activities that celebrate our Moon.

Photograph: Anup Anand Singh

Photograph: Arvind Balasubramanian
Captured using 5.12” Newtonian Reflector
(CELESTRON® AstroMater 130EQ)
Processed Using RegiStax®

Bombs in the Universe

Mayank Kumar

A*akashganga* organised its first talk titled “Bombs in the Universe” by Dr. Poonam Chandra on September 08, 2014. Dr. Poonam Chandra is an Astronomer working at the National Centre for Radio Astrophysics - Tata Institute of Fundamental Research (NCRA – TIFR), Pune and is presently studying transient objects such as supernovae and gamma ray bursts.

The talk was focused on supernovae and gamma ray bursts, the biggest of explosions that our universe witnesses every second. Dr. Chandra explained in her talk how we owe our existence to these bombs- all the heavy elements which were formed in huge stars were released due to supernovae explosions. Another important achievement of the work on thermonuclear supernovae has been the verification of the acceleration of the Universe.

The interesting talk was followed by an equally interesting interaction session with the audience.

Astrophotography
THE ART OF COLLECTING LIGHT

Rugved Pund

The world of astrophotographs; a world that begins with an encounter with that colourful image in some magazine, or a wallpaper somewhere- with those exquisite earthly landscapes under endlessly starry skies, or simply an abstract cloud of gas peppered with stars that are curiously captivating and with a sense of scale rarely experienced otherwise. Since then, all photographers have wished, at least while looking at those photographs, to spend hours under the starry skies hoping to master arguably the most frustrating form of photography of nature.

For the first time we have our cameras out at night and have decided to brave the cold for those colourful results. Fancy names like the M31 Andromeda, M42 Orion Nebula, or the NGC5139 Omega Centauri are all floating in our head hoping for the best as we plan our night at the terrace of our high-rise. Click. Almost invariably as with anyone attempting their first astrophotographs, like us, our 'first light' photo is absolutely dark. Nothingness.

No surprise there. With so many lights around us all the time, it is not unusual to lose a sense of the magnitude of darkness that night and all these beautiful objects are to be associated with.

Our eyes, the camera that survived natural selection, work by collecting light that is sufficient in amount to be processed by our brains for interpretation. And since they were never actually intended for much use at night, like most standard cameras, we suffer immensely at night.

Enter telescopes. They collect a large amount of light and direct it all into our eyes, our cameras, so that we can 'see' better.

Let us also try and increase the sensitivity of our eyes, hypothetically, or instead using the appropriate setting (a.k.a. high ISO) in the camera. This further increases our ability to discern faint details as much as possible from the light that we manage to collect.

And finally, let us make sure we are collecting all this light for a sufficient period of time so that the digital sensor in the camera gets exposed enough. We don't want to expose the digital sensor in our camera for just one-hundredth of a second now, do we? When light hits a digital sensor, a photographic film, or our eyes, it causes a series of events that make part of the image brighter than the rest. If more light continues hitting that area, then that part keeps getting brighter (unless it 'saturates' to its limit of highest brightness).

This completes our 'Exposure Triangle' for getting those dark photos to actually start revealing more than just the bright stars in a photo that is supposed to be filled with galaxies or nebulae.

We now probably see why we couldn't see any of our beautiful objects in our photos. So we prepare the camera and attach it to the telescope, with all the appropriate settings. Everything is set. Cluck…click. (The opening and closing of our camera's shutter). A few bright stars and a lot of reddish glows all over the photo. Definitely not our beautiful object. What is happening? Didn't we expose everything correctly for this beautiful object?

This is a consequence of what is infamously known as ‘Light Pollution’; a result of city lights pointing at the sky when instead they could have better illuminated what they were supposed to illuminate. A notoriously persistent glow in the world’s skies thanks to city lights.

So we have to pack up our stuff and head out to a place that is away from any major cities or human settlements, which can also mean the islands of Hawaii.

Here, even before our equipment is out, our eyes are in for a treat. With almost no city lights to pollute the view, the pristine black sky is peppered richly with stars and more stars. Some regions of the sky have so many stars that they nearly look uniform!

We get our equipment out. Hopes high. Set it all up for our beautiful object. Cluck...click. Lots of lines. Throughout the image. Of exactly the same length. Faint traces of our beautiful object, but smudged as if it was wiped along the lines, as if it was moving while the sensor was getting exposed. Exactly like a uniform camera movement. Something is wrong with the way we are imaging our beautiful object.

Just like the Sun and the Moon, all stars appear to be moving across the sky as a result of the Earth’s rotation- the Earth’s Diurnal Motion. As our exposure times got longer, we forgot to make sure our beautiful object remained in our telescope’s field. We notice that we need to keep moving the telescope such that our beautiful object always appears stationary to the camera. Only then can the camera effectively collect all the light correctly. In other words, we need to track our beautiful object’s motion across the sky.

And then, we get it.
After all the considerations.
After all the deliberations.
Our very first beautiful photo.
A journey through optics and celestial mechanics to get closer to the treasures of nature.

Rugved Pund is a second year BS-MS student at the Indian Institute of Science Education and Research (IISER), Pune.

Around the Universe in Thirty Minutes

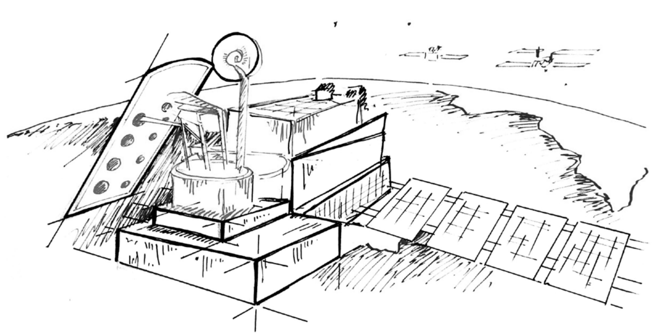
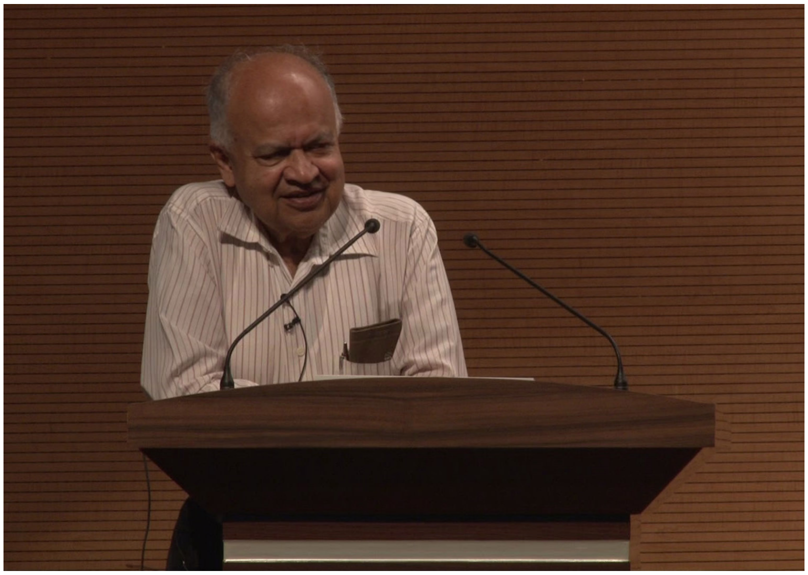


Illustration: Swastik Mishra

Aakashganga, in association with the Quiz Club of IISER Pune, organised an Astro Quiz, titled “Around the Universe in Thirty Minutes” for teams of two on September 15, 2014. Sujay Mate and Chaitanya Afle were the winners of the quiz, followed by Harshini Tekur and Shishir Sankhyayan as the runners-up.

The Amazing World of Astronomy

Anup Anand Singh



Prof. Jayant Narlikar during his talk at IISER, Pune. October 10, 2014.
Photograph: Manish Kumar Tekam

October 10, 2014. Sir CV Raman Auditorium at IISER Pune. It was a rendezvous with one of the greatest astrophysicists in the world, *Padmavibhushan* Prof. Jayant Vishnu Narlikar. Internationally renowned for his work in cosmology, Prof. Narlikar is a proponent of the Steady State Theory, an alternative to the popularly believed Big Bang model.

It was a great honour for *Aakashganga* to host a talk by Prof. Narlikar. The talk was aimed at countering the general impression that astronomy, being a study of remote objects like stars and galaxies, is irrelevant to the needs of the common man on our planet.

Prof. Narlikar adopted a historical approach to show how the present day, long-term benefits enjoyed by the society from satellite based communication technology owe their origin to the curiosity of a few astronomers who were keen to understand the night sky with its stars and the planets. He then explained how someone's (Tycho Brahe's) desire to watch the planets in the sky resulted in the formulation of the laws of planetary motion (by Johannes Kepler) and eventually in a theory describing the motion of all objects in the universe (by Isaac Newton).

Prof. Narlikar also emphasized how the studies of our Sun and other stars done in the past led to the foundations of Nuclear Physics; another evidence of "Astronomy leading the way with new discoveries in Science."

"Astronomy has been and will continue to be an important component of human knowledge base."

Towards the end of the talk, a possibly dramatic situation was envisioned in which knowledge of Astronomy comes as a saver of human civilization; making it evident how "Astronomy has been and will continue to be an important component of human knowledge base useful not only for a better understanding of Science but also for the welfare of humanity." The session ended with an interesting half an hour long interaction session between the audience and Prof. Narlikar.

08

Seeing What We Hear!

Sujay Mate

This is an important year for Gravitational Wave astronomy. The current two working detectors (LIGO - Hanford and Livingston, USA), which had been non-functional as they were getting upgraded, will be coming up online around mid-2015, giving hope to direct detection of gravitational waves. There has been no direct detection of gravitational waves till date. Many of the claims are still debatable. But due to the efforts going on currently, it is almost certain that there will be a direct detection in the next few years or maybe this year (being too optimistic!). But let's say we successfully detect gravitational waves, what then?

Gravitational waves are analogous to sound waves. We cannot extract as much information about the source from gravitational waves as we can extract from any kind of light wave. Consider the explosion of a firecracker. By just hearing the explosion we can tell the direction in which the cracker went off, how far it was and what kind of firecracker it was, if we know how different firecrackers explode. Same is true for gravitational waves! If we detect them we can know the following things about their source- direction and inclination in sky, distance from earth, its mass, its spin but nothing else. To know more about the source we must "see" it; which means, detect any kind of electromagnetic radiation emanating from it. This is a big challenge and a lot of exciting physics will come up if we are able to detect it. In this article, I will briefly discuss about electromagnetic counterpart detection of gravitational waves and the challenges which will be faced to detect the counterpart.

Let's begin with the source of gravitational waves, because the kind of electromagnetic radiation we will detect is completely determined by how it is generated. The current best models suggest that detectable gravitational waves will be generated by Neutron Star-Neutron Star, Black Hole-Neutron Star or Black Hole-Black Hole mergers (Kilonova). All these are highly relativistic and high energy phenomena. This clearly implies that when the merger happens we should expect emission of high energy photons (Gamma rays / X-rays). As all the above objects are spinning, the emission will be highly confined and it will be a jet coming from a point along the axis of rotation. We will be able to detect such emission only if the axis is aligned towards us. Also, the duration of emission will be very short, few seconds to minutes. This clearly suggests a very rare detection probability.

The next obvious question that arises is whether this is the only emission. No. We expect at least two more types of emissions, by processes called 'R-Process Nucleosynthesis' and 'ISM' interactions. The former process happens in the medium surrounding the merged compact objects. The emission is isotropic and hence, unlike the high energy bursts, we can see the emission irrespective of the orientation of the source. The emission is mostly in optical and near IR region. It is slow and is predicted to last for hours to few days. Detecting this kind of radiation seems probable but is non-trivial. Both the above processes will produce the third kind of emission which is due to the interaction of above emission with the inter stellar medium (ISM). As this emission is due to the re-emission of absorbed high energy photons, it is expected to be in the radio region of EM - spectrum. It is isotropic and very slow emission and is expected to last for weeks to months and hence detecting such radiation is a lot easy compared to the other two.

Now, from the above information, except for the first case (burst emission), it seems that the counterpart detection is easy. Just keep a telescope ready and point it as soon as a gravitational wave is detected. But is it really that simple? No. It's a very non-trivial task.

The first and the most important non-triviality is that since there are very few detectors, the localisation (direction of source) we get from the gravitational wave detectors is very poor. It is not a point but a circle of few hundred square degrees with a certain probability for the location of source at every point within the area. This means we don't know the exact location of the source and need to scan the entire area if we wish to detect a counterpart. This leads to another problem. A field of view (FOV) of typical observatory class telescope which can detect stars, say up to 20th magnitude is around few square arc minutes. This implies that a 10 square arc minutes FOV telescope will take around 36,000 pointings to cover around 100 square degrees circle! If we consider each pointing to be for a minimum of 30 seconds (exposure time), the total observational time will be 300 hours! This is huge amount of telescope time and it is very difficult to get this much time on any big telescope because it has to observe other targets as well.

So, it is clear that an optimization is needed in the observing strategies and a wide FOV telescope is necessary. Optimization may include automation of telescopes so that they can point immediately after a gravitational wave detection notice is sent, algorithms for optimized pointings so that telescope can cover most probable regions first, etc. Hence, as mentioned earlier, the counterpart detection of gravitational waves is not as simple as it may sound.

Another level of complication will arise when we want to analyse the collected data. The counterpart is a transient phenomenon- it will appear for some time and then fade away. The best way to detect such a source is image subtraction. In this, an older image is subtracted from the newer one; if there is a transient, it will be seen in the subtracted image. But the major problem is that we don't have deep images of the entire sky. It means that if we observe some area of the sky for possible counterpart, we are not guaranteed to have an image of that particular area to which we can compare the newly observed image. We have to wait and observe the same area later in order to compare the data. This is a time consuming process. Also, while analysing, one has to neglect false positives. These can be comets, asteroids, defects in camera pixels, etc. All this put together makes a pipeline for data analysis of transients which needs to be very robust and precise to claim confirmed detection of counterpart.

How do we, as in India, stand in this area? Well as far as detection of gravitational waves is concerned, India will have its own detector in the next few years which will be called LIGO-India. This will be a great addition to the current detectors since all these detectors together will lend a better localisation. This means less pointings for counterpart detection. As far as counterpart detection is concerned, we are quite behind. The largest FOV telescope in India has FOV of about a square degree. All our telescopes are manually operated. This means that if we wish to follow up on gravitational wave detection, we need to give the coordinates of all the pointings, which are in thousands, to the telescope operator. This is a time consuming and boring task for the operator. Also, we don't have the pipeline to reduce the data of a transient which plays a major part in this counterpart detection process. Therefore, there is a lot to be done in this area with many new opportunities available to us.

Sujay Mate is a fourth year BS-MS student at the Indian Institute of Science Education and Research (IISER), Pune.

The Mysterious Sun

Prathamesh Madhav Datar

Dr. Durgesh Tripathi, Assistant Professor at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, delivered a talk for *Aakashganga* on October 16, 2014. Dr. Tripathi is working on the problems of the coupling and dynamics of the solar atmosphere.

The speaker gave a basic introduction to the Sun, why we study it, and also how the Earth's magnetosphere prevents energetic particles of the Sun from reaching the Earth. Along with talking about the internal structure of the Sun, he also discussed how Solar Astrophysics is related to other branches of Physics like Space-weather dynamics, Plasma, Atomic and Gravitational Physics. The speaker later discussed about sunspots in various regions of the solar atmosphere. Since most of the solar activity is of magnetic origin, he emphasized the importance of studying the magnetic field of the Sun. He also discussed about the sunspot cycles.

After discussing some major challenges in Solar Physics, he talked about the upcoming Indian Solar Mission, *Aditya*-1. All in all, the lecture was a very interesting insight into the "star" of our solar system, with some witty humour to go along with it.

The Mysterious Magnetic Personality of Our Sun

Anwesh Bhattacharya

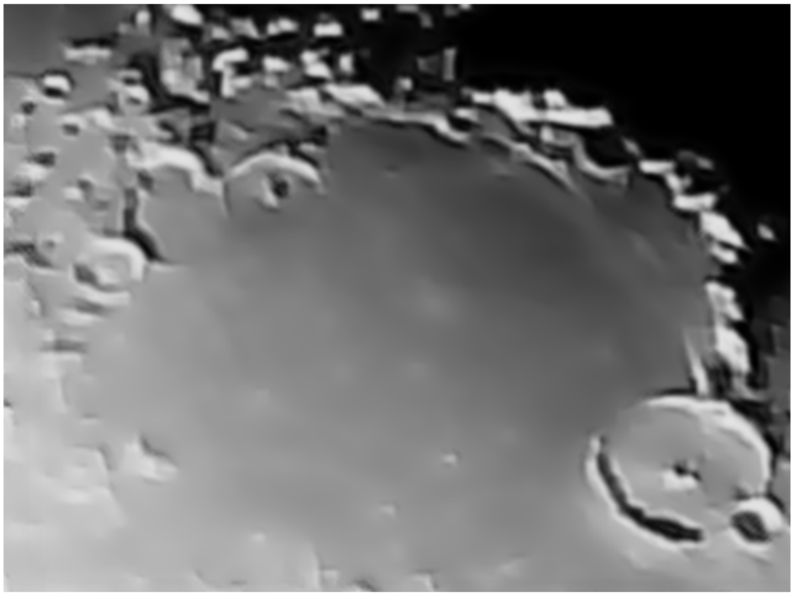
The last talk of the semester titled, "The Mysterious Magnetic Personality of our Sun" was delivered by internationally acclaimed theoretical astrophysicist Prof. Arnab Rai Chaudhuri (Department of Physics, Indian Institute of Science, Bangalore) on November 12, 2014. Prof. Rai Chaudhuri has been working on Astrophysical Magnetohydrodynamics (MHD), especially in solar MHD.

He began his talk discussing a power grid failure in Quebec, Canada in 1989 due to a solar storm which was several orders of magnitude more powerful than the most powerful bombs created by humans. He spoke of how solar disturbances like solar flares could cause power grid failures, make polar airline routes dangerous & disrupt electronic & satellite communication. He gave an overview of the history of solar astrophysics and particularly of the work done on sunspots. Then, he explained, in very simple terms, the formation of sunspots.

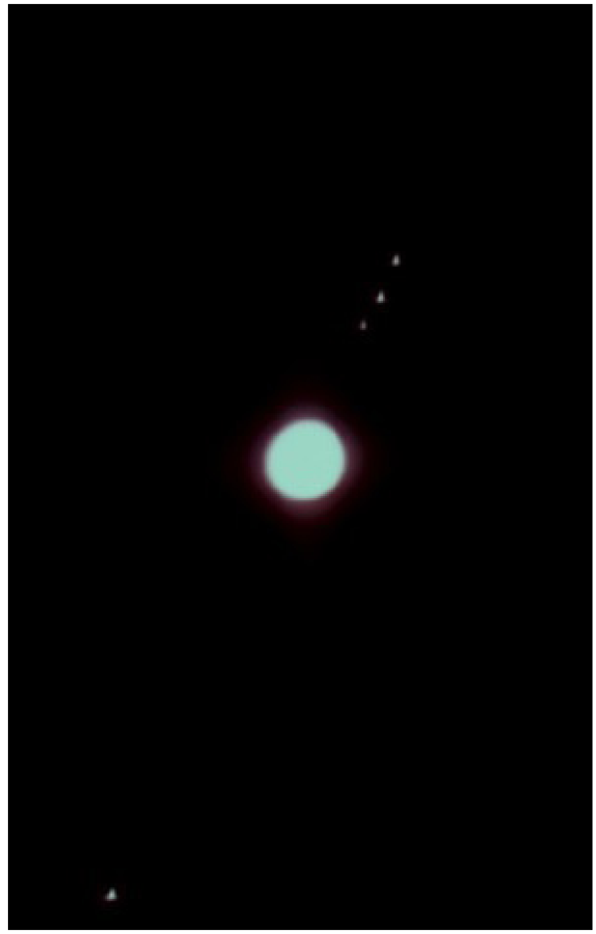
The talk was followed by a very interesting discussion session in which Prof. Rai Chaudhuri gave very clear answers to all the questions. Prof. Rai Choudhuri also presented *Aakashganga* a copy of the manuscript of his upcoming book *Nature's Third Cycle*.

In the Neighbourhood...

IMAGES FROM THE SKY WATCHING SESSIONS

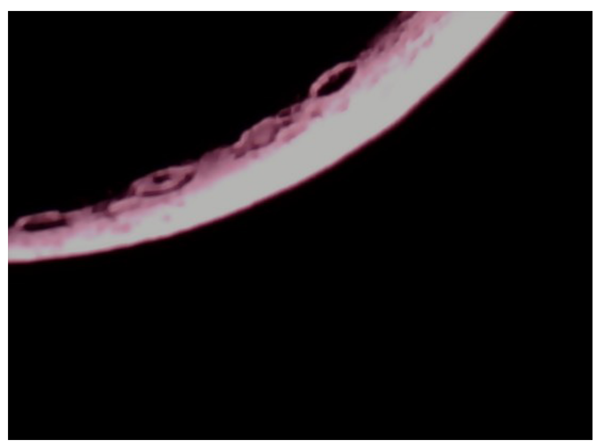


Earth's Moon
August 06, 2014



Jupiter and its four Galilean moons:
Io, Europa, Ganymede and Callisto
November 06, 2014

Earth's Moon
August 06, 2014



Earth's Moon
August 08, 2014

Photographs: Arvind Balasubramanian
Captured using 5.12" Newtonian Reflector (CELESTRON® AstroMater 130EQ)
Processed Using RegiStax®

Nature's Third Cycle

A STORY OF SUNSPOTS

Author: Arnab Rai Choudhuri
Publisher: Oxford University Press
Release Date: January 29, 2015

The diurnal cycle of day and night and the annual cycle of seasons are the two very familiar natural cycles around which many human activities are based. However, there is a third cycle in nature; although "very erratic and apparently chaotic", it has an average period of 11 years. This cycle of sunspots is the "third cycle" in Prof. Arnab Rai Choudhuri's book.

Nature's Third Cycle is a fascinating journey through the story of sunspots; the first popular science book explaining the science behind sunspots and their 11-year cycle. It highlights and tries to explain how solar events can have long-term impacts on the Earth and its climate. The book gives a non-technical introduction to the theory of stellar structure and to the field of plasma physics and its applications.

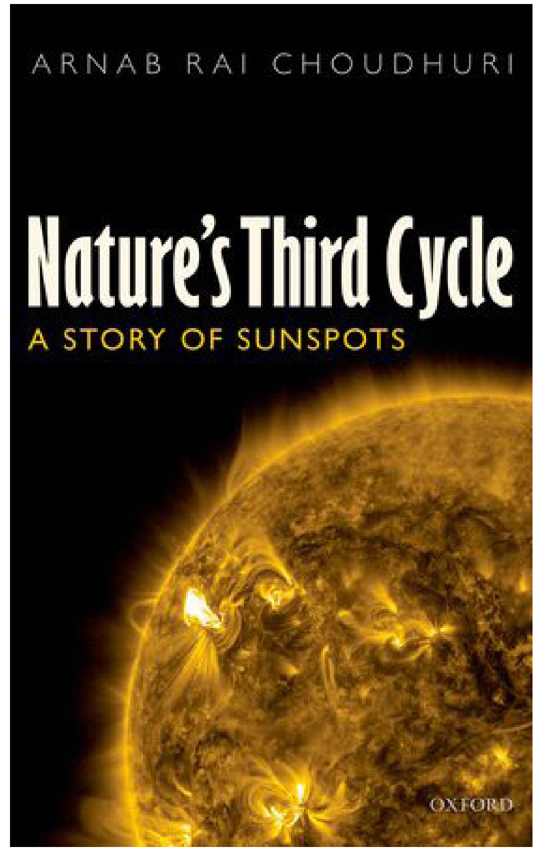


Image Courtesy: Oxford University Press

Nature's Third Cycle is an autobiographical account of the author as well. Through his story, he has "tried to write about a scientist's hopes and fears, friendships, competitors, jealousies, and the utter joy of occasionally discovering a clue to understanding some deep mystery of nature."

Nature's Third Cycle promises to be an interesting read for the general public, amateur astronomers as well as professional solar physicists.

About the Author

Prof. Arnab Rai Choudhuri (Professor, Department of Physics, Indian Institute of Science, Bangalore) is a theoretical astrophysicist working on the problems of Astrophysical Magnetohydrodynamics of the Sun and other astrophysical systems. He is a Fellow of the Indian Academy of Sciences and a Fellow of the National Academy of Sciences, India. He has authored two popular books in the past: *The Physics of Fluids and Plasmas: An Introduction for Astrophysicists* and *Astrophysics for Physicists*, both published by the Cambridge University Press.