



# BASE line

A Quarterly Bulletin of the Jawaharlal Nehru Planetarium, Bangalore Association for Science Education

## Contents

- 25 years ago
- News
- Cosmic Perspectives - II  
- C V Vishveshwara
- Lessons from the History of Science - II  
- S Lokanathan
- Poor Man's Space Probes – Meteorites  
- Bharat Adur

Number #16 August 2018

## 25 years ago – From the Visitors' Book

Charles W Misner, Professor of Physics, University of Maryland, visited the Planetarium 25 years ago to discover the new talent of his Ph D student C V Vishveshwara.

DATE	NAME & ADDRESS	REMARKS
8 June '93	Charles W. Misner, Univ. of Maryland	I did not know when Prof Vishveshwara studied in Maryland that his talents extended beyond theoretical physics, to administration, art and music – a very impressive show!

He wrote: *I did not know when Prof Vishveshwara studied in Maryland, that his talent extended beyond theoretical physics, to administration, art and music – a very impressive show!*

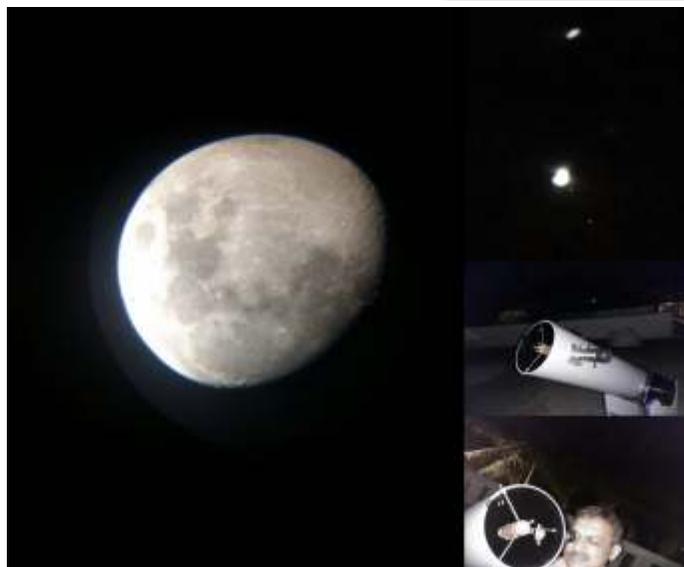
## News

The summer programmes of the Planetarium cater to different age groups and are very popular; they attract children from outside Bengaluru with parents eager to bring them and take them back every day for ten days.

This summer saw workshops on new themes– on telescope making and on astro-photography.

## Telescope making Workshop

The participants of the telescope making workshop had a different experience over three days. They were taught the basics of telescopes for example, the geometric optics, aberrations and function of eye pieces. They had a feel of the different types of telescopes – binoculars, refractors, reflectors, their advantages and disadvantages with practical demonstrations. Special sessions were held on naked eye astronomy inside the sky theatre which helped



Harish Kumar photographed the Moon with his new telescope

them identify a good number of constellations. They learnt to use the star charts and star dials which enabled them to plan their observations. The process of making of telescopes with demonstration of the methods employed for testing the optics and alignment constituted a major part of the sessions. They measured the focal lengths and the other parameters like the f ratio. The hands on experience with the handling of telescopes from the stages of assembly to scan the sky built the necessary confidence in operation of the telescopes. They took home the telescopes and have been using them successfully. The participants came from remote areas like Laksmeshwar, Kaduru, Malavalli and Dodda Arasikere.

## Astrophotography workshop

Photographing celestial objects requires special attention apart from patience. Owing to the faintness of all these objects, including the moon (not the sun), exposures have to be longer and in this aspect they are different from terrestrial photography. The rotation of the earth puts a limit on the exposure time, the objects will look trailed. Tracking them using telescopes was the method employed by professionals for over a century. Now digital photography has made life easy but one has to extremely careful in using these techniques. The digital processing of



astrophotos require unique techniques. Mr Ajay Talwar, an expert astrophotographer explained to participants the various techniques that can be used to enhance the images. He also demonstrated how a video can circumvent the effect of rotation of earth.

## Asteroid Day

June 30<sup>th</sup> is celebrated as the Asteroid Day to mark the anniversary of the first ever recorded impact of a meteor. This happened exactly 100 years ago at Tuguska in Russia. This event was used to educate people about the importance of monitoring such impacts. Dr Bharat Adur from the Akash Ganga Center for Astronomy, explained the method of extracting the pieces of a meteorite once the location has been identified. The fragments are easily lost amidst the terrestrial stones. Bharat Adur further explained the procedures of chemical analysis and the interesting results obtained by his team from the meteor lake in Lonar, Maharashtra. The fragments can be traced even today after 50000 years of impact.

Prof Narendra Bhandari, former professor, Physical Research Laboratory, gave a special lecture on "Falling stones, colliding Asteroids and secrets of the Universe" He explained the basics of the event of impact, the energy and most importantly the need for the study of this subject. He educated the audience about the threat posed by the Near



Earth Asteroids. The special robotic telescope survey like NEAR and LINEAR have been successfully tracking small objects hovering near the earth. The Radar techniques also help in getting the details on the shape and velocities of these objects. These small bodies can tell the history of the solar system. Very recently a cigar shaped asteroid named Oumuamua, was found to have arrived from beyond the solar system.

There was a display of posters on asteroids. A collection of meteorites from Dr Bharat Adur, Prof Keshav Bulbule and also the large ones donated by Mr Makhi of Pune also were displayed.



## Cosmic Perspectives - III

- C V Vishweshavara

### *The Whisper from the Past*

In the year 1965, one of the most important discoveries in modern cosmology was made which offered perhaps the strongest evidence for the big bang cosmological models. Arno Penzias and Robert Wilson, two scientists from the Bell Telephone Laboratory in the United States, detected a background radiation in the microwave region, at about a wavelength of 7 cm, using a huge horn shaped antenna.



*Wilson and Penzias in front of the antenna*

It sounded like the unwanted noise one hears on a wireless set. No effort, including the formidable task of removing two pigeons that had made the antenna their home, could eliminate the background noise which was unaccounted for. Moreover, it was isotropic, that is of equal intensity in all directions, and did not seem to emanate from any particular source. This radiation was a mystery to the two scientists who had accidentally stumbled on it.

On the other hand, this was not at all a surprise to some theoreticians who had anticipated the existence of such radiation. According to the big bang scenario, a few moments after its origin the universe was dominated by extremely hot radiation at some ten billion degrees. When radiation in a heated enclosure is in equilibrium, it is known as the black body radiation. It has a characteristic spectrum with the intensity peaked at a particular frequency which depends upon the temperature. Hotter the enclosure, the higher the frequency. The cosmic radiation too must have been of this nature. As the universe expanded, the temperature of this radiation dropped while the radiation retained the black body characteristic all along. In 1948 Ralph Alpher and Robert Hermann, working with their mentor George Gamow, concluded that such an all pervading cosmic radiation should have cooled down to about five degrees Kelvin by now. Assuming that the radiation discovered by Penzias and Wilson had indeed the black body spectrum, its temperature could be fixed at about 3 degrees, not far from the predicted value. Subsequent observations confirmed that the radiation has in fact the black body spectrum. Detailed information has been obtained from the data collected by the Cosmic Background Explorer (COBE), the satellite that was launched in 1989. The fit to the black body curve is excellent corresponding to a temperature of 2.73 Kelvin.

Another important property of the microwave background is its striking isotropy. In whichever direction we look, it would have the same intensity. This means different parts of the universe are exactly alike. This creates a problem. If we look, for instance, at the opposite extremities of the sky, light would have just travelled these distances to reach us. Since their mutual separation is larger than this distance and light takes a finite time proportional to the distance travelled, there could have been no time for these remote regions to be in communication even by radiation let alone material particles. In the absence of any mutual interaction, they could not therefore have been homogenized if they had started out with different characteristics. This is known as *the horizon problem*. Of

course, if we assume that the universe has been uniform all along right from the beginning, such a problem would not even arise. However, such an arbitrary assumption is looked upon with disfavour by cosmologists.

The *inflationary model* of the universe offers a remedy for this situation. In this model, the universe undergoes an initial stage of swift, exponential expansion before assuming the present rate. It can be shown that during this inflationary phase different parts of the universe could have interacted to bring about the observed isotropy as reflected by the microwave background radiation.

The microwave background is no doubt a relic of the Big Bang itself. In addition, it is expected to carry the imprint of a later stage of cosmic evolution when the large scale structure comprising galaxies and clusters of galaxies formed. Within the framework of the big bang cosmology, theories of structure formation assume that initial small scale inhomogeneities or lumpiness in the matter distribution would grow to become the large scale structures that we observe today. This process is expected to have left its finger-print in the form of minute fluctuations in the microwave background. Amazingly enough, COBE satellite reported these exceedingly small fluctuations that have become an essential input for the theoretical studies of structure formation. This is another important problem yet to be solved satisfactorily.

### *The Age of Ferment*

We have very briefly outlined some of the developments that have taken place in modern cosmology touching upon just a few of the many unsolved problems. As in any other branch of science, so in cosmology progress takes place by the way of constant interaction between observation and theory. To a cosmologist, the entire universe is a laboratory, the grandest one there is. But a unique one though with no possible control over it. And the observations have to be made, mercifully, at vast distances from where the fiery phenomena take place. There lie the charm and challenge, the triumph and travail of cosmology. Since the days of Hubble and Humason, when they made new pathways into the universe with their fuzzy photographs painstakingly taken over hours, observational techniques have come a long way. Highly sophisticated telescopes, refined image processing, data analysis with high speed computers - these are but a few common tools of the modern day observer. What he observes could be complex, confusing and chaotic as it happens with any significant step taken in science. So would be the theories

that try to explain the observations - until the basic simplicity of nature underlying all this is revealed by some brilliant mind. It happened with Newton and it happened with Einstein. No doubt it will happen again. At the moment, however, there may be many a John the Baptist, but no Messaiah in sight.

Take for instance the Hubble Space Telescope, a spectacular achievement of modern technology. Freed from the obscuring envelope of earth's atmosphere, it has been sending spectacularly clear data. This very clarity could lead to measurements that would seed new controversies as has happened with the age of the universe bringing back a possible lower value. Another significant development that has occurred is the observations of supernova explosions in very distant galaxies. This leads to the measurement of their vast distances enabling the determination of the cosmic expansion characteristics with enhanced precision. From this, a startling possibility might have emerged. The universal expansion may not be slowing down, but actually speeding up! To explain this, one may have to resurrect the cosmological constant that had been disowned by Einstein as the beast that marred the beauty of his theory. In parallel with all this, various theories have been put forward especially in order to describe the origin of the universe. Heady brews have been fermented stirring up together gravitation, particle physics, quantum theory, string theory and so on, often stretching both imagination and credibility to their limits. All this should be considered as tentative until firmly established, even if one does not go so far as to subscribe to the dictum of the Russian physicist Lev Landau that 'cosmologists are often in error, but never in doubt'.

Let us return to Edwin Hubble with whom we began our discussion. Hubble wrote,

" The explorations of space end on a note of uncertainty. And necessarily so. We are, by definition, in the very center of the observable region. We know our immediate neighborhood rather intimately. With increasing distance, our knowledge fades and fades rapidly. Eventually, we reach the dim boundary – the utmost limits of our telescopes.

There we measure shadows, and we search among ghostly errors of measurement for landmarks that are scarcely more substantial.

The search will continue. Not until the empirical resources are exhausted, need we pass on to the dreamy realms of speculation."

Yes, the search will continue. But, at no stage of this cosmic journey can the human mind be stopped from venturing into the dreamy realms of speculation.

*Acknowledgement:* I am grateful to Prof. Jesus Moya for inviting me to write this article and for translating it into Spanish. It is a pleasure to thank Ms. G K Rajeshwari and Mr. HR Madhusudana for their valuable help in the preparation of the manuscript.



## Lessons from the History of Science -III

S Lokanathan

### Bohr's Hydrogen Atom

My last example is strictly not about experiment but rather the birth of a theory in 1913 – Bohr's hydrogen atom<sup>1</sup>. I am going to say a few words about this because there are some fellow teachers who hold the view that we should not formally teach Bohr Theory at all. I shall say a few words about this later. Many refer to Bohr's H atom as a model rather than a theory and today I would agree with that but I think it is retrospective wisdom. Bohr had before him the Rutherford atom and the major problem was to explain the stability of the atom. Bohr said that he was not quite aware of the spectral data, Balmer's lines and in any case hardly a few of them were known to any great accuracy at that stage. The two radical ideas of Bohr were that only certain orbits were stable (rather, quasi stable) and that spectral emissions arose from transitions from one orbit to another. Bohr had given ad hoc rules for the allowed states – the famous angular momentum rule. A little later, Bohr added the exclusion principle to his theory and (with Stoner) was able to explain the logic of the periodic table. One of the amusing troubles I had as a teacher is when a bright student asked me 'how did Bohr explain the stability of the atom' and on reflection, I told him that Bohr just said "these orbits are stable" and that was that!

What could have gone through Bohr's mind as he struggled with the problem? The similarity with the planetary model is obvious but there is an essential difference. There are only a small number of planets of our solar system and why their orbits are what they are may interest cosmologists but it was not a pressing issue in Newton's time. In the case of the atom it was THE issue since 'zillions' of atoms emit the same spectra and this could only mean that their structure had to be the same. Indeed if one plays around with dimensional considerations and assume that somehow

Planck's constant must be involved, you could arrive at the order of magnitude of the radius of the atom. In other words, Newton only had to answer for the circular (or elliptic) orbits; Bohr had to answer for the identity of size of all H atoms. The philosopher Popper claimed that the role of induction in spawning a theory was negligible. Popular conception of induction is that it is a generalisation made from empirical evidence. But a theory emerges from a selection of key data and if that is not induction at least it is a crucial awareness of empirical evidence – even if we cannot easily describe the magic of creativity which ignores the unimportant. I find this excessive debunking of induction absurd. Consider the remarks of the Nobel Laureate Sir Neville Mott on the belated arrival of Quantum ideas. "it seems to me that the basic evidence that the energy of an atom is quantized, at any rate as far as the ground state is concerned, existed far back in the 19<sup>th</sup> century. Such evidence is in kinetic theory of gases and in particular in the theory of specific heat of gases". What could Mott have meant?

The breakdown of equipartition law was known. As an example the specific heat of Hydrogen (molecule) shows only 3 degrees of freedom below about 75 K and evidence of rotational degrees of freedom above. Considering the relation  $kT \sim (\frac{1}{2}) I \omega^2$ , ( $I$  is the moment of inertia of the molecule,  $k$  the Boltzmann constant,  $T$  the temperature and  $\omega$  the angular velocity) one wonders why the angular velocity  $\omega$  does not adjust itself to any value of  $kT$ . Quantum physics demands that a minimum energy is required to set the molecule in rotation<sup>2</sup> and the breakdown of the classical law is heralded by the arrival of the new constant of nature, the Planck constant.

It is the practice, even today, to introduce quantum physics in undergraduate classes telling them that classical physics fails to explain black body radiation, photo electric effect and the Compton effect and occasionally, specific heat anomalies. It is amusing that this is one case where I would be wary of choosing the historic path for pedagogy: for one thing black body radiation is too esoteric for many students at this level.

### History and Pedagogy

But let me return to the question, whether or not we still teach the Bohr model. It had a relatively short life since it took only about 12 years before the Quantum Mechanics was developed by Heisenberg, Schrodinger and Dirac and one would certainly not characterize QM as a model today

although its bizarre features continue to attract the hope that at least new interpretations may emerge. I think of model as a version in which one truncates the variables so that the problems become manageable. To the extent that this is done deliberately one can recognise models even at their inception. For e.g. the Fermi Thomas model of atoms, the liquid drop model of the nucleus and so on. In this sense I hardly think that Bohr would have thought in such modest terms at the time he propounded his ideas. The problem with Bohr's version is that it has features which are unacceptable in the modern QM, the problem of defined orbits and the difficulty of conceiving an  $l=0$  (i.e. zero orbital angular momentum) ground state which arose from the so called pendulum orbits. But the idea of stationary states, energy levels characterised by quantum numbers are all worth retaining. Moreover, even if the picture of orbits is obsolete, it has its uses in understanding directed chemical bonds and orbitals. I am reminded of the famous Cheshire cat in Lewis Carroll's "Alice in Wonderland", in which the cat disappeared but its grin survived long after! (Lewis Carroll was the pseudonym used by the mathematics don C.L. Dodson).

Admittedly my purpose in telling these tales from the history of Physics of the last century was to amuse you. I am wary of gimmicks like the 'discovery' approach as though if you arranged an apple to fall on a student's head he or she will discover gravitation. Instead, experiments should have multiple aims, skilling, sophistication in design and measurement as well as to appreciate experiments of a crucial nature such as the oil drop experiment.

My next reason is a personal one. Despite my comments at the beginning of my talk, I do not subscribe to agnosticism in Physics, i.e., disbelief in orthodox physics. Indeed I believe that it is futile to talk of Science as a search for the 'truth' since that does not mean much. Science is a way of relating phenomena which seemed unconnected at one time. The major achievement of Galileo and Newton was that they saw that the laws of the earthly bodies were the same as of the heavenly ones. A more modern example is the variety of ways from which the so called Avogadro's number has been determined. Avogadro's contribution, around 1811, was the conjecture that at fixed temperature and pressure equal volumes of gases contain equal numbers of molecules. Loschmidt is credited with an approximate determination of the number of molecules in a gram mole,  $\sim 0.5 \times 10^{23}$ . Its value was still imprecisely known in the early nineteenth century when Einstein came

## Poor man's 'Space Probes' – Meteorites

- Bharat Adur

up with several ways of determining it, all from different phenomena. One was from Brownian Motion, another from the black body radiation law, yet another from the flow of incompressible solutions and so on. In fact, the history of the slow acceptance of the reality of molecules and the kinetic theory, of which the understanding of Avogadro number is an important one, would make a very interesting account. Earlier, I had referred to the way we initiate the undergraduates in quantum ideas through a variety of seemingly unrelated topics. Sadly, this is presented as if it is a 'point count' for a question bank that a student prepares for for the examinations. I admit that pedagogy should not always take its cue from history but when we do use this route we should emphasize the remarkable fecundity of a new theory and that is what Science is about.

My last point is that despite all the contrary views of some philosophers of Science in recent years, there is a sense in which Science progresses. Theories may come and go but relationships endure and get more quantitative although the new theories may get more abstract. The philosopher, Paul Feyerabend<sup>3</sup> made two points in an essay. First, that Science is just one of the ideologies, like religion, that propel society and second that mankind should act accordingly and protect itself. The first, in my opinion is pure poppycock and I hope that the very few examples I have chosen (from a huge list) would convince you. But Feyerabend's second point should be taken seriously precisely because Science is not just ANOTHER ideology. I do believe that openness and public awareness of Science will be the most important issue in the coming decades and that may require 'defence' as Feyerabend puts it but certainly not ignorance of Science.

### References:

1. Bohr, N, 'On the Constitution of Atoms and Molecules', Phil. Mag. Ser 6. Vol 26, 1-25 (1913)
2. The minimum energy for rotation to set in is  $\sim h^2/2I$ , where  $I$  is the moment of inertia and  $h$  is Planck's constant divided by  $2\pi$ ; the heat energy  $kT$  must supply this. If  $a$  is the inter atomic distance and  $M$  the atomic mass,  $I=M a^2/2$ . For a  $\sim 0.75 \text{ \AA}$  the energy requires a temperature of about 75 K.
3. Feyerabend, P 'How to Defend Society Against Science' from 'Philosophy of Science' ed. By Klemke et al, Prometheus Book, N.Y (1988), page 34.



Since time immemorial, meteors have fascinated mankind, they were referred as "fiery falling stones" as well as a warning from Heavens! They have made entry in to historical records, works of fiction and fantasy. These falling stones were revered and worshipped too, even today where they fall, the locals throng to collect pieces. Recorded history of meteors and meteorites dates back to 1009 A.D, with the one seen from Djorjam. It weighed 850 kgs. In India earliest written record is dated Apr.17, 1620, at Jalandhar; it fell with great light and noise.

Let us understand what the terms meteors, meteorites, fireballs....etc. mean -

Meteoroid: An object, can be a molecule or an asteroid traveling in space

Meteor: The light phenomenon associated with a meteoroid passing through Earth's atmosphere

Meteorite: A meteoroid after it landed on Earth or any other planetary surface.

Here are some technical words;

Meteorite fall: A recovered meteorite that was seen to fall

Meteorite find: A recovered meteorite without a record of its fall

Meteorite names: After landmarks near their place of fall or find (e.g. the Honolulu meteorite)

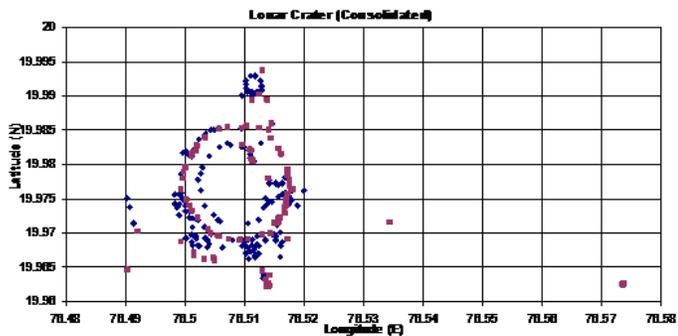
Meteorites recovered in areas with a lack of landmarks (e.g., Antarctica, Sahara desert), are named after the general area of recovery, and given a number (e.g., ALH84001; Sahara 97166).

### Studies on Lonar lake

Lonar Lake (19°.9851 N, 76°.5210E) is a saline soda lake located at Lonar in Buldhana district, Maharashtra, which was created by a meteor impact during the Pleistocene epoch; and it is the only known hyper velocity impact crater in basaltic rock anywhere on Earth. This lake, which lies in a basalt impact structure, is both saline and alkaline in nature. It has a mean diameter of 1.2 kilometers and is about 137 meters below the crater rim. The meteor crater rim is about 1.8 kilometers in diameter. Our team prepared this map based on the study of samples collected as described below.

The circular depression bears a saline water lake in its central portion. The crater's age is usually estimated to be  $52,000 \pm 6,000$  years (Pleistocene).

# BASE line



Impactites materials collected by AGCA

Lonar Lake lies within the only known extra-terrestrial impact crater found within the great Deccan Traps basaltic formation of India. The lake was initially believed to be of volcanic origin. A recent study assigns an age of about 570,000 years, as the result of the impact from north direction with a velocity of 19.6 kmph by a meteorite of about 60 meters in diameter weighing a million ton. This resulted in release of tremendous amount of heat, which melted the rock forming the crater.

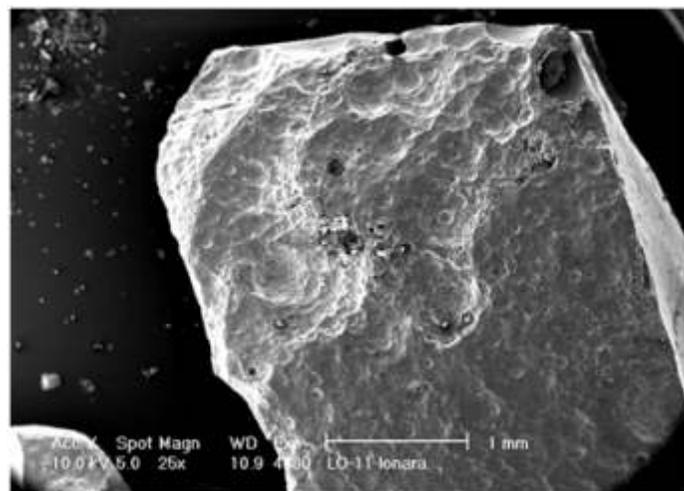


Shatter cone from Ambar Lake

Another study recognizes it as an impact crater created by the hypervelocity impact of either a comet or an asteroid explaining the oval shape. The meteorite impact came from the east, at an angle of 35 to 40 degrees. Geological features of the Lonar crater have been divided into five distinguishable zones, showing distinct geomorphic characteristics. The five zones are:

- The crater rim
- The slopes of the crater
- The crater basin, excluding lake
- The Crater Lake

These are known as Impactites of Lonar



Geochemistry of Lonar Crater & it's meteorites



Lonar Lake Panoramic view



Streptomyces alkali thermotolerans is a alkaliphilic and thermotolerant bacterium species from the genus of Streptomyces which has been isolated from the Lonar soda lake. Rise in nitrogen and phosphorus levels has triggered algae growth, blocking oxygen necessary for the survival of the lake's unique population of magnetic and methane-eating bacteria.

FurtMagneto tactic bacteria (MTB) are motile, aquatic prokaryotes that swim along geomagnetic field lines. These bacteria display a myriad of cellular morphologies, including coccoid, rod, vibrioid, spirilloid etc. with their unique 'magnetosomes' within the cells. The MTB isolated by the 'magnetic collection' and 'capillary racetrack' methods showed a typical response in the form of movement towards the magnet and precise alignment at the edge of the hanging drop. Intracellular iron accumulation studies on these bacteria showed up to 11.5 times more iron than non-magnetic bacteria.

The studies of the shatter cones and impactites under Scanning Electron Microscope (SEM) Show micro cratering within the secondary rocks, impactites; these were analyzed at Earth Sciences, IIT (Mumbai). Stishovite, maskelynite, obsidance were seen in these sample.

Thin section of over 30 samples were looked at for the above compositions.

## Geochemistry of Lonar Crater & it's meteorites

Chemical analyses of meteorites have played a key role in understanding the origin and evolution of these extraterrestrial rocks and the relationships.

Today, the majority of new geochemical data on meteorites is for trace elements at the level of parts per billion to million, often on single mineral grains. Yet, as we enter a new era in space exploration, we find that much of our new geochemical data for planetary bodies (e.g., Moon, Mars, and asteroids) is limited to major elements that can be measured remotely.

Elements that can be measured for abundance include Si, Al, Mg, S, Ca, Fe, O and K and, possibly Ti, Cr, Mn, H, U and Th. A small number of other minor elements (e.g., Ni, Na, P)

are routinely measured during bulk chemical analyses of meteorites. All elements except Th and U are reported as weight percent of the element and elemental ratios are weight percent ratios. Th and U abundances are reported as ng/g.

Using the bulk compositions of these meteorites we can (1) determine how well different groups of meteorites can be distinguished on the basis of both element-element and element ratio-element ratio plots and (2) investigate the extent to which the range of bulk chemistries can be related to the Cosmo chemical and geologic processes that are known to produce them. From decades of detailed laboratory and theoretical research, our goal is to review of meteorite element compositions based on meteorite petro genesis, which incorporates major element chemistry as part of a synthetic approach to unraveling meteorite origins.

With a humble beginning to understand the chemistry of Lonar Crater, AGCA has extended its wings to reach the other meteorites all over the globe.



Bharat Adur is the Principal investigator of Akash Ganga Centre for Astronomy (AGCA, Badlapur, Dist. Thane 421 503); His team includes H. Mali, A. Kadam, L. Garg, A. Parkar, A. Kamat, J. Rathod, R. Patil, S. Naik, K. Adur, A. Bhaskar, J. Karekar, T. Varade (2005). J. Mayekar, O. Khare, B. Todankar, K. Dhanmeher, V. Sarogi, and A. Rangare.



## Congratulations to REAPers on successful completion of PhD

- Nagendra Kumar P (Boston University)
- Vinutha A (JNCASR)
- Sharada G (IISc)
- Kaumudi Prabhakara (Cornell University)
- Akarsh Simha (University of Texas)
- Achyuth Jamadagni (Clemson University, South Carolina)

Editor : B S Shylaja  
Published by Director

## JAWAHARLAL NEHRU PLANETARIUM

Sri T. Chowdaiah Road, High Grounds, Bengaluru-560 001

Ph: 080-22379725, 22266084

E-mail: info@taralaya.org Website: www.taralaya.org

