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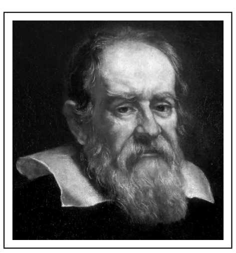

Editorial

Homage to Narendra Dhabolkar

On 20 August 2013, while out on a morning walk, Dr. Narendra Dabholkar was shot down by two criminals near Omkareshwar temple, Pune at 7:20 AM. This barbaric act has shocked the democratic minded people all over the country and the world.

He had founded the Maharashtra Andhashraddha Nirmoolan Samiti — MANS ("Committee for Eradication of Superstition in Maharashtra") in 1989, and had been campaigning against superstitions and other unscientific practices prevalent in the society. He wrote several books on superstitions and their eradication, and addressed over 3,000 public meetings. He was deeply loved by the people of Maharastra. The very many protests, bandhs and dharnas both within Maharastra and across the country bear testimony to this fact.

Dabholkar had made several attempts to get an anti-superstition law enacted in the state of Maharashtra. Under his supervision, MANS drafted the Anti-Jaadu Tona Bill (Anti-Black Magic Bill). A couple of weeks before his death, he had pointed out that the bill had not been discussed despite being tabled in seven sessions of the state assembly. Finally a day after Dabholkar's murder, the Maharashtra Cabinet cleared the anti-black magic and superstition ordinance.

The harbingers of renaissance movement in our country, Rammohan Roy and Vidyasagar had initiated a great cultural movement to free the people from all sorts of obscurantist ideas and practices of its medieval past. They had dreamed that free India would also be free from those maladies in the cultural field. Unfortunately even after independence these unscientific practices and beliefs continue to get encouragement from the powers that be for vested interests and have become more rampant now. As Tolstoy said "The strength of the government lies in the people's ignorance, and government knows this, and will, therefore, always oppose true enlightenment."

It is in this context that Dhabolkar's efforts are important and there is a definite need to continue the struggle that he waged. We salute Narendra Dhabolkar for the courageous struggle he led in defense of reason and scientific thinking.

Comet ISON: Our New Guest in the Sky

Subhasis Basak *

Who or what is ISON?

In November-December of 2013 we are going to get a visitor from the *Oort Cloud*. The Oort cloud is pretty far from us, roughly 50,000 AU (Astronomical Units, or the distance between the sun and the Earth) away from us, from where even light takes close to a year to reach us. This celestial traveller is a comet named ISON which is officially designated as C/2012 S1. Comets visiting the inner solar system from Oort Cloud is not a rarity in itself, they come often but mostly stay dim and consequently go un-noticed. Only the professional astronomers and serious amateur astronomers take notice of them, perform scientific observations and measurements. Very few of them become bright enough to appeal to the curiosity of the general population. The last time such thing happened was in 1997, when comet Hale-Bopp became quite bright, stayed so for a month and was easily visible to the naked eye. This time around, Comet ISON holds such possibility to become extremely bright, can outshine Hale-Bopp and perhaps rival Venus in brightness. Thus ISON has created a fair bit of sensation world wide and has become an eagerly awaited event. It is going to provide us a brilliant opportunity to marvel at another celestial wonder along with a good chance to trump over the dark, superstitious streak of our mind through a proper appreciation of the phenomenon.

*Dr. Basak is in the faculty of Physics at the National Institute of Science Education & Research (NISER), Bhubaneswar, Orissa.

What is the big deal about ISON?

Comet ISON was discovered on September 21, 2012, by the Russian amateur astronomers Vitaly Nevski and Artyom Novichonok in the framework of a monitoring program called International Scientific Optical Network or ISON, which gave the comet its name. During the time of the discovery the comet was at a distance of 6.29 AU, i.e., as far out as Jupiter, and its magnitude was approximately +18.8 which was too dim even for many professional telescopes. A series of follow up observations soon concluded that the size of the core or "nucleus" of ISON is about 5 kilometers in diameter, which is fairly large for a comet but not as huge as the comet Hale-Bopp (core diameter 30 kilometers). The orbit was found to be nearly parabolic, suggesting it may be a new comet fresh out of the Oort cloud. This means it still carries the materials initially accreted in the earliest days of the solar system formation. What is particularly interesting for the scientists is the fact that its top layer might be almost intact, which is not true for the other comets which lose quite a bit of material every time they come close to the sun. ISON will be closest to the Earth on December 26, 2013 flying past at a distance of 64 million kilometers or 0.42 AU. In fact the orbit brings it to an extremely short perihelion (closest approach to Sun) distance of about 0.012AU or 1.8 million kilometers on November 28, 2013. This makes it a *sun-grazing comet*.

But apart from everything, what made

Naming of Comets

For several centuries naming of comet has not followed any uniform approach throughout the globe. After the famous work of Edmund Halley, the discovery of comets increased many folds. So the necessities arose to name the comets in a scientific manner. In 1994 International Astronomical Union approved a new naming system. Comets are now named by the year of their discovery followed by a letter indicating the half-month of the discovery and a number indicating the order of discovery. Accordingly, the ISON which was the first comet discovered in the second half of September 2012, would be designated 2012 S1. Prefixes are added to indicate the nature of the comet:

P/ indicates a periodic comet (defined for any comet with an orbital period of less than 200 years).

C/ indicates a non-periodic comet (defined as any comet that is not periodic).

X/ indicates a comet for which no reliable orbit could be calculated (historical comets).

D/ indicates a periodic comet that has disappeared, broken up, or been lost.

A/ indicates an object that was mistakenly identified as a comet, but is actually a minor planet.

For example, Comet ISON's identified as non-periodic, designation is C/2012 S1. So Halley's Comet, the first comet identified as periodic, has the systematic designation 1P/1682 Q1.

ISON most exciting was its projected brightness as it approaches the Sun passing the Earth along the way. Based on how bright it was at the time of discovery and the amount of gas and dust it was ejecting even at such far away point, the speculated brightness during the few hours of perihelion passage was suggested to be -16 which is about the brightness of full moon! No wonder that thousands of amateur binoculars and telescopes, almost all the major ground-based professional telescopes and about 20 space-based assets are trained towards this comet.

What are comets, by the way?

The comets are essentially loose and heterogeneous conglomerate of rock, dust, watery ice and frozen gases such as carbon monoxide, carbon dioxide, methane and ammonia. Besides, a variety of organic compounds like methanol, ethanol, formaldehyde including complex molecules such as glycine can also be part of the mixture. These icy and dusty bodies are thought to come into existence about the same time when the solar system was forming with the proto-sun at its centre. While the planets formed by accreting material from the dusty nebula around the sun, the bodies that formed in the outer edge of the nebula are the comets. They are pushed further outwards to the edge of the solar system by the immensely powerful solar wind of the newly formed Sun. They eventually formed what we call the Kuiper belt and the Oort cloud.

Comets are believed to originate in either of these two places—the Kuiper belt is the region beyond the orbit of Neptune, and the Oort cloud is at the extreme edge of the solar system. Here vast stretches of the primi-

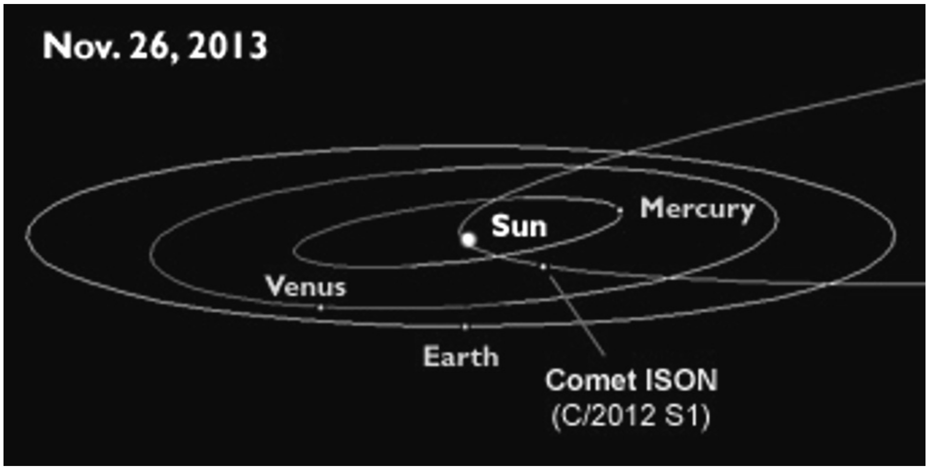

Figure 1: The orbit of Comet ISON.

tive icy fragments, gravitationally dispersed during the early stages of solar system's evolution, are thought to be still orbiting the Sun in almost the same state as they were originally formed. Often these bodies in Kuiper belt are thrown into an elliptical orbit under the gravitational influence of the Sun and the large planets like Jupiter, Saturn, Uranus and Neptune. In the case of Oort cloud, the objects are occasionally tossed in parabolic or hyperbolic orbits by the gravitational influence of nearby stars that happen to come close. The comets are essentially these inhabitants of the Kuiper belt and the Oort cloud, set on course towards the Sun by the gravity of such massive objects. Owing to such unusual origin, comets therefore contain rather rich information about the early days of solar system.

But what about their tails?

When comets get out of the Kuiper belt or the Oort cloud to begin their Sun-bound journey, they are just lumps of rock, ice and dust but no tail or coma. These lumps form the core or nucleus of the comet. Their sizes range from a few hundred meters for the smaller comets to some 50 kilometers for the very large ones. Since they have very low mass and density, they cannot become spherical under their own gravity, and instead, have irregular shapes. The characteristic tail and bright head or coma that we associate with a comet do not appear until a comet gets within orbit of Saturn or Jupiter.

As a comet approaches the Sun, somewhere between the orbits of Neptune and Jupiter, the solar wind (the stream of energetic particles ejected out of the Sun)) and radiation pressure on the cometary nucleus become strong enough to initiate vaporization of the frozen volatile gases. The gases start streaming out of the comet's nucleus, carrying dust and small fragments of rocks with them. While some escape the gravitational pull of the comet, the rest cling to the weak gravity forming a huge swollen but extremely thin atmosphere around the comet, extending hundreds and thousands of kilometers. This gassomer blanket of dust, rocks, ice and gases form the *coma* of the comet. The intense UV radiation from the Sun ionizes the gas particles near the surface of the coma. The coma reflects sunlight more strongly than the nucleus and, around this time only the comet becomes visible to the telescope. Actually the nucleus of a comet, because of its composition, is one of the least reflecting objects in the solar system. For instance, the nucleus of the comet Halley has been found to reflect less than 4% of sunlight that falls on it compared to 7% that asphalt or road surfaces reflect.

The force exerted on the coma by the solar wind causes the coma to extend away from the direction of the Sun forming the signature tail of the comet. How large the coma and subsequently the tail will form depends on the *activity* of the comet, i.e., the amount of dust and gas released by the comet per minute. Usually the more massive the nucleus is, the more activity should it show, the more brighter it will glow and the more larger the tail will it sport. The tails can extend to great distances, often running to more than 1 AU or 150 million kilometers. The tails of comets are extremely rich in structure and exhibit complicated dynamics in response to the solar wind, Sun's radiation pressure and its magnetic field. Actually comets can have multiple tails, with different compositions of gas and dust, pointing in different directions. The prominent one that we see is the dust tail which points away from the Sun but trail behind comet's orbit in a curved manner. The most interesting tail, however, is the ion or plasma tail which gets more affected by solar wind and follow the magnetic field lines of the Sun.

There are some side-effects of the coma and tail that are formed inside the inner solar system. The journey of the comet in its orbit through inner solar system towards perihelion is the most perilous part. Once the comet has crossed the *Roche limit*, which is about 3-4 AU distance away from Sun, when the ice of water starts evaporating, it faces the most intense solar wind and radiation pressure. Many comets have disintegrated at this point, but mostly they start shedding enormous amounts of dust and rock, leaving a trail of solid debris along their orbit. If the Earth, while moving in its orbit, comes in the vicinity or crosses these cometary orbits, then the Earth's gravity can pull in those dust and rock fragments into its own atmosphere, resulting in meteor shower or sporadic "shooting stars". The Perseid and Orionid meteor showers that occur in August and October every year are believed to be happening from the debris of the comets Swift Tutle and Halley respectively.

How frequent are cometary visits?

Based on the periodicity and nature of orbits, comets are largely divided into two categories, short-period and long-period. The short-period comets also happen to be periodic comets whose orbital periods round the Sun are less than 200 years. These comets move in highly elongated elliptical orbits, whose aphelion points lie anywhere between Jupiter's orbit and a little beyond Neptune's orbit. They stay more or less close to the ecliptic plane (except a few like the Halley's comet) and move in the same direction as the planets. Comet Halley is a notable example of short-period comet whose aphelion is beyond Neptune and has orbital period of 76 years. Comet Encke, on the other hand, does not even reach Jupiter's orbit. So far about 550 short-period comets have been observed out of which 470 have aphelion near Jupiter, called Jupiter-family comets, while the rest belong to the Neptune-family. Nearly all short-period comets are thought to have originated from the Kuiper belt.

Long-period comets have almost parabolic or hyperbolic orbits. The ones that are periodic have periods ranging from

Research on comets' physical characteristics

Scientists are searching for the amount of ice in a comet. In 2001, NASA's Deep Space 1 captured high-resolution images of the surface of Comet Borrelly and it exhibits distinct jets with a dry surface. In recent finding it has been observed that the majority of comets water ice is stored below the surface and that these reservoirs feed the jets of vaporized water that form the coma. On January 2006 dust samples were collected from the coma of comet Wild 2 which reached the Earth by the Stardust spacecraft. Experiments show these materials were crystalline and could only have been "born in fire." A team of scientists from the University of Arizona found evidences of the presence of liquid water in comet Wild 2. The European Rosetta probe will go into orbit around the comet ChuryumovGerasimenko in 2014 and with a small lander that will land on the comet surface.

200 years to thousands or even millions of years. The aperiodic ones simply get lost from the solar system after a single trip to the Sun. Besides, comets belonging to this category make perihelion approach from any direction and their orbital plane can have any inclination with respect to the ecliptic plane. Nearly all the famous bright comets like Hale-Bopp, McNaught, Ikeya-Seki, West, ISON belong to this class of comets. Usually such long period comets originate from the Oort cloud and we always see them in their maiden perihelion voyage. Being so, the cometary nuclei stay almost as intact and pristine that it born with, therefore carrying valuable information on the condition at the time of their formation and of the baby solar system. Never having to shed any part of the nucleus, these long-period comets spew more gas and dust, consequently become more bright and come under more scientific investigations.

What happens to the comets, eventually?

Comets can meet multiple possible fates depending on their origin, size, and orbit. Periodic comets can just become extinct. After a few hundreds to a couple of thousands perihelion passages, comets lose most of their volatile material and turn into small, dark, inactive lumps of rock or rubble. But they will keep on moving in their elliptical orbits unless they break up somehow. Comets can simply disintegrate into numerous small fragments under the strong tidal gravitational forces of the Sun or Jupiter. The long-period (or aperiodic) comets can just leave the solar system.

Of all these various ways of ending, the most spectacular ending is perhaps when a comet either collides with a planet or plunges into the Sun. Plenty of comets must have ended their lives by hitting the planets or their satellites in the early days of the solar system which are evident today from the large craters found on them. A more recent collision of a comet with a planet happened in 1994 when comet Shoemaker-Levy broke up into pieces and smashed into Jupiter. But the ones that approach the Sun at a very close perihelion distance, called the *sun-grazers*, can get tugged by the immensely powerful gravity of the Sun and can dive into its inferno. Very few sun-grazers like the *Great Comet of 1860* or recently the comet Lovejoy have escaped that fate. To put things in context, Comet ISON is also a sun-grazer and it may also end up diving into the Sun.

How comets shed their bad reputation?

Because of comets' sudden and unannounced appearances, they all along had very bad reputation in the history of mankind. Comets were abundantly referred as bearer of ill omen and catastrophes. Stray coincidences of appearance of comets with wars and natural calamities gave them bad name. Even very recently, the appearance of comet Hale-Bopp in 1997 led to mass suicide of the Heaven's Gate cult in the USA. But at the same time many scientists and philosophers of the time had thought differently, not necessarily correctly. Aristotle, for instance, associated comets with the natural phenomena of the upper atmosphere.

Tycho Brahe in the 16th century demonstrated that the comets must exist beyond Earth's atmosphere. Ultimately, comets came to be recognized as natural objects and subjects of scientific observation when Edmund Halley made detailed observation of a comet that appeared in the sky in the year 1682. He compared the orbital characteristics of that comet with the observations of many other earlier comets and by applying Newton's law of gravity he predicted the return of the comet 76 years later. Although Halley was not alive to see it, the same comet did return bang on the 76th year. The comet quite naturally was christened as Halley's comet and became part of history.

Comets are subject of regular scientific studies these days, even dedicated telescopes and satellites are used to understand them in details. Although bright visible comets are rather infrequent, smaller and dimmer ones appear aplenty that even 6-inch amateur telescopes can pick up several in a year.

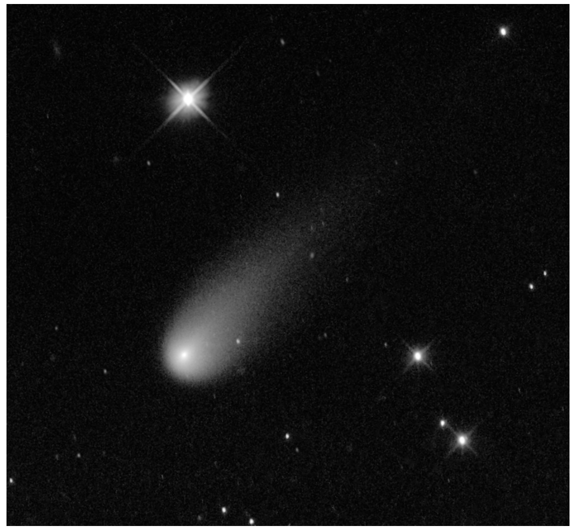

Figure 2: The Comet ISON, as seen through a telescope.

How does ISON fit the bill for a great comet?

As discussed before, ISON is just another comet fresh out of Oort cloud, and naturally is a long-period comet. It is at the same time a sun-grazer. Sun-grazing comets generally end their lives plunging into the Sun and such comets are briefly detected by Sun monitoring spacecraft like the "Solar and Heliospheric Observatory" (SOHO). But it appears that ISON is a big sun-grazing comet that will be seen until its perihelion. At perihelion the temperature can reach as high as 2700°C and extremely strong gravitational pull of the Sun can completely disintegrate it. As a result ISON will become extremely bright when it is closest to the Sun, it will also be difficult to see because of the Sun's glare. But a few days before perihelion and if it survives the perihelion passage and re-appears, then there is a strong

Table 1: The list of comet expeditions by different spacecraft year wise (from http://en.wikipedia.org/wiki/Comet).

Comet	Year of discovery	Spacecraft	Year of visit	Closest approach (km)	Notes
Borrelly	1904	Deep Space 1	2001	?	Flyby
Churyumov-Gerasimenko	1969	Rosetta	2014	?	Planned to orbit
Giacobini-Zinner	1900	ICE	1985	7800	Flyby
Grigg-Skjellerup	1902	Giotto	1992	200	Flyby
Halley	Antiquity	Vega 1	1986	8889	Flyby
Halley		Vega 2	1986	8030	Flyby
Halley		Suisei	1986	151000	Distant flyby
Halley		Giotto	1986	596	Flyby
Hartley 2	1986	EPOXI (Deep Impact)	2010	700	Flyby; smallest comet visited
Tempel 1	1867	Deep Impact	2005	Impacted	Flyby; blasted a crater using an impactor
Tempel 1	1867	Stardust	2011	181	Flyby; imaged the crater created by Deep Impact
Wild 2	1978	Stardust	2004	240	Flyby; returned samples to Earth

possibility that ISON will become one of the most spectacular comets of our time shining at -3 to -4 magnitude brightness competing with Venus. To top that, it is expected to develop a huge bright tail.

It is this estimated brightness of ISON that has created a sensation. Of course to the scientists and astronomers there is more to studying comets than just looking at how bright it is or how big its tail is. Usually they study how big they are, anomalies in their orbit, how much dust they are producing, their tail size and type, composition of their nucleus which carry information of their birth place and so on. Among other information, the astronomers also publish what is called *lightcurve* of the comets. Based on hundreds of initial measurements of brightness, the lightcurve is a plot of the observed and predicted brightness (apparent magnitude) of the comet against calendar dates. The resulting initial plot for ISON showed that, as it heads for perihelion its brightness may reach magnitude -17 which is brighter than the full moon!

Although not a guess work, predicting the brightness of a comet is a very difficult job particularly near perihelion and more so for a sun-grazing comet. But this piece of information about its brightness was enough to create sensation and “comet of the cen-

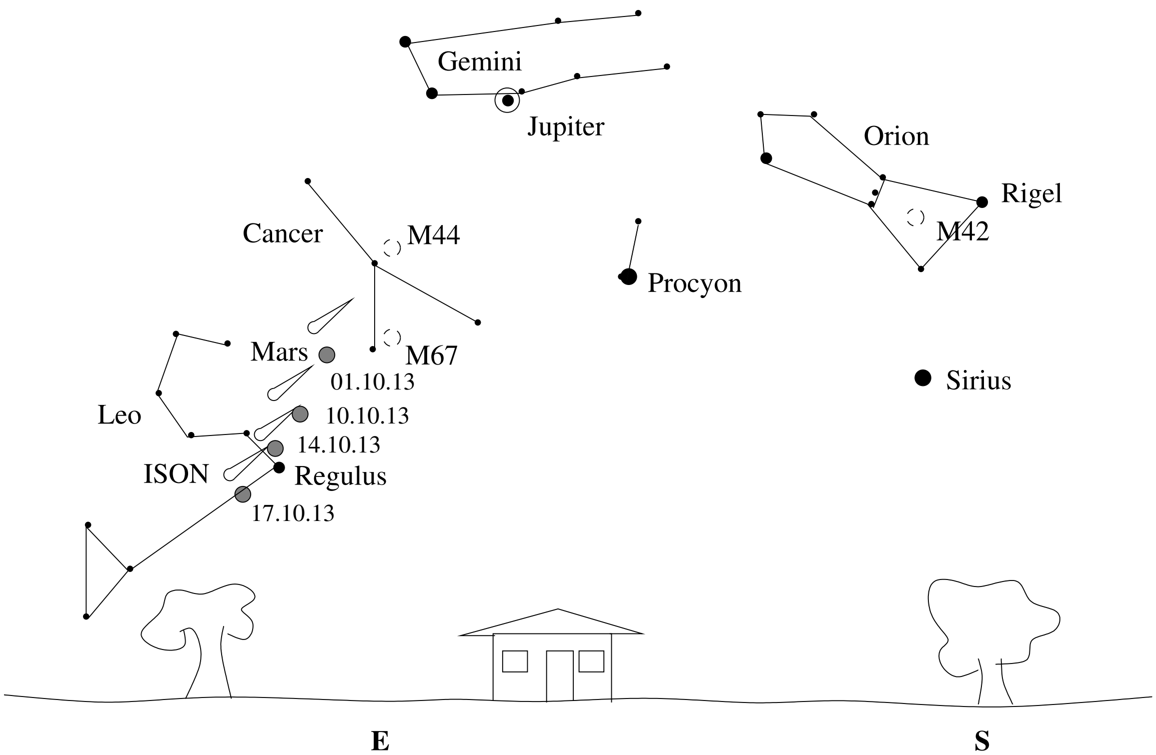

Figure 3: The Ison-Mars-Regulus rendezvous in October. The picture shows where the comet will be visible on 1st, 10th, 14th, and 17th October 2013.

tury" title for ISON. A more reasonable estimate of ISON's brightness occurring in the few hours' passage through the perihelion is somewhere in the range of -3 to -5. Nonetheless, ISON is expected to be one of the brightest comets in the past several years since the appearance of the comet Hale-Bopp, and is an eagerly awaited event.

What is ISON up to at this moment?

Comet ISON presumably began its journey about 10,000 years ago from the Oort cloud, but got caught in telescope only in September of 2012. It stayed in view of large telescopes including Hubble and a few other space missions since then. It was found to be emitting significant amounts of carbon dioxide and other dust but relatively less water. In April, when ISON was roughly 3 AU away, the Hubble Space Telescope measured the size of its nucleus to be 5 kilometers in diameter, the dusty coma or the head of the comet to be 5000 km and the tail to be 90000 km long. The size of the nucleus was considered to surprisingly small given the then brightness and amount of activity.

ISON was behind the Sun as seen from Earth during the entire June and July, 2013, and only in August it has emerged in the dawn sky with a brightness around +14, which seems to be 2 magnitude fainter than anticipated. However, as it gets closer to the Sun, more of its volatile icy materials will start sublimating and vaporizing. More recently, in early August the comet is thought to have passed the so-called *frostline*, about 3 to 3.5 AU from Sun, from which onward ISON will receive enough radiation from the Sun for the watery ice to sublimate in large quantities, consequently brightening up the comet. In the past, some comets have broken up upon crossing the frostline.

When and where to observe ISON?

In September and October, ISON is expected to be bright enough to be visible at least through binoculars and small amateur telescopes in the pre-dawn hours in the east sky. In October the comet will be squarely placed against the constellation Leo, rather close to the bright star Regulus, and right next to Mars making ISON easy to spot. Particularly on October 01, the day when ISON will be closest to Mars, we from Earth will get a show to enjoy—around 4:00 am ISON will be found in company with Regulus, Mars, Jupiter, Sirius, crescent moon, Orion nebula and Beehive cluster. But October 17 should be *the* day when ISON, Regulus and Mars will fit in the same field of view of a binocular.

ISON will keep on increasing its brightness throughout November and might become visible to the unaided eye about a couple of weeks before November 28, the day of perihelion passage. It would certainly be a binocular object. Even though the bright star Spica and Saturn would be there to guide us spotting ISON, it will be quite close to the Sun and the morning sky will be lit up significantly by the time ISON rises reasonably high up in the east sky. At this stage ISON will be undertaking the perilous maiden journey round the Sun through the perihelion point and can end up getting consumed by the Sun. If, however, ISON emerges from its closest approach to the Sun unscathed, then perhaps the best treat is due in December. The sun-grazing comets are usually more active and brighter after they have gone round the Sun, and ISON might be no different now sporting a long tail. It will be visible to naked eyes both in the east and west sky during sunrise and sunset respectively in December. No pointers should be necessary to spot it, ISON's majestic presence alone is expected to capture our awe. In January, the chances are that ISON will drop below naked eye visibility, remaining visible only to telescopes. After dark in the New Year, the comet will be high up in the north sky with tail pointing towards Polaris continuing its journey back to the icy depth of space, never to return.

And finally!

All along, mysteries have surrounded the appearance of comets. Once considered harbingers of doom, today the bright comets are seen as some of the most beautiful objects of the night sky. All over the world, the appearance of a bright comet excites the interest not only of the scientists, but also of the lay people. It offers an opportunity to scientists and science activists to dispel the myths and superstitions in the common people surrounding the comets.

ISON is expected to tell us extraordinary stories about the time of birth of the solar system, about the inter-stellar space it travels through, and so many other exotic things. Above all, simply watching it can be a jaw-dropping experience. We are all waiting eagerly to see what ISON really has in store for us. □

References

1. www.wikipedia.org
2. www.waitingforison.wordpress.com/comet-oberving
3. www.skyandtelescope.com
4. www.isoncampaign.org

Cloudbursts and Flash Floods in the Himalayas

A. K. L. Asthana *

Introduction

The rainfall season (NW monsoon season) between July to September is often a sad period in the mountainous areas of Uttarakhand and Himachal that lie between 1600 to 2200 meters altitude, because this region usually experiences natural disasters like cloudbursts, landslides, etc., almost every year. On 16th and 17th June this year, the upper catchment areas of the Mandakini River, the Bhagirathi River and the Alaknanda River at Kedarnath, Gangotri and Badrinath regions have experienced unprecedented devastation due to extreme precipitation, causing heavy casualty of life and properties of people living in the area and of the huge number of visiting pilgrims. Kedarnath, Rambara and Gaurikund of Uttarakhand Himalaya have been washed out by the torrential rain and cloudburst.

Since time immemorial, the shrines of the Garhwal Himalaya, like Badrinath, Kedarnath, Gangotri, and Yamunotri, known as Char Dham (four sites), have been the destinations of countless pilgrims. Before the 1960's this rugged mountainous terrain was undeveloped and accessibility to these sites was difficult. There were no road links beyond Srinagar in the Alaknanda valley. Badrinath, along with the old temple at Kedarnath, are the most revered places of worship in Garhwal for the Hindus. The Shiva temple at Kedarnath (3562m above the mean sea level) is located on the left bank of the Mandakini River. The river Mandakini originates from Chorabari glacier 6 km upstream from the temple. The population of the Kedranath Township and of the number of seasonal pilgrims are increasing day by day with proportionate increase in the necessities for their lives. To meet the requirements of the tourists / pilgrims a large number of unplanned and unauthorised houses, hotels, restaurants, shops and dharamsalas have been constructed on the river bed of the Mandakini around the temple, which was the old outflow of Mandakini River.

On 17th June, 2013 the Mandakini valley witnessed one of the worst natural disasters when heavy flash floods caused massive damage to the life and property in Rudraprayag district of Uttarakhand. The Kedarnath temple in the district of Rudraprayag in Uttarakhand, one of the four holy Dhams, has been one of the worst hits in the flash floods (Fig. 1). Torrential rains and increased gully erosion caused a large volume of water laden with sediments and boulders to flow along the valleys and to hit the Kedarnath settlements, which washed away the Rambara town. This was further aggravated by the bursting of the moraine dammed Chorabari Lake giving rise to a flash flood, devastating Kedarnath and the towns of Gau-

*Dr. Asthana is with the Wadia Institute of Himalayan Geology, Dehradun-248001, E-mail: aklasthana@wihg.res.in

rikund, Sonprayag, and Phata downstream. According to reports, while the temple is safe, the outer compound has been damaged and the town around the temple has suffered massive losses as it felt the full force of the flowing waters with big boulders, debris and mud flows of morainic deposits (Fig. 2). More than 6600 pilgrims and local residents have been reported to have lost their lives, 365 houses have been destroyed 275 houses partially damaged, and about 90 Dharamshalas (rest houses for pilgrims) are swept away in the flash floods; 500 roads and 150 bridges have been destroyed as per Uttarakhand government record. In the downstream, the flash flood struck and washed away the Rambara Township completely while the Gaurikund and Sonprayag townships have been partially destroyed in the downstream area of the Mandakini River.

Past cloudburst incidents

Cloudburst activity happens in every monsoon season in Himachal Pradesh (Kullu valley) and western Uttarakhand (Chamoli, Uttarkashi, Tehri, Rudraprayag and Pauri districts). Sometimes it happens in the Kumaun Mandal (Pithoragarh, Almora, Bageshwar, Champawat and Nainital Districts) and Mussoorie hills of Dehradun district and in the Lesser Himalaya and Siwaliks also. Though 4 to 5 events of cloudburst happens every monsoon season, we give below only those incidents in which there is great loss of life and property.

The cloudburst and subsequent flash flood which occurred in late hours of August 10, 2002 caused considerable damage to life and property in some parts in Medh Gad and Dharam Ganga valleys in Budha Kedar (Thati Kathur) area in the northern part of Ghanshyali Tehsil of Tehri Garhwal district. Cloudburst and an area of 54.10 sq.km in Medh Gad and Dharam Ganga basin was affected by landslides, debris flows and debris slides. These two channels are the major tributaries of the Balganga draining the Higher Himalayan region. The lower and middle slopes between 1600m and 2000m altitude facing towards south and southwest were mainly affected by landslides and debris flows (Sah et. al. 2003). The cloudburst and associated mass movements caused death of 28 people, 99 cattle and completely damaged 38 houses in the area. More than 1200 people of 17 villages were affected by this event.

In the month of August 2004 the forest area of Tevala in the district Kullu of Himachal Pradesh experienced a cloudburst. Severe flash flood occurred in the Jagri Nala (stream) which trapped the labourers building a tunnel in a NHPC Project. Due to the sudden flash flood a 2 km stretch was filled with mud and debris. The front of the 1200m tunnel was covered by mud and debris. The fast flowing water of Jograi Nala (stream) has changed the direction of the Parvati River and has created a lake there. After overflowing the lake, the velocity of water was so high that the road was washed away.

The Mandakini valley had experienced a flash flood in 2005, close to NH-58, Rudraprayag and Kedarnath National Highway, Augustmuni, Vijaynagar and Dhanyu villages were affected. Several people were reported to be buried in the debris and many were wounded. Due to the sudden torrential rain, the Vijaynagar Gadhera (stream) became a death stream for the locals. Below the village Dobha several cracks developed and a bridge at Dhanu was washed out.

Due to cloudburst and heavy rain in the eastern Uttarakhand Himalaya, the Dharchula and Munsiyari areas were also extensively damaged during the same period. From Alaghat to Tavaghat and

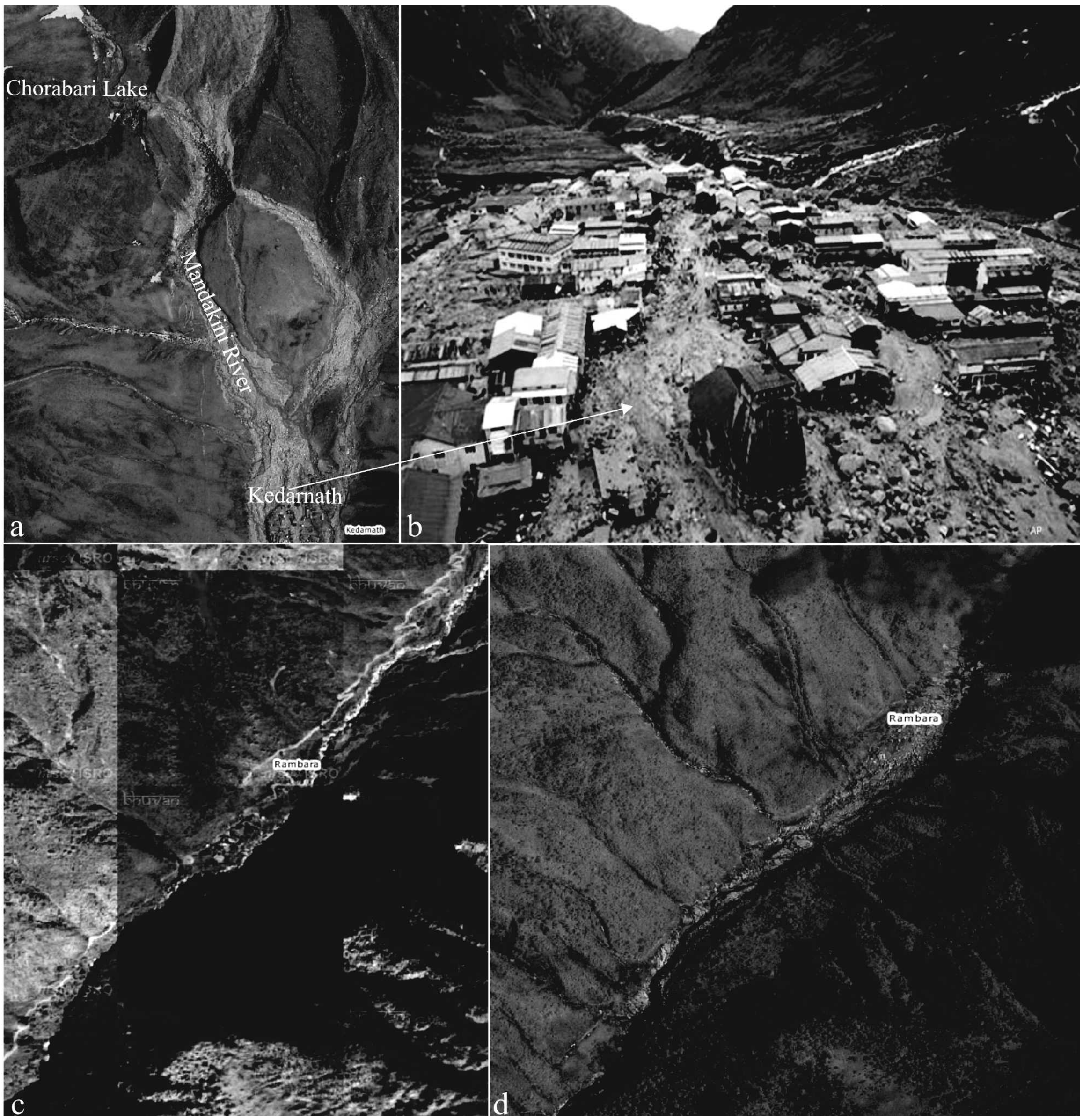

Figure 1: a) Image showing the devastation at Kedarnath and Rambara along Mandakini River. b) Destroyed Kedarnath Township due to flash flood and cloudburst (source : internet). c) Rambara before the debris flow. d) Rambara after the debris flow. Image source: Indian remote sensing agency (Bhuvan)

Tavaghat to Chhirkila the pilgrim route of Kailash Mansarovar was damaged badly by the heavy rain. Agricultural fields and a bridge at Syangatha were completely washed away. Near Sambala the army camp was filled with water. A temporary lake was formed in Kulagad near Kali River. Madhkot area of Munsyari has been destroyed due to lake formation by the Gori and Kali Rivers. A road between Jouljibi and Madhkot has been washed away. Big trees, house logs, house goods like Gas cylinders, pots etc were seen floating during floods in the rivers. Maize crop had been completely destroyed during the floods.

500 meters road of Gangotri National Highway in Uttarkashi district and Kura village has been severely damaged due to a cloudburst. About 5 hectare land in Kura village was converted into barren land due to debris flow. In the year 2005 the holy Sikh pilgrim route Hemkund Sahib, and the main place Govindghat have been destroyed due to cloudburst in Tuphani nala. 11 people lost their lives. More than 200 vehicles, 20 shops, hotels, human settlements have been washed away. Due to the cloudburst, electricity, drinking water supply and telecommunication facilities were severely affected in Givindghat.

Some cloudburst activities in Uttaranchal are shown in Table 1. The Kullu valley around Rohtang Pass area of Himachal Pradesh is also vulnerable to cloudbursts, like Uttaranchal. Several cloudburst activities have been recorded during the last few years. In 1993-94, Salang, Kothi, Palchan, Rubaru, Majhajh and Ulang villages have been affected due to cloudburst events. Gaujara village in Kullu valley has been severely damaged due to cloudburst in August 1999. The cloudburst activities became quite frequent during the monsoon season in the last few years. Now we discuss the factors responsible for cloudburst activities in the Himalayan region.

Cloudburst disaster in the Himalayas

The monsoons play an important role in the young, high and brittle ecosystem in the Himalayan mountain range. On the one hand the monsoon is the saviour for agricultural activity, is a life saving phenomenon for the humans, but on the other hand it creates natural disasters on the mountain slopes causing loss of life and property. During monsoon, the southern faces of the Himalayan mountain slopes are more prone to natural calamities and events of devastation like cloudbursts. The landforms of the Himalaya, between altitudes 1600 to 2200 meters are extremely sensitive in the months of July and August during the monsoon season. The Himalayan Range is 2500 kilometers long and 500 kilometers wide from east to west in the northern part of the Indian subcontinent. The monsoon wind which originates from the Bay of Bengal blows towards the North-West direction over the Indian plains. The Himalayan Range produces a geomorphic barrier for the monsoonal winds from July, that is why the rainy season continues till September in this region.

In the Himalayan mountain ranges there are two faces—the northern and the southern. The northern faces are generally covered with dense forests whereas the southern faces receive full sunlight so that agriculture (irrigated and non-irrigated) thrives here and human settlements exist on these slopes. The cloudburst events generally occur on these faces, and quaternary sediment deposits are present. These superficial deposits are less compact, loosely laid on the surface of various types of pre-existing rocks and are mixtures of fine sand, silt, coarse gravel and even boulders. These loose sedimentary materials on the land and high altitudinal features like cirques, hanging valleys, broad valleys, saddle, cliff like landforms and Oak and Rhododendron mixed dense forests create suitable conditions for the cloudbursts.

Table 1: Cloudburst events in Uttarakhand Himalaya since the year 1970.

No.	Place	Year	Height in m.a.m.s.l.	Affected areas
1.	Belakuchi (Birhi River) Chamoli	July 1970	2150	Southern Face
2.	D.M. Slide Gangnani (Kandauliya Gad) Uttarkashi	August 1978	1950	South-East Face
3.	Kaunth Chamoli	July 1979	1800	South-West Face
4.	Mandakhal Pauri	August 1981	1950	South-East Face
5.	Dhaijuli Thalisain Pauri	August 1989	2150	South Face
6.	Neelkanth Pauri	July 1990	1800	South-East Face
7.	Mandal Chamoli	August 1991	1800	South Face
8.	Bhenti, Ukhimath Rudraprayag	August 1998	1800	South Face
9.	Phata, Rudraprayag	August 2001	1650	South Face
10.	Mussoorie Hills Dehradun	August 2001	1650	South-West Face
11.	Gouna Tehri	August 2001	2000	South Face
12.	Burhakedar-Agunda (Balganga valley) Tehri	August 2002	1650	South Face
13.	Shilagarh Village Shimla	16 July 2003	2100	Southern face
14.	Tevla village Kullu valley	August 2004	2250	Southern face
15.	Dhanu village Rudraprayag	July 2005	1750	Southern Face
16.	Viilage near Shimla	August 2007	–	Southern Face
17.	Leh (Laddakh)	August 2010	–	South Face
18.	Asiganga Uttarkashi	5 July 2012	2000	Southern Face
19.	Dayara Bugyal Uttarkashi	August 2012	2150	Southern face
20.	Bageshwar, Kapkot near Almora	19 Sept. 2012	–	Southern Face
21.	Kedarnath	16-17 June 2013	3562	Southern Face

What is a cloudburst?

Heavy and sudden torrential rainfall (¿100mm/hour) in a short period of time in a small area (30 to 50 sq km) is defined as a cloudburst. A definition given by a site on the internet is as follows: "Cloudburst is actually a situation when the intermolecular forces between the H_2O molecules get very high due to the rapid decrease in the temperature or excess of electrostatic induction in the clouds causing the lightning to remain inside the cloud only, which causes hyperactive energy inside the cloud. The water molecules get denser and denser and get condensed but do not leave the cloud due to excess of electrostatic forces. The water concentration gets higher and higher and the weight gets heavier, thus water is no longer able to maintain the force within the clouds and so it falls and gets precipitated. As the water content is so high and also (as per the law of conservation of energy) the electricity remains in it, the cloud seems to burst." Another blogger gives a definition "Cloudburst is a sudden violent rainstorm falling for a short period

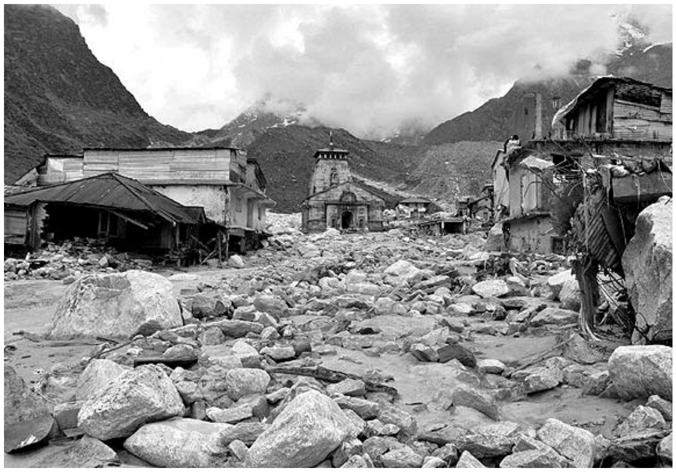

Figure 2: Big boulders and debris with mud deposited on the bottom of rive Mandakini. Several pilgrims has been buried in the 10ft high debris. (Source: Internet)

of time limited to a small geographical area. The rain is of the shower type with a fall rate equal to or greater than 100 mm per hour. Cloudbursts are usually associated with thunderstorms."

The air currents rushing upwards in a thunder cloud hold a large amount of water. If these currents suddenly cease, the entire amount of water descends over a small area with catastrophic force all of a sudden and causes mass destruction. They occur most often in desert and mountain regions and sometimes in the interior regions of continental land masses. They are called cloudbursts probably because it was believed earlier that clouds were solid masses full of water. The main reason for the cloudburst is the rapid condensation of the clouds. Therefore it is clear that without any intimation and anticipation sudden torrential rain causes the extensive erosion in the area. The loose materials made up of mud, debris and boulders roll down the slopes along with the water and cause devastations.

Tropical regions have high humidity. Here formation of big drops of water is a natural phenomenon and here convection current becomes strong. Deep cumulus convective clouds form here, and when the cumulus clouds full of water come down, heavy showers of rain occur with a fall rate equal to or greater than 100 mm/hour (4.94 inches/hour); this is called cloudburst (Das et al. 2006). A heavy downpour occurs over the terrain and due to weak soil and friction on the slopes, the rain water along with the mud, debris, boulders give rise to flash floods. Cloudbursts occur during the monsoon season due to strong convection associated with orographic forcing over the Himalayas.

Why cloudburst occurs

The cause of cloudburst events is still not fully understood by the researchers and scientists. However, some conceptual hypotheses are discussed below.

1. In the Himalayas the moisture laden monsoon clouds move from south to north. When these clouds are trapped from three sides by the geomorphic features such as cirques they become stag-

nant. At this moment the clouds are structured into layers. Subsequently these clouds are unable to hold the existing humidity weight for a long duration which results in the torrential rain.

2. The relief of a particular place, topography, high percentage of humidity, accumulated clouds in the hanging valleys, high variation of temperature along the mountainous slopes and valleys are the responsible and controlling factors for the cloudburst events.

3. Generally it is observed that cloudburst activity happens during night and the western, north-western and south-western slopes on the mountain are the major affected areas. It seems that formation of cumulus clouds which are full of humidity, continuous accumulation in the enclosed valleys during day and mountainous convection during night producing localized cyclonic situations cause the cloudburst events to occur.

4. The cloudburst events occur between 1600 to 2200 meter altitudes in the Himalayan mountainous ranges because in these high altitude zones cumulus clouds gather during night and produce cold and warm cyclones causing torrential rain in the area.

5. Main Central Thrust (MCT) and Main Boundary Thrust (MBT) are two major geological structures in the Himalaya which are located parallel to the Himalayan ranges. The MCT and MBT are structurally weak zones containing crushed and highly foliated rocks. Cloudburst activities near Bhonti, Tyuni (Uttarkashi) Bhatwari, Burhakedar (Uttarkashi, Tehri), Ukhimath (Rudraprayag), Neelkanth (Pauri) and Mussoorie (Dehradun) are between these zones and their effect on the weak rocks are disastrous.

What happens when a cloudburst occurs?

The runoff capacity of the rivers and rivulets is totally saturated by the cloudbursts causing floods. The torrential rainfall also increases the erosion on the valley slopes, thus increasing the incidences of landslides. At this time rain water flowing with debris, mud and boulders becomes devastating in the downstream areas. Along the banks of rivers and rivulets the existing natural resources are also ruined by the flash floods. Heavy devastation takes place in the areas of alluvial fans and fluvial terraces where agricultural practices are prominent, and also in the regions where the remnant of old landslides exist. Due to sudden floods, changes take place in the river valleys and lower areas.

How to reduce the impact of cloudbursts

As I have stated earlier the event of cloudburst is a natural disaster which is controlled by the distinctive geographical and geomorphic features of the Himalayan mountain ranges. Among these features the height of a particular area, the presence of cirques, saddles, hanging valleys etc., formation of cumulus rain clouds with high humidity, formation of cold and warm convection current play important roles. These circumstances and parameters are controlled by nature, not by the humans. Thus the events of cloudburst cannot be prevented, but the loss of life and property can be minimized by taking certain precautionary measures. For this, landslide-prone zones are to be identified, and human settlements and construction work may be avoided in those areas and proper land use planning may be initiated in those areas for the development of the region by eco-sensitive planning.

Following mitigation measures may be adopted to prevent landslides in cloudburst zones and to reduce the impact of flash floods and debris flow during cloudburst events.

1. Avoid settlements near old landslide zones, along abandoned channels and near the rivers and rivulets.
2. At the time of construction of roads rocks proper protective measures against landslides are to be taken. Steps (afforestation, horticulture etc.) should be taken to prevent soil erosion and soil creep on the mountain slopes.
3. Unplanned construction activity on unstable slopes and along river courses and abandoned channels must be stopped.
4. Geological, geomorphological and environmental study should be done by expert agencies during the construction of roads and canals.
5. The construction of canal should be made with cemented material to prevent the seepage of water.
6. Terrace preparation for the agricultural practice on the mountain slopes (spurs) should be carried out in an organized way.
7. A scientific view point should be evolved among the local people by training and vigilant programmes on the topic of landslides, soil creeps, erosion processes, preparation of terraces and land use planning etc.
8. Drainage and sewer line facilities should be developed in villages.
9. New technological know how should be given to the local people so that they can utilize it in construction of houses, environmental safeguards and also in agricultural work to improve their economic conditions.
10. Meteorological parameters like wind velocity, volume of rainfall, relative humidity, flood levels etc. should be monitored regularly.
11. If rainfall is occurring in any particular place continuously, the water levels in the rivers are to be continuously monitored, so that advance warning can be given for floods to save the life and property of the people living in that area.
12. Human greed must at least be restrained; relevant authorities must keep ample vigil.

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References:

1. Das, S. Ashrit, R. And Moncrieff, M.W. 2006. Simulation of Himalayan Cloudburst event. J. Earth Syst. Sci. 115 no.3, pp. 299-313.
2. Kumar, V.V.G., Jain, K., and Gairola, A. 2013. A study and Simulation of Cloudburst event over Uttarakhand region using river tool and geometric techniques. International journal of soft computing and engineering (IJSCE). ISSN: 2231-2307, Vol. 3, Issue 1, pp.121-126.
3. Sati, S.P., Sundriyal, Y.P., Rana, N. and Dangwal, S. 2011. Recent Landslides in Uttarakhand: Nature—fury or human folly. Current Science, Vol. 100, no.1, pp 1617-1620.
4. Sah, M.P., Asthana, A.K.L. and Rawat, B.S., 2003. Cloudburst of August 10, 2002 and related landslides and Debris flows around Budha Kedar (Thati Kathur) in Balganga Valley, District Tehri. Himalayan Geology. Vol.24, pp 87-101.

Global Position of India in Scientific Research Where we were : where we are

Dr. A. K. Maiti *

In 1928 the German physicist Sommerfeld visited Kolkata on the invitation of Prof. C.V. Raman. That time India had a galaxy of scientists like P.C. Roy, J.C. Bose, S.N. Bose, M.N. Saha, K.S. Krishnan, and others, internationally famous for their pathbreaking researches. Seeing demonstration of Raman effect and other front-line experiments at the Indian Association for the Cultivation of Science (I.A.C.S.), Kolkata, Sommerfeld commented : "India has suddenly emerged in research as an equal partner with her European and American sisters."

In 2013, Prime Minister Mr. Manmohan Singh expressed concern at the Science Congress that India's relative position in the world of science was declining and India was outshone by countries like China.

This article aims to quantify the decline in research conducted in the universities, research institutes and industries in India.

The number of scientific publications (quantity) is considered as the research output of a country. As per the DST report [1], prior to 1980, India was top in research among developing countries. The number of publications remained almost the same at 15,000 from 1981 to 2000 (global share decreased from 3.2% to 2%). It is claimed that after the year 2000 it has regained and reached 45,000 publications in 2010 (global share in 2010 was 3.5%). China has overtaken India in 1995 in global share of scientific publication and China's global share was 12% in 2010, next to the USA which is 30%.

Has India really has regained as claimed in the DST report?

For this, we should consider it with respect to Gross Expenditure in Research and Development (GERD) in billion dollars of "Purchase Power Parity" (written as b$ PPP) [1]. The DST report shows that the number of publications with respect to GERD drastically came down from 1980 to 2000 (from 5000 to 1500 per b$ PPP). After that it remained approximately steady at 1500 publication per year per b$ PPP upto 2008, then again declined till 2010, as the total number of publication has remained unchanged from 2008 to 2010 but GERD has increased.

The global impact of a nation in Science and Technology depends not on the volume of research but on the standard of research, which depends on the number of publications in the top 1% impact making journals, number of scientists known for pathbreaking research and the Nobel laureates. Nobel laureates are the pride of a country. As per the number-count, Nobel laureates in Physics, Chemistry, Medicine are 237 in USA, 67 in Germany, 8 in Italy, and only

*Dr. Maiti is with the Advantech Instruments, 20 Allied Ind. Estate, M.M.C. Road, Mahim (W), Mumbai – 400 016

[1] PPP is Purchase Power Parity. The cost of the same amount of goods and service are same in $(PPP) in different countries. At present, in our country approximately 1 $(PPP) = Rs 18, while 1 $ = Rs 54.

Table 1: Comparative study of India's scientific performance with China and Italy. Data of 2007 [1], FTE is Full Time Equivalent of research personnel.

	GERD Billion $ PPP	GERD % of GDP	FTE	Number of publication /GERD b$PPP	Global rank	Nobel laureates since 1900
India	25	0.9	1.5 Lakh	1,642	9	1
China	102	1.49	14 Lakh	1,025	2	0
Italy	22	1.18	1 Lakh	2,046	7	8

one (C. V. Raman) in India and no one from China. Not that all great scientists get this award, but those who get are greats. Only 2.7% of the Indian papers are published in the top 1% impact making journals each year from 2001 to 2010. The last Nobel prize for India in science was 80 years ago. Since independence we have failed to produce scientists of Bose-Saha standard.

China is spending four times more than India and getting three times more papers. But the number of publications per unit b$ PPP is less than India's. Absence of any Nobel laureate in China indicates it has never reached the top standard, where India was once there in the past.

On the other hand, Italy spends less money, having less manpower, producing more research publication and eight Nobel laureates so far. Their last Nobel prize in Physics was in 1984, in Medicine in 1986. Such an extraordinary performance of a small country having population of only 6 Crore !

At present, India's global position in scientific research in both quantity and quality is at a low level although Govt. spending for research is much higher. Presently Italy is achieving much higher standard than ours spending less money. China's scientific output does not look impressive, although their GDP and GERD are quite high compared to India's.

To improve the effectiveness of the spending in scientific research, it is necessary to introduce accountability in the system. The scientific administration should set a target, then it should make a detailed *plan* to fulfill the target, *do* as per the plan, then check after some time whether things are going on in the right direction, and if not, change the plan and *act* accordingly to achieve the target.

Reference

[1] Bibliometric study of India's Scientific Publication outputs during 2001-10 Evidence for Changing Trends, Prepared by : Department of Science and Technology, Government of India, New Delhi, July 2012

Prof. C.V. Raman joined the Calcutta University with half of the salary than his Govt. job, at the initiative of Sir Ashutosh Mukhopadhyay, the then Vice Chancellor of Calcutta University. That time, India used to get very little fund from the then British Govt. for research but the standard of research was at the top level. Besides, the V.C. set a target to Prof. Raman (it is in the form of a humble request from a wise man to a genius scientist) that he expected him to bring a Nobel prize for the country. Unfortunately, Sir Mukhopadhyay was not alive when Prof. Raman got it.

A Brief History of Science
Part 4: The Renaissance

Soumitro Banerjee *

The social background of renaissance

We have seen in the last instalment of this essay that the medieval period or the "dark age" was characterized by predominance of belief systems and the absence of scientific enquiry. The social structure was feudal, characterized by landowner-serf production relation. The kings, aristocrats and noble-men ruled in collusion with the Church, which propagated ideas conducive to the maintenance of the feudal society. The necessity of trade and commerce was minimal due to the self-sufficient nature of the village economies. There was no division of labour: the same people, who tilled their allotted land, would play the role of barber, iron-smith, or carpenter in their free times. The methods of agriculture and other crafts became stagnant, with little innovation occurring for a long span of time.

Yet, within the womb of such a static form of society, the seeds of change started germinating in the fourteenth and fifteenth centuries. Some handicrafts like glassware, pottery and weaving slowly developed into a stage where the volume of production could increase. But there was no market. This development of the productive forces was incompatible with the feudal economy, where very limited trade and commerce existed only for the benefit of the aristocratic class. The towns had very marginal, almost parasitic role in the feudal economy.

All this began to change as the volume of trade increased. Towns gained importance as trading centres, and the traders, who were subdued through taxation by the kings and nobles, began to be financially powerful. Earlier, the traders used to buy goods from the village artisans, and sell them in distant places where the same things were not produced. But the "village artisan" form of production of the feudal times was very inefficient, and the amount of goods that could be traded was low. As the traders gained financial power, they tried to increase the volume of production by starting "manufactories" where a large number of artisans would work under the same roof, on the raw material supplied by the trader, to produce the finished goods.

But this form of production came in direct conflict with the existing order of things. In the feudal economy people were bound to the land. If they continue to be tied to the land, where would the workers for the manufactories come from? So there was a necessity to free the people from feudal serfdom, so that they can become wage labourers. But the people were bound not only by the landowner-serf relation, but also by the culture of feudalism, and by the value system created by religious beliefs. So there was necessity to break these in order to establish the new form of production. Thus it was in the interest of

*Dr. Banerjee is in the faculty of the Indian Institute of Science Education & Research, Kolkata

the nascent wealthy business class ("bourgeoisie" in French) to break the shackles of feudalism — in politics, in economy, and in culture. Not only that, increase of production demanded new technology, which in turn demanded correct understanding of nature. Thus the resurgent bourgeois class needed to break the belief systems and religious authority that stood in the way of advancement of knowledge.

In the Dark Age the cultural environment was such that most people were conditioned into the belief systems propagated by the religious authorities. The call of the day was "believe, don't question." People who questioned the established beliefs, or whose beliefs differed with the official credo of the Church were prosecuted and punished, and were brought to submission. Now came a time where these people found support from the wealthy business class that was slowly becoming powerful. More and more people started questioning the established beliefs. More and more people started harbouring views and opinions at odds with the Church-propagated views. Initially they were suppressed through the "inquisition", a mechanism of trial and punishment of the heretics. But, with the support of the bourgeoisie, the opposition became bolder, and a full-blown struggle broke out in the area of ideas.

This struggle, erupting in the area of culture from the fifteenth century, is called the renaissance. The call of the new way of thinking was "question, don't believe." The whole world-picture adopted by the Christian faith came under the scanner. So far God was at the focus of everything, individual men being insignificant creatures at the service of God. During renaissance, the focus changed. Man became the centre of everything. The old values, ethics, morality, justice — everything came under question. New values, new ethics, morality, and sense of justice emerged. It did not happen in a day. It took long and arduous struggle for centuries to win the day in favour of the new way of thinking.

In the political-economic sphere, feudalism was giving way to capitalism, which was won through prolonged struggles with the ruling elite: the monarchs, kings, nobles, and feudal lords. In England and Holland bourgeois rule could be established only in the mid-seventeenth century, in France only in the late eighteenth century, after the French revolution (1789-1799).

The renaissance was to have profound impact on the development of science, since it gave birth to modern science as we know today. It gave birth to the methodology of doing science, the approach towards knowing what we don't know yet.

The voyages

As the demands of trade increased, people started looking for better and efficient means of transport. In those days land transport was very inefficient: the load that could be carried was small, and the speed was also very low. In contrast, waterborne transport was much more efficient: much bigger load could be carried, and with the aid of a favourable wind the speed could also be much greater. So sea transport gained in importance. But there was one problem: how can one locate one's own position in the middle of an ocean? So long as this problem was not solved, the ships had to sail close to the shore, and as a result had to travel much larger distances in order to reach a destination. In the fifteenth century people started attempting to find the location by observing the stars and planets: if one knew how the positions of the stars and planets should look from different locations in the ocean, one could figure out one's location by tallying the observation with available charts.

Thus man's attention was again turned to the actual motion of the objects in the sky. In the Middle Ages nobody really looked at the sky with interest because the Church propagated the Aristotelian and Ptolemaic pictures of the universe, and people were content with that. But now the understanding of the motion of the heavenly bodies became a matter of paramount interest and practical need.

Another aspect of trade opened up new horizons. The primary items of trade of the late medieval period were the spices, silk, muslin, gemstones, etc., that were in great demand by the European aristocracy. These items were produced in Asia, mainly in India and China. So, establishing sea-routes between Europe and Asia became a matter of interest. Initially the route was through the Gulf. But the increasing military activity of the Turks made this route inaccessible to European traders. So they looked for alternative routes to reach India. One possibility was to sail around Africa all the way to the south-most tip, and then to turn North-East. Today, looking at the map we can easily identify this possible route. But for the people of that time it was not easy, because it was not known if the African continent extends all the way to Antarctica. Somebody had to explore that through arduously long journey through unknown oceans. The psychological roadblocks were even bigger. Many people in those times believed that the Earth is flat and ends at some point, and if you sail into it you fall into abyss. Anybody trying a voyage into unknown places had to overcome such mental blocks.

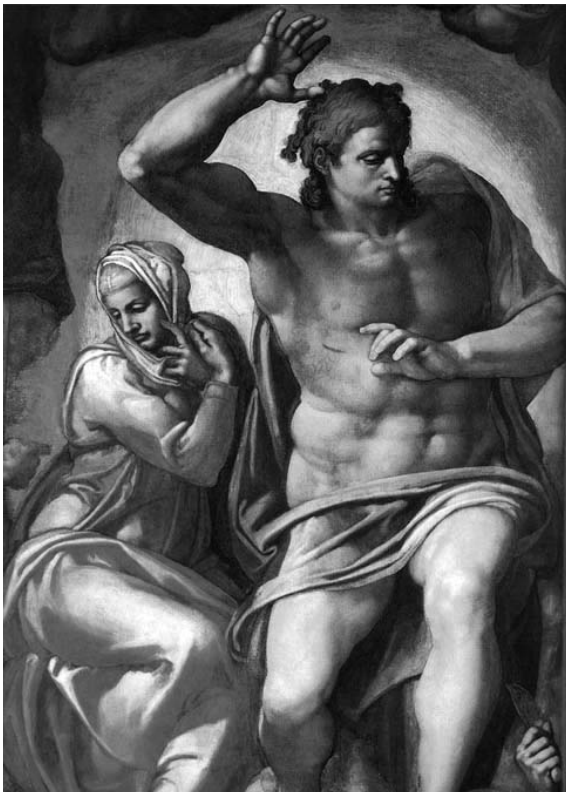
The first drive was initiated by the Portuguese and the Spanish. Bartolomeu Dias circumnavigated the African continent in 1486, and eleven years later Vasco da Gama travelled by the same route and landed in Kerala. Christopher Columbus, a penniless adventurer from Spain, had a different idea. He argued that if the Earth was really a sphere, it should be possible to reach India if one sails West straight through the Atlantic. After his funding proposal was rejected by one court after another, he finally managed to secure support and sailed — to reach the Bahamas in 1492. He thought that he had reached India, and the realization that this was a new land came much later, with the voyage of the Italian Amerigo Vespucci (after whom America is named). In 1519-22 Magellan attempted to circumnavigate the world but was killed in the Philippines by the locals. Fortunately one of his ships managed to reach Spain with only a handful of survivors — which finally convinced people that it is really possible to sail eastwards and to come back to the same land from the west.

These voyages and the stories of these adventures caught popular imagination, and helped in opening peoples' minds, making them receptive to new ideas.

The Arts

The effect of the opening of mind was felt first in the area of arts. When an artist paints or sculpts, he looks at the subject through his mind's eyes and expresses to the rest of the world what he sees. That is why, even when the artist is painting scenery, a natural object, or a human figure, his worldview dictates the way he sees it, perceives it, and paints it. The worldview is reflected in his choice of subject also. When this worldview of man was undergoing a radical change at the time of renaissance, naturally it was reflected most vividly in the area of art.

In the medieval times, in all pictures God or Jesus Christ was the central figure, and man was depicted as insignificant elements of the image. At the onset of renaissance, it all changed, and man became the central



The portrayal of Christ by Michelangelo in the great mural on the wall of the Sistine Chapel, Rome.

figure. God also had to be depicted, as the paintings or sculptures were mostly commissioned by the Church, Kings, or noblemen. But increasingly God was depicted in the form of a powerful man, devoid of the "other-worldly" features.

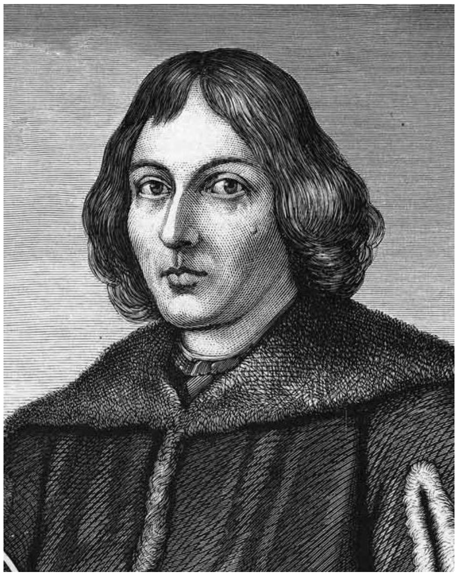
The artists of this time came out of the old mental images of the human body, and wanted to depict the human body in its real beauty. For that they had to learn from life. Not only that. They had to know what lies beneath the skin — the structures of the bones, muscles, arteries and veins. That could be learned only by dissecting dead bodies. Thus the great artists of that time like Michelangelo (1475–1564) and Leonardo da Vinci (1452–1519) ignored the Church strictures against touching the cadaver, and dissected human bodies. That is what made Michelangelo's sculptures of David or Moses so living. Leonardo went a step further. He was not only an artist who painted the famed "Mona Lisa," he was at the same time a scientist and an engineer. By dissecting dead bodies and sketching what he saw, he was the first man to discover the different chambers of the heart, the pipes going into and out of them, and the valves that regulate the flow of blood. He devised various devices for pumping water, for throwing projectiles, and even conceptualized a contraption for flying! We find all these in his notebook.

The renaissance personalities in science

Nicolas Copernicus (1473–1543)

Nicolas Copernicus was a Polish monk, who was well trained in mathematics and astronomy. He knew about the anomaly between the Ptolemaic picture of an Earth-centric universe with planets going in epicycles, and the actual observation about the motion of planets. The university scholars of the time tried to account for this anomaly by adding epicycles over epicycles, as a result of which the picture of the universe became immensely complicated. Copernicus noticed that all this complication can be avoided if we assume that the sun is at the centre of the solar system, and the Earth is a planet moving around it. Thus we see the other planets which are going round the sun, sitting on a planet which is also going round the sun. Using geometry he reasoned that the observed motion of the planets can be better explained using this alternative cosmological picture.

He being a monk knew very well that this view went against the official Church belief,



Portrait of Nicolas Copernicus.

and would be treated as heresy. Though he worked out the mathematical details early in his life, he did not publish it for many years. Finally, when he was ill and knew that the end is near, he entrusted the job of publishing the manuscript to his pupil Georg Joachim Rheticus. Rheticus in turn assigned the job to his friend and Lutheran theologian Andreas Osiander, who finally published the book. Copernicus got to see the book when he was in the deathbed.

Osiander's own theological beliefs went against that of Copernicus. So he changed the text here and there without the consent of Copernicus, and added a preface which basically said that the book contains matters of imagination of the author which do not reflect reality. Even the title of the book De Revolutionibus Orbium Coelestium (On the Revolutions of the Celestial Spheres) was given by him which did not have the approval of Copernicus.

That did not save the book from the Church's wrath, however. It was banned from circulation. But by then some people, especially the ones with an open mind, had read it, and a few copies remained unnoticed here and there.

Giordano Bruno (1548–1600)

In a place close to Naples, Italy, Giordano Bruno was studying to be a monk, when one day he noticed a copy of the book in the Church library. He read it, and agreed with the arguments. Thinking about Copernicus' heliocentric theory, he also became convinced that the stars in the sky are not bright spots in a dark canopy as was believed at that time; rather they were like our sun, each one having a planetary system around it. Then he took it as his life's mission to propagate this new view of the universe. Soon he realized that the Church is not the place for doing that. So he left the Church, left Italy, and toured the countries of Europe to propagate his views. He went to Geneva, Toulouse, Paris, Oxford, Prague, Frankfurt, and was driven out of one city after another — catholic or protestant — because of the views he propagated. Believing in a sun-centric view of the solar system was a heresy by itself; harbouring a different view about the realm of stars only increased the dimension of the crime. That is why, all the while Bruno was travelling through Europe, the Church authorities in Italy grew more restless to capture and punish the heretic.

Finally a trap was laid: Giordano received an invitation from a wealthy young man of Venice to be his tutor. Tired of a travelling life away from his homeland, he fell into the trap, and accepted the offer. Soon after he landed in Venice, he was arrested and put in prison.

The Inquisition started its work: interrogation accompanied by inhuman torture — aimed to force him to admit that he had erred in his views. But nothing could break the determination of Bruno. After eight

Statue of Giordano Bruno at the Campo dei Fiori square in Rome.

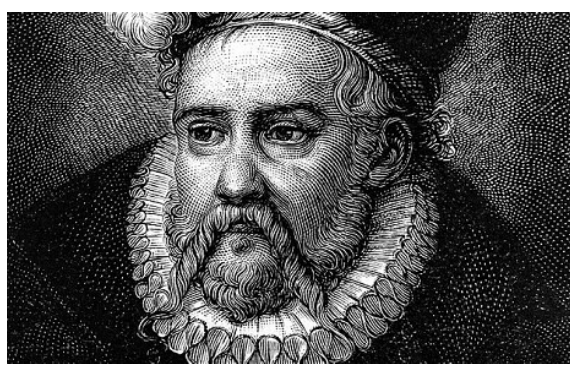
weeks of torture he was brought to Rome. This time the prison was a small metal box which became unbearably hot in the summer and unbearably cold in the winter. He was kept there for six years. Still they failed to make him admit that he had erred. Finally an Inquisition court pronounced its verdict: He will be killed in a "merciful" way, shedding no blood! Hearing the verdict, Bruno commented "Perhaps you who condemn me are in greater fear than I who am condemned."

On the 17th of February, 1600, he was burnt at stake at the Campo dei Fiori square in Rome. He was the first martyr for the cause of science.

Tycho Brahe (1546–1601)

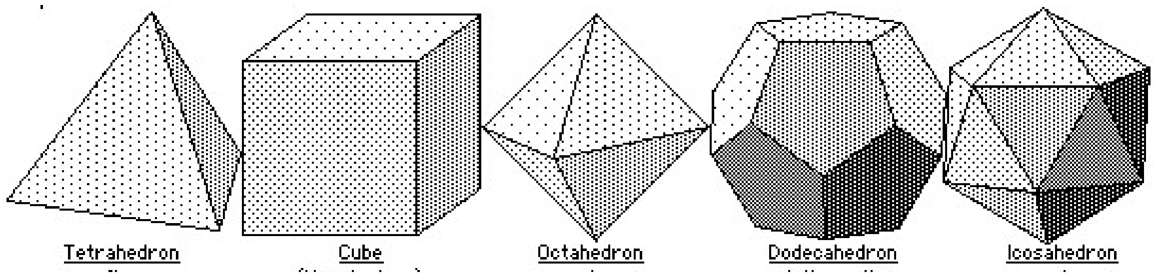
Tycho Brahe was a Danish astronomer who had enormous influence on subsequent development of science. His first scientific work started on 11 November 1572, when an interesting event happened. He was returning home at night when he noticed a new star. It was a faint star, but his knowledge about the objects in the sky was so thorough that he could immediately tell that he had not seen this star before. It was believed at that time as a part of the religious dogma that beyond the realm of the planets there lies a dark canopy containing the bright specks of light, and that in this domain everything is perfect, unchanging, and unchangeable. He noticed that this new star had no apparent motion with respect to the other stars, which implied that this object was a member of the dark canopy that was believed to be the end of the universe. This in turn implied that everything is not really unchanging and unchangeable in this domain. He trusted his eyes rather than the existing belief. He kept observing the star for months, which increased and then decreased in brightness over a period of time, and then disappeared from view. He published his results in a book "Da Nova Stella" (The New Star). This was the first demonstration that the domain of stars is also not unchangeable.

Tycho Brahe built the largest observatory of the time called Uraniborg at Hven, a small island on the Denmark coast. At this isolated place he spent 21 years from 1576 to 1597 recording the apparent motion of the planets — the most accurate ob-



Portrait of Tycho Brahe.

Series Article



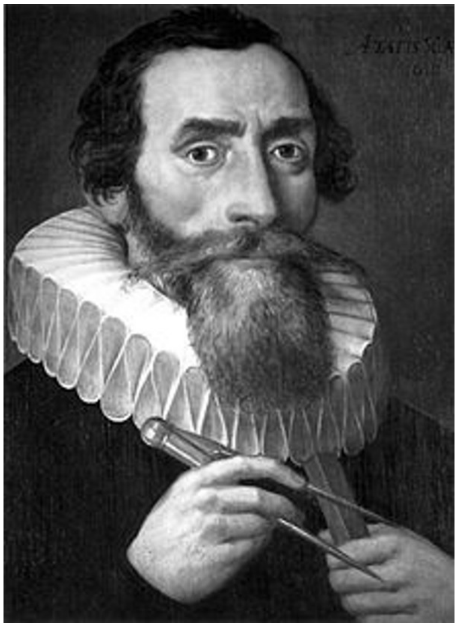
The five regular polyhedrons.

servation that was possible without the aid of a telescope. Subsequently he fell out of favour of the Danish king, and had to leave the country. He went from place to place appealing for financial support to set up another observatory. Fortunately he found support in Prague, and again devoted his time and energy to build the observatory and continue his recording of the motion of the planets. Soon he accumulated a mass of data that was to prove invaluable for the progress of science. He died in 1601, a year after Bruno's death.

Johann Kepler (1571-1630)

Johannes Kepler joined Tycho's team as an assistant at Prague in the year 1600. He was well versed in mathematics, but had no prior experience in observational astronomy. He had joined Tycho's team with a specific objective. He had a "pet theory" about the solar system. At that time only five planets were known: Mercury, Venus, Mars, Jupiter, and Saturn. He was intrigued by the question: Why was there only five planets? He knew that there can be only five regular polyhedrons: tetrahedron, cube, octahedron, dodecahedron, and icosahedron. So his pet theory was that these polyhedrons sit one inside the other, and the planets are placed at a corner of each polyhedron. This implies specific distances of each planet from the sun. So he went to Tycho to get access to the data with which he could test his theory.

After a year of his apprenticeship, Tycho died, and the mass of data came into Kepler's custody. He then sat down to test his theory. The more he checked the more he found the data to be at odds with his theory. He was depressed, torn in the struggle with his own self. But the wind of renaissance was blowing, and it had its effect. He believed Tycho's observations and jettisoned his own theory. Freed of the mental roadblock, he then sat down to work out the actual geometry of the orbits of planets. After many years of arduous work with mathematics and tallying with the data, he came up with the three laws now known as Kepler's laws. The conclusion that the planetary orbits are ellipses was particularly difficult because of the age-old belief that the circle is a perfect shape, and hence heavenly bodies must move in circles. Kepler tried in many ways to fit into this belief, by considering eccentric circles and equants, and the trajectories calculated by such means came as close as 8 minutes (one-sixtieth of a degree) from the observed data. Anybody else would have accepted the small difference as observational error. But Kepler knew Tycho's meticulous method of observation, and decided that it was impossible for Tycho to have erred by 8 minutes. So he again abandoned his preconceptions about the perfectness of the circle, and only after doing that, could find



Portrait of Johannes Kepler.

that the planets really move in ellipses with the sun at a focus.

Kepler's book "Astronomia Nova" was published in 1609, only nine years after Bruno was burnt at stake for believing that the sun was at the centre of the solar system.

Galileo Galilei (1564-1642)

The central figure of the renaissance was Galileo Galilei. Most other prominent figures of that time had some hangover of the earlier beliefs. Copernicus believed in the Pythagorean idea that the circle is a perfect shape and so the planetary movement must be in circles. Tycho Brahe believed in the geocentric theory, and that prevented him to see that his own observations supported Copernicus' heliocentric theory. Kepler, as we have seen, initially set out to find evidence in support of his own belief. But Galileo was free from all such hangovers from the past belief systems, and in that sense he was a true renaissance man.

At the time of Bruno's trial, Galileo was a young professor at the University of Pisa in Italy. Like all other professors, he had to teach Aristotle's theory in mechanics. To recall, Aristotle's theory was that 'force produces motion'. According to Aristotle, it follows from common sense that a bigger force produces a larger motion, and hence if a heavier object and a lighter object fall from a certain height, the heavier one will fall faster. While teaching this, Galileo told his students "let us test it".

So he took his students to the leaning tower of Pisa, and dropped a heavy piece of rock and a lighter piece of rock from the top of the tower. To everybody's surprise, they both fell with the same speed and one could hear a single sound when both touched the ground.

It was a simple experiment. But it completely changed the way we do science. All through history up to the time of Galileo, people have tried to obtain answers to their questions through personal realization. This was the "subjective" way of thinking, where one does not bother to test whether the answer was indeed correct. In contrast, what Galileo introduced was an "objective" way of thinking which recognizes the possibility that answers arrived at through personalized thinking could be wrong, and so it demands test of the theory by direct observation of nature or through experiments. "The simultaneous clang of these two weights sounded the death knell of the old system of philosophy, and heralded the birth of the new" (Sir Oliver Lodge, Pioneers of Science, McMillan, 1910).

Galileo laid the foundation of modern mechanics through experiments on the pendulum. He showed that the period of oscillation does not depend on the mass of the bob, nor does it depend on the amplitude of oscillation so long as the amplitude is small. Through elaborate experiments on masses sliding down inclined planes he came to conclusion that force does not produce motion as was believed following Aristotle. Force in fact produces change in motion. These findings were later formalized as Newton's first and second laws. He also laid the foundation stones of the theory of relativity by showing that there is no difference between the state of rest and that of uniform rectilinear motion. He was the first to emphasize the importance of expressing physical quantities in terms of numbers, and expressing physical laws in terms of mathematical relation between these quantities (for example, acceleration is proportional to the force). Thus he can be rightfully called the pioneer of modern mechanics.

These discoveries, however, did not please his colleagues and superiors at the University of Pisa. They tried to defend the Aristotelian beliefs by quoting from ancient texts. When they did not succeed, they attacked Galileo with the allegation of being a non-believer. Galileo started facing numerous hurdles in continuing his research, and was forced to leave Pisa.

Fortunately, the University of Padua offered Galileo a professorship in mathematics. It was in Padua that Galileo made his most momentous contributions in astronomy. He heard from sailors that a Dutch lens-maker had made a device through which one can see distant objects larger. Using his knowledge of optics, Galileo figured out how that could be achieved using two lenses placed at the two ends of a cylinder. He fabricated a telescope of improved design. Then he did something no one had done before: He turned it toward the sky.

He saw mountains on the moon. He saw spots on the sun. He discovered four satellites of Jupiter. The fact that the satellites go round Jupiter immediately proved those theories wrong which said that the planets are embedded on crystal spheres. He saw phases of Venus. He knew that a planet can exhibit phases only if its orbit is inside the Earth's orbit. All these observations pointed to the correctness of Copernicus' heliocentric theory. He invited his colleagues to look through the telescope, to see with their own eyes what he was observing. Blinded by Aristotelian beliefs, most of them refused.

He was cautious in exposing his findings. But events forced him to come out openly in favour of the Copernican system. In the year 1604, a star exploded (a nova), and there was quite a controversy centring round the question whether this object was located on the dark canopy (which was believed to be unchangeable) or was a nearby object. Galileo actively participated in the debate, to show that it was located far beyond the realm of the planets. This exposed his opposition to the age-old Aristotelian cosmology.

After his telescopic observations of the sun-spots were published, his opponents attracted the attention of the Pope to his heretic views. In 1615, the Pope invited him to explain his discoveries and their implications. Galileo saw this as an opportunity to make his theory accepted by those who mattered, and elaborately explained how his observations supported the heliocentric picture. That was a mistake: He was sternly warned against supporting and propagating the Copernican view and in 1616 the Church authorities banned all discussion, reading, and writing on the motion of the Earth.

For a few years after this debacle, Galileo refrained from getting into any controversy and continued his research in silence. At this time he found patronage from the Medicis — the progressive wealthy businessmen of Florence. Then in 1632 he

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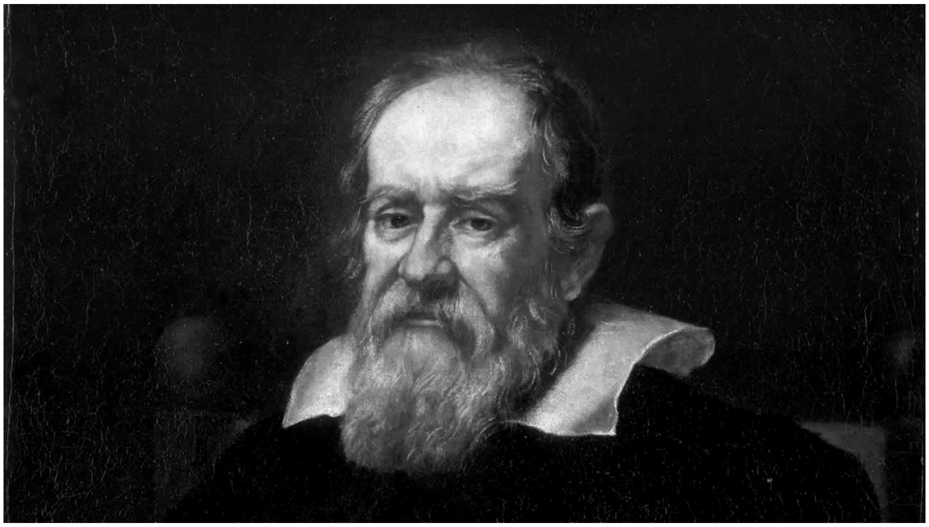


Portrait of Galileo Galilei.

again came out in the open by publishing the famous book "Dialogue concerning the two chief systems of the world, the Ptolemaic and the Copernican." In this book he adopted a peculiar style of dialogue between three characters, one representing the Aristotle-Ptolemy line of thinking, one representing the Copernican line of thinking, and the third an uncommitted person, who finally accepts the Copernican idea based on evidence. In this dialogue style, Galileo presented many of his theoretical work on mechanics, his telescopic observations in astronomy, and made a strong case for the sun-centric picture of the solar system.

The Church promptly sprang into action. The Inquisition summoned him in 1633; a trial ensued accompanied by torture. Galileo saw that things were going in the same direction as Bruno's trial. But he was a scientist. He had unfinished research to do, and had to inform the rest of the world about the results he obtained. So, weighing the options, Galileo took the strategy of recanting and signed a declaration reaffirming his faith in the Christian dogma. As a result, he did not receive the verdict that Bruno did, and was put under life imprisonment. Later it was changed to a house arrest in view of his age and ill health. He fully utilized the thin opportunity that the house arrest offered, and completed some of his unfinished research on statics and dynamics and published the results that paved the path for the emergence of a Newton. All this came to an end in 1637 when he was completely blinded. He died in 1642 — the year Newton was born.

After Galileo

Even though the Church tried its best to put down the rebellion in the field of ideas, the effort of Copernicus, Bruno, Tycho, Kepler and Galileo finally opened the window. More and more people started accepting the heliocentric view of the known universe, and within a few years it was accepted by most of the learned people of the time. Then came the time of a rapid development of science, which will be the subject matter of the next part of this essay. □

The Birth of the Concept of Temperature

K. Sampath *

Understanding of science lies in the understanding the relationship among facts, concepts, theory and experiments.

Let us consider, for example, the concept of temperature.

What is temperature?

1. The degree of hotness or coldness of a body, a substance or an environment
2. A measure of the average kinetic energy
3. The movement of the particles in a substance.

Temperature is expressed in terms of units called degrees, designated on a standard scale.

People observed for quite a long time that some substances like ice, rain water and well water are very cold, cold, and slightly cold or normal respectively; some other substances are hot, hotter and very hot. Also, they noticed the effect of fire in making water boil and the action of flame on all sorts of materials.

Even the atmosphere is sometimes cold, hot, hotter and very hot, depending on season. This kind of feeling is sensed through our skin. But this is not a very accurate sense; sense tends to compare rather than measure the property. Also sensing of coldness or hotness differs person to person.

It was also known that different materials differ in the capacity of absorbing heat or thermal energy. For example, if a wooden, plastic and metal spoon is dipped in boiling water, for say, 5 minutes and taken out it is found that metal spoon is very hot, and then follows the wooden spoon and finally the plastic spoon. Metals have a high capacity to absorb heat. That different metals have different heat capacity was also known to them. This fact can be experimentally observed even in our house. It seems for centuries people did not realize how to measure the hotness or coldness that of materials and systems.

Let us examine how this idea came to their minds, how it developed, and what difficulties were faced. Finally scientists or inventors executed it successfully. Firstly the idea of difference in hotness or coldness arose. Secondly, the concept of measuring or quantifying the hotness or coldness came in the minds of some people for practical purposes. (A majority of people who observe these phenomena, do not think about it and even if they contemplate there is great gulf between thinking and doing; this is still continuing!)

Thirdly, the questions are: How to do it? What material is to be selected? These difficulties made them think further. Fourthly, it was also known that when ice melts to water and when water boils, the hotness does not increase. These phenomena helped in identifying two fixed points (often called as the melting point of ice or freezing point of water, and the boiling point of pure water).

The important fact here is the seed of thought, observations, and the chain of rea-

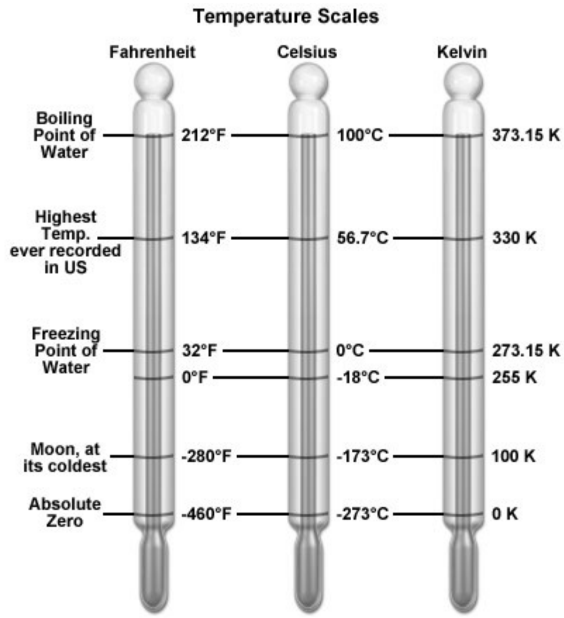
*Dr. Sampath is a retired scientist of the Defence Research & Development Organization.

soning connecting the observational fact or phenomena, forming a concept. Experimentation as also selecting the right material were all crucial. It was observed that when ice melts into water and water boils and evaporates, there is no chemical change in these processes. This fact led them to develop the concept of temperature. They fixed the point of melting of ice (0 degree) as one point of the scale, and the boiling point of water (which is 100 degree at normal atmospheric pressure) as another point in the scale. The gap in between these two fixed points is divided into 100 equal intervals. Each interval is measured as 1 degree.

Fifthly, the property of expansion of liquid on absorption of heat was also known. The method of measuring temperature was developed by combining the two fixed points of water and the property of expansion of liquid on heating. This completed the goal.

Even though the thermometer was known around the year 1630, the satisfactory thermometer was developed only around 1730. Thermometers were made which contained mercury or alcohol in a bulb and a column in a sealed-off tube.

Note that *temperature* is different from *heat*, though the two concepts are linked. Temperature is a measure of the internal energy of the system, while heat is a measure of how energy is transferred from one system or body to another. No heat will be exchanged between bodies of the same temperature. Heat spontaneously flows from bodies of a higher temperature to bodies of lower temperature. Heat transfer occurs by conduction, convection and radiation. The flow of heat depends on the temperature difference of systems and the thermal conductivity. The greater the heat absorbed by a material, the faster the atoms within the material begin to move and thus the greater the rise in temperature.



Temperature also determines the thermal radiation emitted from a surface. In the incandescent light bulb, a tungsten filament is electrically heated to a temperature at which it emits visible light.

Several temperature scales exist. In America, the Fahrenheit temperature is most commonly used. In most parts of the rest of the world, the SI unit viz., Centigrade/or Celsius is used. The Kelvin scale is used often in physics.

The lowest temperature that is possible is called absolute zero i.e., 0 K or -273 Celsius, where all thermal motion of the molecules stop (only a tiny amount of motion due to the uncertainty principle of quantum mechanics remains).

Scientists have produced superheated gas systems with temperatures exceeding of 2 billion degrees Kelvin, or 3.6 billion degrees Fahrenheit. This is hotter than the interior of our Sun, which is about 15 million degrees Kelvin. The feat was accomplished in the Z machine at Sandia National Laboratories. □

Organizational News

Kerala

Kottayam district

8 June: Talk on communicable diseases by Dr. Geetha Devi. (Dept. of Community Medicine, Medical Collage Hospital, Kottayam.) at the Astronomy Club.
29 June: Workshop on Madam Curie's life and contributions. Speakers: M.K. Shahasad and Prof. P.N. Thankachan.
13 July: Talk on History of Surgery by Dr. V.S Jose (Dept. of Surgery, Medical Collage Hospital, Kottayam.) at the Astronomy Club.
1 August: Talk on life and contributions of Madam Curie at Girideepam Bathany School, Kottayam. Speakers: Prof. P.N. Thankachan.
6 August: Workshop on the occasion of Hiroshima Day at Jawahar Balbhavan, Kottayam. Dr. C.S Menon discussed "Nuclear Chain Reaction", Dr. Thomas Kannampally discussed "Health Issues of Radiation", and Sri. Ganesh Kumar discussed the socio-political background of 2nd World War.
6 August: Horoshima Day observation at Jawahar Navodaya Vidyalayam, Kottayam. Speakers: Sri. Vipin Dev (RIT Pampady) and Prof. P.N. Thankachan.
10 August: Sharing of Utharakhand Experience by Muhammed Shaffek (Medical Collage Hospital, Kottayam.) at the Astronomy Club.
17 August: Horoshima-Nagasaki day observation at St. Michels School, Kaduthuruthy. Speakers: Master Yadukrishnan and Sri. Sreenivasan.
21 August: Horoshima-Nagasaki day observation at Kendriya Vidyalaya, Kottayam. Speakers: Vipin Dev and Nithin Raj of RIT, Papady.
27 August: Talk on History of Vaccination by Prof. PN Thankachan jointly organized by Galileo Science Club Periyapram and LP & UP School Onakkur.

Ernakulum district

July 13: A talk by Prof. M.K Prasad (Ex-Pro Vice Chancellor, Calicut University) on the "Protection of Western Ghats on the backdrop of Madhav Gadgil report" at the PWD rest house, Thrippunithura. The programme was presided over by Shri Francis Kalathunkal, district convener of Breakthrough Science Society. Shri C. Ramachandran (Retd scientist, ISRO), Shri K.S. Harikumar, Shri P.P Sajeevkumar and shri P.P Abraham spoke.

A series of programmes were taken during the month of August in five educational institutions highlighting the perils of nuclear warfare to commemmorate Hiroshima and Nagasaki. The programmes included talks by Shri K.S. Harikumar, anti-war exhibitions and photo-poster exhibitions.

Pokkali rice cultivation

A specific rice variety called "pokkali" has been traditionally cultivated in the Pattanakad block of Aleppey district. Over the past quarter of a century, the local land-owners have gradually shifted towards cultivation of salt-water prawn, with disastrous consequence on the environment

Students planting the Pokkali rice in Kelala

and on the people living along the perimeter of these fields. There has been an increasing demand to re-introduce the cultivation of pokkali rice, and for that purpose a struggle committee has been formed in the Ezhupunna panchayat. The Committee decided to re-establish the cultivation of Pokkali rice in 140 acres of land belonging to the Puthenkari padam which is owned by the Tharakan family trust. In spite of Aleppey district magistrate's order proscribing prawn culture in pokkali fields during the the paddy crop season from June to November, the land owners refused to comply with it. The struggle committee, in a written assurance to the district collector, submitted that they will undertake paddy cultivation provided that the usual subsidy of Rs. 25000/- per hectare earmarked by the state government for paddy cultivation in fallow land be allocated for this purpose. A pact was inked in presence of the agricultural officer on 21st May. But the government agencies have not released any fund so far, nor has it provided any material support in the form of seeds, pump, etc., and instead have charged to the tune of Rs. 38800/- for giving electrical connection. In dire financial straits the committee resolved to approach all well meaning people to support the effort by subscribing to "POKKALI BONDS". This is an informal arrangement whereby pokkali bonds valued at Rs. 1000/- per unit can be subscribed by any individual who supports this cause. The amount shall be repaid back in full without any interest six months later when the subsidy amount due from the govt. is received. If the paddy crop is successful, then the committee will decide accordingly to pay dividends in terms of the produced paddy.

Odisha

The *Bigyana Chetana Mancha*, Odisha, organised a seminar on the discovery of Higg's Boson at the Chitola College of Jajpur District on 12th August 2013. Sri Badrinarayan Ray, one of the founder members of the college, inaugurated the seminar. Dr. Sidhartha Varadwaj, faculty from the Ravenshaw University, discussed the recent developments in particle physics and the significance of the discovery of Higg's Boson. More than 100 students of the college participated in the seminar. Mr. Rajesh Mishra and Mr. Srinibas Mohanty, both lecturers of the Chitola College, discussed the importance of building scientific bent of mind in the students. Mr. Kulamani Nayak and Mr. Kirtani Jena of Bigyana Chetana Mancha, Bari unit, organised the programme.

Karnataka

12 May: Extended study class on 'Socio-economic roots of Newton's Principia' was conducted by Mr. Satish K.G., State convener of BSS at the Raman Research Institute.

19 May: Mr. Satish K.G., State convener BSS and Mrs. Rajani K.S., BSS Bangalore District President, gave a lecture on 'Life and scientific contribution of Acharya P. C. Ray', and a session on "Basics of Astronomy" in the Makkala Koota, which is an annual summer camp for school children in Bangalore.

29 and 30 June: A two-day science experiment demonstration workshop was conducted by the BSS, Bangalore unit in Bharath Scouts and Guides hall, Bangalore, for science activists. 40 participants attended the workshop. On the first day match-stick models and geometric proofs to algebraic formulae were taught and the participants tried their hands on the match-stick models. Around 20 physics models were demonstrated in the second session of the first day. On the second day, demonstration of 10 chemistry experiments was done. In the last session a brief discussion on the future activities and demonstration of science experiments in various schools and colleges was discussed.

27 July: A discussion on 'Approach and stand of science activists towards God, belief systems, social, political and other economic issues' was conducted in the BSS, Bangalore office. It was conducted by Sri K. Radhakrishna, senior advisor, BSS Karnataka, and Mr. Satish K.G., state convener of BSS Karnataka.

3 August: Science experiment demonstration was repeated for other members who could not attend the 2 day workshop which was conducted earlier. Mrs. Rajani K.S., BSS Bangalore District President, conducted this class at the Raman Research Institute.

24 August: A study class on 'Challenges ahead of Science Movement in the background of murder of Dr. Narendra Dabholkar' was conducted at the Raman Research Institute by Mr. Satish K.G., State convener BSS and Mrs. Rajani K.S BSS Bangalore District President. The study class covered the issue on rationalist movement in India with specific reference to Dr. Narendra Dabolkar. A condolence meeting and candle light vigil in the memory of Dabholkar was planned.

29 August: The Bangalore Unit of BSS organized a lecture at Sapthagiri PU College in Tumkur district, Karnataka on 'Life and Scientific Contribution of Albert Einstein', conducted by Mrs. Rajani K.S. Over 100 2nd PU students attended the talk. A chart exhibition on the life and contributions of Albert Einstein was on display through the day. Hundreds of students visited the exhibition. After the programme a few students came voluntarily to join BSS and to start a science club at the college.

31 August: On this day, the BSS Bangalore unit organised three programmes successfully.

BSS team comprising of Executive committee members Chandresh, Nandish and members Ashik Raj, Charishma and Nagesh conducted a demonstration session on Match stick models in Sri Acharya Maha

The protest meeting and candle-light vigil in Bangalore after the murder of Dr. Narendra Dabholkar.

Pragya School, Bangalore.

The BSS conducted a science experiment demonstration exclusively for girls and working women in Bangalore, conducted by Executive Committee member Dipthi.

The Breakthrough Science Society organized a candle-light vigil at the Freedom Park in Bangalore, in the memory of the rationalist, social activist and anti-superstition campaigner Dr. Narendra Dabholkar. A public meeting on the challenges of science movement in Karnataka was also organized. Around 150 people attended the public meeting.

Noted film director and theatre personality Sri Prakash Belawadi, Senior Plastic Surgeon and All India Vice-President of MSC Dr. K. Sudha Kamath, noted theatre personality and TV artist Sri Prakash Urs, State convener of Breakthrough Science Society Sri G. Satish Kumar spoke on the occasion. The meeting was presided by Smt. Rajani K.S. (President, Bangalore Unit, BSS).

Smt. Rajani K.S. gave a brief introduction about the life, career and the social movement of Dr. Narendra Dabholkar who had tirelessly dedicated himself for a social change and the 'Anti-superstition and Black Magic bill'. Sri Prakash Belawadi spoke about how the media, film and theatre should actively participate in such movements and bring a change in society against superstition and black magic. Dr. Sudha K. spoke about the problems that India is facing in terms of health and the effects of superstition, blind belief and black magic on health and loss of innumerable lives due to ignorance and blind practises. Sri Prakash Urs spoke about the role of individuals in fighting superstition. He called upon the gathering to be vigilant about the various forms of superstitions that cloud the mind. He criticised the mainstream political parties for practising various forms of superstitions in the corridors of power at the cost of public exchequer. He said social pressure should mount on TV channels to stop the telecast of astrology, numerology, reiki, telepathy and such other shows. Sri Satish concluded the meeting by delving into the challenges and hurdles faced by science activists and science popularisation in general. He recollected the glorious saga of the martyrs of science and their efforts to establish truth in society. He spoke about the culture, values and ethics that science upholds. He read out a memorandum with demands to fight against superstition and passing an anti-superstition and black magic bill in the Karnataka Assembly. He said the memorandum will be submitted to the Chief Minister. The memorial meeting ended by observing a minute's silence and paying homage through a candle light vigil.

Andhra Pradesh

The Hyderabad district chapter organized a seminar on "Is nuclear energy safe?" in the Stanley College of Engineering and Technology for women" Hyderabad on 17th July 2013. Dr. Soumitro Banerjee, Professor at IISER Kolkata was the main speaker. Prof. Sharma, HOD Electrical Engineering Department and BSS State Convenor Mr. Gangadhar also spoke in the seminar. Students from various colleges took part in the seminar.

Jharkhand

On the occasion of the Death Anniversary of Madame Curie, the Einstein Science Club of Ghatsila organized a number of seminars in various places, as listed below.

1. Ghatsila College on 4th July 2013. Speakers Mr. Kanay Barik, Patit Pawan Kuila and Mr. Sinha.
2. Marwari High School on 6th July 2013. Speaker: Yudhisthir Kumhar.
3. Narsingharh High School on 5th July 2013. Speaker: Sushil Giri.
4. Laldih local unit on 5th July 2013. Speaker: Asha Rani Paul.
5. Vidya Mandir High School on 8th July 2013. Speaker: Mr. Kanay Barik.
6. Jurodevi High School on 8th July. Speaker: Yudhisthir Kumhar.
7. J.C. High School on 8th July. Speaker: Sushil Giri.
8. Sirlal High School on 8th July 2013. Speaker: Purnima Tudu.
9. Bahragora High School on 8th July 2013. Speaker: Patit Pawan Kuila.
10. Mahuliya High School on 9th July 2013. Speaker: Asha Rani Paul.
11. Raj Estate Gorh Middle School on 9th July 2013. Speaker: Satyaranjan Shit.

The Ghatsila district science conference was organized at Ghatsila College. Chanchal Ghosh was the main speaker on behalf of Breakthrough Science Society. A new committee was formed with S.R. Dutta as the President, Saurav Madina as the Secretary, Anup Patnaik, Srinivas Rao, Shekher Suman Jha, Sujit Bhattacharya and Roopnath Kumar as vice-presidents, and Adil Khan, Jay Mahato and Sunita Hansda as joint secretaries. Kanay Barik the state in-charge of BSS also delivered speech on ethics of science. Around 400 students participated in this programme.

A discussion was organized on the topic "Life Cycle of Star" at Chandil. Kanay Barik the state in-charge of BSS and Patit Pawan Kuila were the main speakers.

West Bengal

World Environment Day: The World Environment Day was observed on 5th June by organizing a protest demonstration on the Second Green Revolution at the College Square, Kolkata. Dr. Abhee Dattamazumdar (from the Saha Institute of Nuclear Physics), Dr. Safique Ul Alam (agricultural scientist), and Mr. Shankar Ghosh (leader of peasant movement) were the speakers.

All Bengal Science Camp: An All Bengal

Science Camp was organized on 22-23 June at the Bengal Engineering & Science University, on "History of Science". Dr. Saroj Ghosh, former Director of the national Council of Science Museums, Prof. Ashoke Mallik, former Professor of IIT Kanpur and Emeritus Professor of BESU, Dr. Ashoke Prasun Chattopadhyay, Professor of the Kalyani University, Prof. Ajay Ray, Vice Chancellor of BESU, and Prof. Soumitro Banerjee, Professor of the IISER Kolkata, were the speakers. Around 300 students and science loving people from all over the state participated in the two-day event.

Acharya P. C. Ray Memorial Lecture: The second Acharya P. C. Ray Memorial Lecture was organized on 14 September at the Darbhanga Hall of the Calcutta University. Prof. Partha Ghose, former Professor of the S. N. Bose National Centre for Theoretical Physics delivered a popular lecture on "The Foundation of Quantum Mechanics."

The other programmes conducted in the past few months were as follows.

28th April: Discussion on "Global Warming" at Nadia Coopers camp.

4th May: Astronomical Slide Show and discussion on New Science Movement at Limgmoo Sr. Secondary High School, Sikkim. Conducted by Sourav Mukherjee

18th May: Documentary show on "Snakes of West Bengal" at Madam Curie Science Society, Behala.

25th May: Discussion on "Evolution of Man", Madam Curie Science Society and Newton Science Association, Behala. Speaker Dr. Radha Kanta Konar.

26th May: Quiz and Drawing Competition at Chetla PSA Kailash Vidyamandir. Conducted by Asish Samanta

26th May: Learning Science through experiments and model exhibition, Maynaguri, Jalpaiguri. Conducted by Chandan Santra.
9th June: "The pros and cons of the use of gene technology in cultivation," Tamluk Science Centre, Speaker: Dr. Nilesh Ranjan Maity and Dr. Sidhartha Bhattarchya

Tamil Nadu

Discussion on Darwin: A discussion on "Darwin and the Tree of life" was held on 16-8-2013 at the Govt Higher Secondary School at Akkaraipet of Nagappattinam, a town hit by Tsunami in 2004. The programme was jointly organized by the BSS and the Singaravelar Association, formed in honor of the freedom fighter Chintanai Sirppy Singaravellar.

Uttar Pradesh

On 15th of August, 2013, Allahabad unit of BSS organized an anti-superstition show at the Government Inter College (GIC), Allahabad. The principal of GIC, Mr. D. K. Singh presided over the programme. Mr. Jaiprakash Maurya, the UP state convenor of BSS, introduced the activities of BSS. Then Mr. Dinesh Mohanta conducted the show. The program was concluded with the president's speech. Around 120 students and teachers were present from five education institutes.

On 13th of September, the BSS Jaunpur unit conducted an anti-superstition show in the UP state-level youth camp at Janpur UP. The programme, involving hundreds of youths coming from both rural and urban areas, was conducted by Mr. Ramasish Maurya.