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New eye to explore cosmic past

Kamala Sohonie
(First Indian woman PhD in Science)

(1912-1998)

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Some recently re-consolidated development-related insights on infusing scientific temper

Dr. R. Gopichandran

The Department of Science & Technology (DST), Government of India has launched several mutually reinforcing initiatives to highlight and mainstream scientific temper. This is especially so this year, designated for this purpose through greater impetus. Thanks to the DST National Council for Science & Technology Communication (NCSTC) that will translate this intent through a series of deliberations across the country to facilitate informed thinking on this aspect. The event at the Jawaharlal Nehru University in February signified this process. Dr Gopalkrishna Gandhi spoke at length on the dynamics of scientific temper in the interface of development. He called for a special focus on three important facets in this context. They are: (i) issues and challenges pertaining to such tangibles as access to energy, performance of infrastructure, preventive strategies for mitigation and adaptation to disasters, etc., with implications for quality of life; (ii) Unbiased science to guide robust communication between scientists and citizens to recognise the contrasting perspectives and choices that guide public policy and plans; and (iii) A broad mindset that accommodates alternative views/values duly recognising diverse cultural contexts. His articulation brought the much needed greater spread and depth of perceptions than one-sided perspectives that tend to be rhetoric at best.

Another major event in February 2014 was the national conference on scientific temper organised by Vigyan Prasar at IIT Delhi. I was particularly inspired by the insights articulated by Dr Satyajit Rath, Dr D Raghunandan and Dr Hamid Dhabolkar. To my mind they appeared to rightly emphasise the need to recognise and up-front acknowledge the limits and limitations of one's own thinking and therefore the basis of world views one holds. This recognition and acknowledgement are founding principles of scientific temper in practice, and most importantly, helps respect points of views others hold. I believe it is essential for people who proselytise scientific temper to also practise it and least of all manipulate arguments and circumstances. The parallel session on the role of scientists and scientific institutions to mainstream scientific temper saw Dr Rahul Siddarthan and Dr Shashidhara highlight such important aspects as the open-endedness of science, changing circumstances and tools of investigations and infrastructure to foster excellence. In this context I wish to present in the following, a simplistic framework of essential interventions and correlates that can be prioritised by scientists and scientific institutions. These are generic and will determine the credibility of initiatives by the respective stakeholders.

Stakeholders	Levels of impacts	Scope	Interventions
Scientists	Individual	Credibility through values	1. Diligent 2. Inclusive 3. Recognise one's own limits and limitations 4. Recognise others' keenness, preparedness to comprehend and wisdom 5. "Fence should not eat the crop"
	Intra institutional	Non-invasive and mutually reinforcing	
	Society	Consistency and unbiased	
Scientific institutions	Individual	Foster excellence	1. Knowledge products 2. Highlight Open-endedness and Contrarianism 3. Build on local strengths 4. Knowledge hybridization 5. Locally relevant and positively influence quality of life
	Inter institutional	Synergies	
	Local, National, Regional and global	Value added and Adapted knowledge systems	

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Why forests are important for our survival?

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> "What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another."
>
> **Mahatma Gandhi**

Scientists explain that life originated and survived in the oceans under water for very long time. The Earth was receiving high doses of UV (ultraviolet) rays from the Sun at the time and we know that UV rays are extremely dangerous for living organisms. Later, when the atmosphere got its ozone layer, the harmful UV rays were stopped from reaching the Earth. Then life could exist outside water and the land also became the abode of living organisms. In due course of time forests evolved and soon the forests became the preferred habitats for most of the land organisms, including early humans. That explains why human history is closely associated with forests and its products.

Historically, the forests provided most of the fuel and construction material. Later, around 10,000 to 12,000 years ago, agriculture was invented and human population started inhabiting areas outside forests. But the close association of forests with human survival continued and it is so even now. That is why we find that there has been strong links between utilisation of forest resources and economic and social development of the human race. The other side of the story is that deforestation and the economic decline has been found to be closely associated. Reason is obvious. Forests provide large numbers of resources. Deforestation results in reduced availability or lack of those resources. Well known among them are timber, firewood, forage, fruits, medicinal plants, nuts, seeds, gum, lacquer, leaves, etc. Some of these are used by the people living in and around the forests and the rest are traded at national as well as international levels.

Globally, about 1.6 billion people depend on forests for their livelihood. About 1% of the world's GDP comes from the forests. For India, it is even more important as a larger percentage of people compared to most other nations depend on forests. For example, about 49% of households in the country use fuel-wood for cooking. Most of it comes from forests. Similar is the case with many other items provided by the forests.

High altitude forest

Forests are distinct ecosystems

There is strong dependence of people on forests for day-to-day requirements of large numbers of products and services. Also, forests play important role in boosting the economy. But these are very small fractions of the total role that the forests play. We need to realise that about one third of the plant and animal species inhabiting the Earth live in forests. In certain areas one hectare of forest supports more than 200 different types of trees. In addition, the forests provide habitats to very large varieties of animals and birds. Rainforests, especially in the tropical regions of the Earth, are extremely rich. They occupy only about 6% of the Earth's surface, but they support about half of the total plant and animal varieties on the Earth. Scientifically and ecologically, the forests represent distinct ecosystems. The forest ecosystems have green plants as producers; herbivores as primary consumers; carnivores as consumers of secondary type and beyond. Then there are different types of scavengers and decomposers in the forests which recycle the nutrients and other elements. Together with the non-living components they complete the ecosystems.

Forest ecosystems provide food, shelter, water, and protection to animals, birds, and many other organisms. That is why they prefer forests as their abode. That also explains why, when the vegetation is removed, the entire ecosystem vanishes. Glimpses of the same can be seen in forests which have contracted in size but have not disappeared. The animals which normally lived within the forest boundaries come out and approach human habitations in search of food, resulting in wildlife-human conflicts. Quite often the animals destroy crops, kill domestic animals or attack humans. For example, elephants ravage agricultural fields and destroy properties. Elephants are herbivorous and they need large quantities of food on daily basis. Also, they need large areas to roam around. In addition, elephants

Jhum agriculture in North-East

have certain traditional migratory routes which they use generation after generation. If the habitat shrinks or their migratory routes are disturbed, their reaction is intense and they cause havoc. No doubt, at the end the elephants lose. They may be killed with one bullet or a little poison. The story of tigers, lions, leopards, wolves and several other animals moving out of the forests and attacking domestic animals and people is similar. Destruction and degradation of the natural habitats of the wild species; i.e., the forests, are the main reasons. We need to realise that we are responsible for the same. We are destroying the forests on large scale for one reason or the other. As a result, the wild animals have to come out of the forests to roam around. In the process the animals encounter humans and conflicts result.

Another dimension is that traditionally, forests have been used for grazing domestic animals. Till recently forest areas were extensive and animal population was limited. Also, other grazing areas were available outside the forests. During last few decades the animal population has gone up, while the grasslands have shrunk and forest areas reduced. That is why there is more pressure on surviving forests, leading to human-wildlife conflicts. In turn, that situation also leads to conflicts between forest officials and the herders. The forest officials try to keep the herders and other squatters away from the forests. In India 1,78,000 families live inside protected areas alone. There is a proposal to relocate them outside forests by providing them monetary compensation.

Role of forests in regulating weather and climate

Forests support large numbers of trees and other vegetation depending upon the prevalent climatic conditions. Right from the surface vegetation to the lofty trees there are plants. We know that plants always do transpiration; i.e., they convert water into vapour and release the same into atmosphere from their leaves and other above ground parts. In physics we learn that when water evaporates, it absorbs high amount of heat energy. That is why the forest environment is much cooler as compared to outside. Also, that explains why, if forest is destroyed, temperature of the area goes up drastically. Forests also play crucial role in giving speed and direction to wind which ultimately reflects on the rainfall, weather and climate of the area.

In recent decades the issue of Climate Change has become a reality. Earlier, the emphasis was on not allowing rise in Earth's average temperature. Now, scientists are talking about keeping the rise within 2°C. Reason is that there is strong possibility that the rise may go up to 4°C, which may prove catastrophic. We know that green plants perform photosynthesis by using carbon dioxide. Carbon dioxide is the main culprit responsible for global warming and climate change. Forests are full of vegetation and they act as effective carbon dioxide sinks. They absorb carbon dioxide from the atmosphere and lock them in plant bodies, commonly known as carbon sequestration. Present estimates suggest that forests store about 652 billion tons of carbon in the form of plant materials. If deforestation or forest degradation is continued, there will be less utilisation of carbon dioxide, which would accumulate in the atmosphere. That is one aspect.

The other side of the problem is that these activities will result in release of carbon dioxide from the dead plant materials into the atmosphere. The dead plant materials are decomposed by decomposer organisms or burnt by people as fuel. In the process the carbon present in the dead organic matter gets converted into carbon dioxide which goes into the atmosphere. Present estimates are that about 80% of the atmospheric carbon dioxide comes from fossil fuel burning and 20% from forest degradation and destruction. Thus forests have the potential to act as source as well as sink for carbon dioxide. It is up to us how the forests will behave. With growing deforestation the role of forests as source of carbon dioxide will become more important. That is why the scientists concerned with climate change are emphasising on forest conservation and expansion, irrespective of where it is done.

Forests and fresh water availability

We know that about 2/3rd of the Earth's surface is covered by water. That is the reason that the Earth is also called "Blue Planet". But most of the water present on Earth is saline, containing high concentrations of salts, mainly sodium chloride. The saline water cannot be utilised by us or by most of the organisms living on land. For day–to-day needs, we as well as the other living organisms inhabiting the land need fresh water; i.e., water that is not saline. The important issue is that the quantity of fresh water on Earth is very small. Of all the water present on Earth only about 2.5% is fresh water; i.e., is not saline and can be directly consumed by us and most other organisms found on land. Next important issue is that all of it is not available for use. Only 1% of all the fresh water present on Earth is available for consumption. Rest is locked in glaciers, snow, and inside the rocks. This 1% is supposed to meet the requirements of

more than 7.1 billion people living on Earth and also of the other classes of organisms present on Earth outside the oceans. With time the requirements are bound to increase as the population will grow and also other activities will multiply.

It may be puzzling for many that although the fresh water sources are regularly exploited, they do not get exhausted. The reason is that nature replenishes it through precipitation. Fresh water sources receive water through different means of precipitation like rain, snow, hail, etc. No doubt, surface water bodies like rivers, streams, lakes, ponds, etc., provide fresh water to large numbers of people all over the world. But ground water is an important source of fresh water for large areas of Earth. Hence, the ground water has to be replenished regularly. Forests play important role in the replenishment process of ground water. When there is precipitation, the forests help in replenishing the soil moisture and underground water table by reducing the flow of water on the surface and providing better opportunity for the water to move downwards by percolation. Also, dead organic matters like leaves, fruits, and twigs etc., on the forest floors soak water and release the water slowly for much longer than the actual precipitation. That helps prolonged replenishment of the ground water reservoirs.

A stream coming down the Forest

Indirectly, the forests also reduce floods and water erosion of soil. Water moves out of the forest areas in reduced quantities and in a slow manner. Hence, possibilities of floods in areas receiving the precipitation water are reduced. Another feature is that in forest areas the rain drops falling down do not hit the ground directly. The drops come down after passing through the vegetation. Hence, their impact is much less and soil is protected against erosion. Roots of trees and other vegetation hold soil particles and do not allow them to be carried with rain water. That also protects soil against erosion. This is an important reason that water provided by forests is clean in terms of chemicals and sediments. In addition, there is evidence to suggest that cloud forests and older natural forests add to the net water flow of an area. Montane cloud forests are even better. Those forests can absorb moisture from the clouds and fog and release to catchment areas.

A shepherd returning back to his village with sheep and firewood

Thus forests have important role in the fresh water availability. Forests also play crucial role in bringing rains. They enrich the atmosphere with water vapour, moderate the temperature, and determine the wind quality. That explains why deforested areas become warmer and drier. In the long run these areas get converted into wasteland and finally into deserts. Forests help the soil in one more way. They add organic matter to soil as dead plants and leaves, fruits, branches, etc. Animals living in forests also add organic matter to soil in the form of shed body parts, defecations, dead bodies, etc. Finally, the organic matter is converted into humus, which improves soil quality and makes it more productive. Also, the humus-rich soils are more resistant to the impacts of rains, floods, storms, etc. They are not easily eroded.

Forests bring many benefits

As noted earlier, forests provide variety of resources. Well known among them are timber, firewood, forage, fruits, medicinal plants, nuts, seeds, gum, leaves, lacquer, etc. India has a very old tradition of use of medicinal plants and food obtained from forests. Experts say that we have about 8,000 types of medicinal plants. Almost 90% of the medicinal plants used in the country and also for export are obtained from the forests. In recent times their exploitation has increased substantially on account of rising demand resulting in large numbers of medicinal plant species becoming threatened.

Among the fruits obtained from the forests well known are jackfruit, wood apple, custard apple, tamarind, drumstick, gooseberry, guava, etc. Also, a variety of corms, rhizomes, nuts, and seeds are obtained from the forests. Honey is another important resource which is obtained from the forests. All these are used as food by large numbers of people living in the forests and in the vicinity of the forests. Also, large numbers of people earn their living by selling or bartering the materials obtained from the forests. Certain products obtained from the wild animals

Road in Himalayas. Destruction of forests & landslide

are also used as food by people living in and around the forests.

Forests provide opportunity for recreation and tourism as well. People visit forest areas for vacations, just to enjoy nature. Recreational activities associated with the forests include camping, fishing, hiking, sight-seeing, boating, cycling and bird watching. Such activities provide positive health benefits to participants, and also provide benefits, including financial rewards, to local communities as well as forest departments. With increasing urbanisation, the demand for outdoor recreational facilities is rising and the forests provide a good option. If a particular forest patch provides opportunities for easy sighting of wildlife, it has added advantage. But this advantage is often misused. Large numbers of tourist facilities are created inside the forests or on the fringe. As a result the forests and also the wildlife present there come under pressure due to constant human interference. Also, wastes are dumped in the forests, firewood and other resources are extracted illegally. Quite frequently there is excessive noise. These activities are detrimental to forests and the wildlife present there. We know that large numbers of foreign tourists visit India just to see the wildlife in Indian forests. Tigers, lions, elephants, deer, crocodiles, leopards, etc., are the major attractions. But we need to understand that if the forests and associated wildlife disappear, the attraction will vanish. As a result, the nation will lose huge amount of money and foreign exchange that they bring.

Continued deforestation – A serious issue

We know that the human race since its origin synchronised with nature and lived in the natural environment for most part of its history. Human race was just like any other organism fully dependent on nature as it existed. At a much later stage in its history the human race learnt to modify nature. The earliest activity in that direction was clearing of forests. The same was done to grow crops and for habitation. As discussed above, agriculture took its roots about 10,000 to 12,000 years ago. From then onwards the direct dependence of human race on forests declined and people started living outside the forests. In due course of time villages, towns and cities evolved.

A parallel development was industrialisation. An important consequence was that during last about two-and-a-half centuries, industrialisation and urbanisation became intense. Large chunks of land were needed for the development of industries and urban centres. Generally the land was obtained through clearing of forests. If agricultural land was used for these developments, a parallel process was started to convert forest lands into agricultural lands. After all, adequate food supply was essential and that was possible only with expansion of agriculture. These assumptions are adequately supported by the estimates which suggest that during the past 5,000 years deforestation has been to the tune of about 1.8 billion hectares. The trend continues even today.

More importantly, with growing urbanisation and industrialisation the speed of deforestation became faster. For example, during the past decade deforestation rate has reached to about 5.2 million hectares per year. Presently, forests occupy only about 31% of the land area on the Earth; i.e., about 4 billion hectares. In per capita terms it works out to about 0.6 hectares. The ideal situation demands that forests should occupy about 33% of the total land area of the Earth. But it is not so. Percentage-wise, Brazil has the highest forest cover, about 56 % of the land area; next is Democratic Republic of Congo with 52%; Indonesia has about 46.5% area under forests, and for Russia the figure works out to about 45.4%. In absolute terms, Russia has the highest area under forest cover, more than 800 million hectares, while Brazil has about 520 million hectares of forests. India stands at the tenth position with about 69 million hectares of forests. 69 million hectares is certainly on the lower side. But one positive feature is that on account of diverse environmental conditions, the country supports different types of forests with high level of biodiversity. For example, we have tropical evergreen, semi-evergreen, tropical moist deciduous, tropical dry deciduous and temperate forests. On account of the diverse nature the forests in India provide multiple types of products and services.

But we cannot forget that the per capita forest area in the country is only 0.06 hectares. This situation is on account of large population and the limited geographical area of the country. Just as a point of comparison, the geographical area of USA is three times that of India while the population is 1/4th of India. As a result, the population density of India works out to be 12 times that of USA. Obviously, the forests in the country are under immense pressure. The north-eastern region of India which includes

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Kamala Sohonie:
first Indian woman PhD in Science

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Gender bias is common throughout the world, especially in the field of science. But the situation in India was probably the worst at the time modern science education started in India, under British rule. There were a few social reformers who advocated for western science-based education for the women, but most of the political leaders at that time were against it. Even Mahata Gandhi was against educating women He said, "Man and woman are of equal rank but they are not identical. They are a peerless pair being supplementary to one another; each helps the other, so that without the one the existence of the other cannot be conceived, and therefore it follows as a necessary corollary from these facts that anything that will impair the status of either of them will involve the equal ruin of them both. In framing any scheme of women's education this cardinal truth must be constantly kept in mind." He further said, "To introduce English education in schools meant for women could only lead to prolonging our helplessness."

In spite of such adverse situation, there were a few Indian women who haddared to join in the arena of science and had established themselves. Most of them came from learned and established society, yet they had to face a lot of difficulties because they were women. Kamala Sohonie was one of them and was the first Indian woman to be awarded PhD from Cambridge University in Biochemistry.

Early life

Kamala was born and brought up in a well-educated family of Bombay (now Mumbai). His father Narayan Bhagavat and her uncle both had completed their graduation with chemistry honours from Bombay Presidency College. Her family members wanted to make her a scientist. Naturally, Kamala was inspired by them to take up science as her future carrier and guided by them seriously from her very childhood. As a result she completed her B.Sc. with Chemistry from

Kamala Sohonie

the Bombay Presidency College with the highest score. At that time Indian Institute of Science, Bangalore was a renowned scientific institution, headed by Prof. C. V. Raman who was the first Asian Nobel laureate in Physics. Most scientists and researchers wanted to join IISc, as it had a well-equipped laboratory. Naturally, Kamala wanted to join the institute because her dream was to be a successful scientist.

Kamala in Raman's Lab

Kamala's true struggle began after Raman denied her admission to IISc, though she had high marks in graduation, only because she was a girl. In spite of her father's requests Raman refused to admit her. But Kamala was made up of a different stuff. She asked Raman directly why girl candidates would not be allowed in his institution and challenged that she would complete the course with distinction. First day Raman ignored her but after much hesitation she was admitted, with a few conditions. The conditions were:

i) She will not be allowed as a regular candidate.
ii) She has to work late night as per instruction of her guide.
iii) She will not spoil the environment of the lab

Kamala was really hurt with that incidence. During a felicitation function in 1997, at BARC, organised by Indian Women Scientists' Association (IWSA) she publicly said, "Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. This was a great insult to me. The bias against women was so bad at that time. What can one expect if even a Nobel laureate behaves in such a manner?"

However, at IISc, she worked very hard under her teacher, Shri Sreenivasayya. He was very strict, demanding and at the same time eager to impart knowledge to deserving students. Here she worked on proteins in milk, pulses and legumes, which had important implications for nutritional practices in India. In 1936, Kamala was the only graduate student perhaps in the world working on pulse proteins. She submitted her research to Bombay University and received her MSc degree.

Kamala had successfully overcome her first battle. She got scholarship for doing research at Cambridge University in UK. She convinced Sir C.V. Raman through her devotion and hard work that a woman is also capable for research work. Next year onward, Raman's door opened for girl candidates too.

Kamala in Cambridge

At Cambridge University, Kamala first worked in the laboratory of Dr. Derik Richter who offered her a spare table to work during the day. When Dr. Richter left to work elsewhere, Kamala continued her work under Dr. Robin Hill, who was doing similar work, but on plant tissue.

While working on potatoes, she found that every cell of plant tissue also contains the enzyme "cytochrome C" and that cytochrome C is involved in oxidation

of all plant cells. This was an original discovery embracing the entire plant kingdom. As suggested by Hopkins, Kamala sent a short thesis describing her finding of cytochrome C in respiration of plant tissue to Cambridge University for her PhD degree. Her PhD degree was remarkable in many ways. Her research and writing of the thesis was done in less than 16 months since arriving at Cambridge. It consisted only of 40 typewritten pages. Those of others sometimes contained more than a thousand of pages. She was the first Indian woman "on whom the title of PhD degree in science was conferred".

Kamala Sohonie at Cambridge University

In this way Kamala spent joyful days at Cambridge, where all the teachers and friends were highly cooperative, and there was a good atmosphere for doing research. With her PhD degree she got the prestige which she really deserved.

Perhaps her Cambridge life was the golden period in Kamala's academic carrier. She got two scholarships. The first one was for research work with the Nobel Laureate, Prof. Fredrick Hopkins in the Sir William Dwan Institute of Biochemistry at Cambridge University. Here she worked in the areas of biological oxidation and reduction. The second scholarship was a travelling fellowship of the American Federation of University Women, when Kamala came in close contact with eminent scientists in Europe.

Kamala during her professional life

After her return to India in 1939 she joined Lady Hardinge Medical College, New Delhi, as professor and became head of the newly opened Department of Biochemistry. But most of the workers in the department were male. So she could not find good working atmosphere there.

Later she joined as Assistant Director of the Nutrition Research Lab, Coonoor. There she conducted important research on the effect of vitamins. She published a few scientific papers in many journals. However, due to lack of clear avenues for career advancement, she started thinking of resigning. Around this time, she received a proposal of marriage from M V. Sohonie, an actuary by profession. She accepted the proposal and moved to Mumbai in 1947.

The Government of Maharashtra invited applications for the post of Professor of Biochemistry in the newly opened Biochemistry Department at the (Royal) Institute of Science, Bombay. Kamala applied and was selected. During her tenure at the Institute of Science, she worked with her students on nutritional aspects of *neera* (also called sweet toddy or palm nectar), pulse and legume proteins as well as *dhan* (paddy) atta. All the subjects of her research were very much of relevance to Indian societal needs. In fact, her work on *neera* was started on a suggestion from the then President Dr Rajendra Prasad. Further, she also advised the administration of the Aarey Milk project on improving the quality. Research work conducted by her students showed that introduction of *neera* in the diet of tribal malnourished adolescent children and pregnant women caused significant improvement in their overall health. Kamala Sohonie received the Rashtrapati Award for this work.

Even at the Institute of Science, Bombay, she was kept away from her rightful position as Director of the Institute for four years. When finally she was given that post, Dr Derik Richter, her first guide at Cambridge, remarked that she "has made history by being the first lady Director of such a big science institute."

Other activities

Kamala Sohonie was the founder member of Consumer Guidance Society of India (CGSI), which was the earliest consumer's organisation in India, founded by nine women in 1966, and became the first to conduct formal product testing in 1977. CGSI followed various activities included testing the purity of food products, weights and measures used by shopkeepers and consumer protection in other forms. CGSI publishes a magazine, *Keemat*.

Kamala was also very popular science writer too. She published a good number of books in Marathi for the young students. Besides her science articles, she wore several papers on consumers rights and activities of the consumers.

Heroic end

Kamala Sohonie lived a full life. She was successful in her career – as a research scientist, teacher, social worker, science populariser and science writer. It was in 1998 when Dr Satyavati, the first woman DG of ICMR and Chairperson of Indian Council of Medical Research, learned of Kamala Sohonie and her work and decided to make amends. She invited Kamala, who was then 84, to felicitate her in an impressive ceremony in New Delhi. Ironically, at this ceremony, Kamala Sohonie collapsed. What better end could one wish for such a renowned personality?

Dhrubajyoti Chattopadhyay, Education Officer, North Bengal Science Centre, (National Council of Science Museums) Siliguri (West Bengal). Mainly engaged for popularization of Science and to inculcate scientific temperament among the students.

New eye to explore cosmic past

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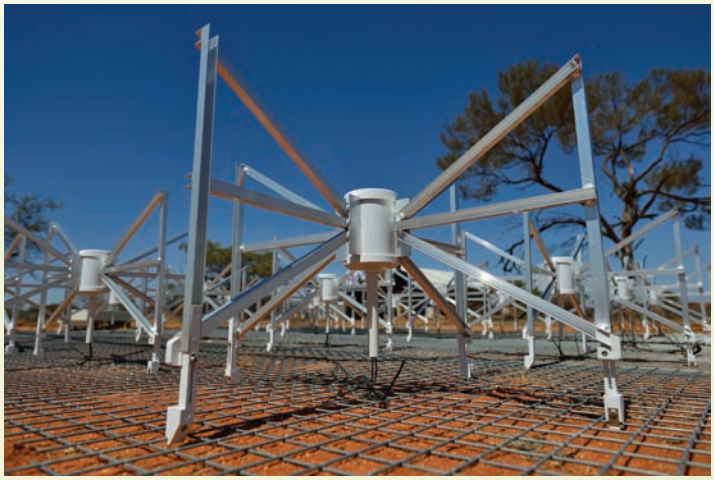
Astronomers the world over are constantly exploring new ways to peep into distant universe – exoplanets, black holes, exploding stars, galaxies, pulsars, Milky Ways and so on. Larger and more powerful telescopes–coupled with super-fast computing capacities are enabling new discoveries in astronomy. In this continuing effort, Indian radio astronomers have achieved a milestone with the commissioning of the powerful radio telescope called Murchison Widefield Array (MWA) in Australia, built by a collaboration of scientists from India, Australia, America and New Zealand. Scientists of the Bangalore-based Raman Research Institute (RRI) contributed significantly to the project by designing and building the digital receivers for the telescope. The MWA started operation on 8 July 2013.

Murchison Widefield Array (MWA) Aerial view (Credit, Dragonfly Media)

Radio telescopes help scientists in their research investigations by deciphering faint radio signals received from deep space. Since these signals are extremely weak by the time they reach Earth, radio telescopes have to be located in places where there is least radio frequency interference (RFI) from man-made sources. Even slightest of interference from FM radio or television broadcast signals could disrupt scientific calculations because these signals are very powerful compared to those coming from space. A cell phone signal, for instance, is several billion times more powerful than cosmic radio waves that radio telescopes can detect. In India, given the vast mobile phone networks, television and radio transmissions and other forms of wireless communication, there are hardly any locations where there is no electromagnetic pollution. That's why the new telescope has been set up in Murchison Shire in the Australian outback, far away from any human habitation. Just a handful of aboriginals belonging to the Wadjarri Yamatji groups inhabit this vast land.

As the name suggests, MWA is an array of antennas arranged as square 'tiles'. It consists of a total of 2,048 dual-polarisation wideband 'bow-tie-shaped' antennas that operate in the frequency range 80-330 MHz. They are arranged as 128 square 'tiles', each having 16 pairs of antennas. The antenna distribution is designed for precision imaging of a wide field of several hundred square degrees of the sky at any instant and over a wide frequency band. The antennas are connected to digital receivers, which process the data before transmitting it via high-speed fibre optic network to a centralised imaging system located 800 kilometres away at Perth.



MWA tile close up (Credit, Curtin University)

MWA Tile wide (Credit, Curtin University)

The Bangalore-based Raman Research Institute designed and built the digital receivers that take the signals from the

antennas and perform complex high-speed signal processing of the data prior to transmission to the central processing unit which computes the imaging information. The telescope is a result of international collaboration involving several funding agencies and research institutes. The Department of Science and Technology, which funds RRI, has supported building of the MWA. In addition, the Australia-India Strategic Research Fund is supporting collaboration between RRI and Australian teams. The completion of the MWA is a milestone towards the setting up of the Square Kilometre Array (SKA), a massive global project to build the world's largest radio telescope across Australia and South Africa. SKA is going to be the world's largest and most sensitive radio telescope ever built. As part of this project, thousands of linked radio wave receptors will be located in Australia and in Southern Africa. The signals from the antennas in each region will be combined to create a telescope with a collecting area equivalent to a dish with an area of about one square kilometre. The arrays of dish receptors will be located across eight African countries with the Karoo desert of South Africa acting as the central core region. Murchison will house a smaller array of dish receptors and an array of low frequency aperture arrays. SKA will be so sensitive that it will be able to detect even airport radar on a planet 50 light years away.

Outrigger tile at night (30 sec exposure, full moon) (Credit, Pete Wheeler, ICRAR)

The scientific goals of MWA are very interesting and important. "It will help humanity take the first exploratory steps into times in our cosmic history that have remained inaccessible to date. MWA will enable astronomers to glean insights into our own Milky Way and galaxies beyond, pulsating and exploding stellar objects, and the influence of the Sun on inter-planetary space weather close to the Earth," explained Prof Ravi Subrahmanyan, Director of the RRI.

"This telescope is an exciting and necessary part of the process of discovery and I see it as a step towards, if not the tool for, an important scientific breakthrough", feels Professor Brian Schmidt AC, joint winner of the Nobel Prize for Physics in 2011 and member of the advisory board for MWA. "For the first time, we will be able to look at the transformation of the universe from a rather boring environment of hydrogen and helium to the point where the stars, galaxies, and black holes create the vibrant Universe as we know it".

Silhouette (Credit, Natasha Hurley-WAlker, ICRAR)

The MWA has already begun gathering weak radio signals from deep space that will be analysed over the coming years by scientists at RRI and in the US and Australia using massively parallel computing systems.

Looking for a view of the birth of the first stars and galaxies almost 13 billion years ago – what astronomers refer to as the 'Cosmic Dawn' – is a long-term goal of astronomers who will be using the new telescope. The MWA will perform several surveys of the entire Southern sky and make extremely sensitive images of targeted regions. The data is expected to provide astronomers insights into the dramatic evolution experienced by the primordial cosmic gas as the first stars and galaxies formed in the early universe. MWA will image the intergalactic hydrogen gas surrounding early galaxies during the cosmological epoch of re-ionisation.

In addition, MWA data will help study structure of the gas in our Milky Way galaxy and of its magnetic field. It will also be able to pick up cosmic radio sources that are transient and periodic, which is a newly evolving field of research. High-speed digital signal processing capabilities and the ability to process stupendous data volumes will make such studies possible.

Another important aspect of the studies is the science of space weather that connects our Sun to the environment near the Earth. MWA will help detect and monitor massive solar storms which affect communication satellites, GPS navigation systems and other systems linked to the earth. The telescope will aim to identify trajectory of solar storms, which can help reduce the warning period currently provided by near-earth satellites. MWA research groups seek to observe and locate radio bursts on the Sun that lead to coronal mass ejections and then determine the density, velocity and magnetic fields of these ejections as well as the background heliosphere; and measure fluctuations in the earth's ionosphere during quiet and geomagnetically disturbed conditions.

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Birth of Modern Cosmology

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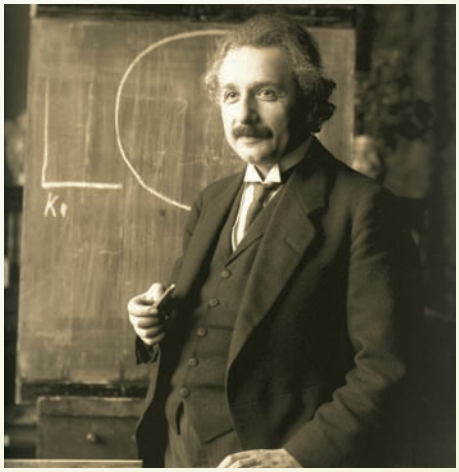
Today, each of us is aware of the vastness of the universe we live in. We know that our gigantic Earth is but only an average-sized planet in the solar system held together by a gigantic hot gaseous body called the Sun. The Sun again is but only an average-sized, average age, star in the vast Milky Way galaxy, which consists of 1,00,00,00,00,000 stars rotating around its centre. The Milky Way galaxy is again a member of a *cluster of galaxies* called *the local group*. Each cluster of galaxy consists, on an average, of about one thousand galaxies and the universe is a large conglomerate of clusters of galaxies. Thus the universe is very vast. But still a question that comes to one's mind sometimes is: How vast is this universe? Is the universe finite or infinite in size? Is the total mass content of the universe finite or infinite? A thinking person not yet introduced to modern cosmology will tend to believe in the second choice; i.e., the universe is perhaps infinite in size and that so is its mass content. For, if we take the universe to be finite, then the questions which immediately will arise are: What kind of boundary binds the universe and makes it finite? What lies beyond that boundary? Shouldn't we include the boundary and things lying beyond that in parts of the universe itself? Etc.

Is the average matter density of the universe a constant over time or it changes with time? Again, a thinking person unaware of modern cosmology will tend to believe that probably it remains constant over time, as did Einstein in 1917. We will discuss this matter later in the article. For now, let us note that Newtonian physics says nothing definite about the universe *as a whole*. It is only after the discovery of Einstein's general theory of relativity that it was possible to say something definite about the universe. This gave birth to modern cosmology: the science of the universe. (Earlier the universe had only been a subject of speculation!) The study was done by Einstein himself in the year 1917. Because of this, Einstein is regarded as the father of modern cosmology.

In 1905, Einstein formulated his special theory of relativity. In this theory, Einstein discovered that Newtonian mechanics is only an approximation to, but not the truth. Later, in 1907, Einstein discovered to his great surprise that Newton's gravitation theory too was only an approximation to truth! He found that Newton's theory of gravitation is inconsistent with his special relativity. (It is said that when Einstein told about this to his senior colleagues, he was advised not to talk of this as nobody would believe this!) This meant that either Newton's law of gravitation or his special relativity was correct but both could not be. But there were good reasons for his special relativity to be correct (They were precisely the same reasons which made Einstein propound the theory!) Then what is the correct theory of gravity? The path Einstein had to take to discover the correct theory of gravity was really far beyond the imaginations of the most imaginative physicists of the day. What Einstein discovered was that even his special relativity did not explain the universe. It was his then newly discovered theory of general relativity (1915) which really governed the universe.



Albert Einstein

General relativity

General relativity is essentially the new correct theory of gravity discovered by Einstein.(We are going to tell nothing about Einstein's special theory and only the barest minimum about general relativity here because that will take us too far from the story we are intending to tell here.)

One essential feature of Einstein's general relativity, to state in technical terms, is that its equations, unlike that of Newton's, are *nonlinear*. Because of this, the *principle of superposition* does *not* hold good for gravity in Einstein's theory. In non-technical language, the principle of superposition can be described as follows: In Newton's theory, if you find the gravitational field (gravitational force on a unit mass at various points in space) due to one body and that due to another, then, the field due to the two taken together is simply the *sum* (vector sum, to be exact) of the two fields. We say the principle of superposition holds good in Newton's gravitation theory. But in Einstein's theory, this is not so. To find the field due to two bodies, finding the fields due to the individual bodies and then adding does not do here. One has to solve the problem *ab initio* using Einstein's equations. (This last statement of ours which we made to explain the meaning of superposition should not be taken to mean that it is easy to find or people often do find the gravitational field due to two bodies. It is a very difficult problem and nobody has found or hopes to find the solution.)

In Newtonian gravity, the problem of finding the gravitational field due to the entire universe is not at all *different* from finding that due to individual bodies. That is to say, in Newton's theory, the field due to the entire universe will be simply the (vector) sum of the fields due to the individual stars and galaxies in the universe. But this is not so in Einstein's theory. To find the field due to the entire universe, one has to take the problem *ab initio*. Einstein could see here the rare possibility of telling something definite about the universe as a whole! So he attacked the problem in 1917.

To be able solve the problem of finding the gravitational field of the universe one must put as input the matter distribution in the universe in Einstein's equations. For matter distribution only decides the field. Now, who had the knowledge of the matter distribution in the universe at Einstein's time that Einstein could use? (For the reader's information, we may mention that the *galaxies* were not yet discovered in 1917. Galaxies had to wait for about a decade for their discovery by Hubble!) No data about the large-scale structure of the universe were

Edwin Hubble

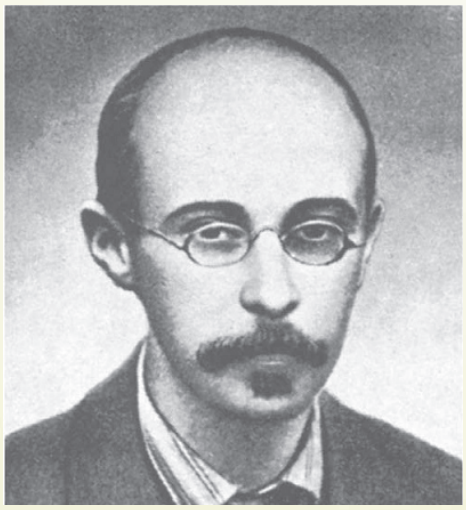
available at that time. Einstein had to make two reasonable assumptions about matter distribution in the universe in order to be able to proceed. The first one was regarding the density of matter in the universe. Does the density of the universe vary from *place to place*, or it is the same everywhere? This depends upon what scale we are talking about. If the scale is a mundane one, then the answer is obviously 'yes'. The densities of matter inside a mountain and in the atmosphere are obviously not the same. Seen on a scale of the extent of the solar system, or a star or a galaxy, the answer is will be in the affirmative. One did not know then what it is only on a cosmological scale. Einstein thought it reasonable to assume the density of matter in the universe on a cosmological scale to be constant everywhere (physicists now find this to be correct from many direct and indirect observations). For if one does not do that, then, one does not know what to do for it! On the other hand, even though the assumption may not be correct, use of it enables one to find for the first time a hint as to what a *physical theory* (general relativity) has to say about the *entire* universe!

Secondly, should one take the density of matter in the universe to be a constant *over time* or variable over time? Einstein took it to be a constant over time. We had said earlier that any thinking person will do so. Why? His/her reasoning will perhaps go like this: The universe has existed for an infinite period of time (perhaps!) and if the density of matter in it decreases or increases with time, by now it should have become either zero or infinite, both of which are absurd!

Einstein put the two assumptions mentioned above into his equations and looked for a solution. He found, to his utter surprise, that the theory did not admit any solution! A universe with a constant matter density everywhere and not varying with time is not possible! What could be at fault? Where might one have gone wrong? The assumption of matter density of the universe to be constant over time seemed so natural to Einstein that he did not doubt this assumption at all. Rather, he doubted his theory and its equations instead!

The original gravitational field equations taken by Einstein were the simplest ones but not the only possible ones. These have scope for modifications without loss of logic or beauty. So he took pains to modify the equations so that these admitted the so called *static* universe solution. Static universe means a universe having a matter density that remains constant and does not change over time. The modification [*see* box] he made was of such a nature that it did not affect the other characters of the theory.

Later, in 1921, Russian mathematician Alexander Friedman discovered that although Einstein's original theory does not admit a static universe, it *does* admit non-static universes. He found that, according to Einstein's original equations, the matter density of the universe should either increase or decrease but cannot remain constant over time. This implies that the universe should either be expanding or contracting!



Alexander Friedman

After about 7 years of Friedman's study, astronomer Edwin Hubble observationally discovered that the universe is indeed expanding. He found that distant galaxies are receding away from us at speeds proportional to their distances from us. The more distant a galaxy from us, the higher is its velocity of recession. This implies that the universe must be expanding. If an object expands, then every particle making up the object

Continued on page 21

The cosmological constant

The modification that Einstein had brought to his gravitational field equations in order to make them admit a static universe solution was adding a term called the 'cosmological constant' to the equations. Later on, he thought that it was unnecessary. A very important discovery made in the year 1998 has again restored the cosmological constant. Most cosmologists now find that the cosmological constant is necessary to describe the universe, though not to have a static universe. Thus the celebrated mathematical physicist Penrose says: "… there is the remarkable observational conclusion of 1998, now largely accepted by the community of cosmologists, that the *cosmological constant* that Einstein introduced in 1917, but which he subsequently withdrew as his "greatest mistake," actually has a small but significant (positive) value. This has the implication that the remote future of the universe will be an (unexpected) exponential expansion. This remains something of a puzzle to theoreticians, but it represents one of the many challenges to be faced by cosmologists in the future. It exemplifies the extraordinary richness that has been opened up by Einstein's fantastic world-view, by his general relativity, of a universe governed, up to its greatest scales, by four-dimensional curved space-time geometry.

What essentially the cosmological constant does is to bring about repulsion between masses so that the universe does not contract despite the gravitational attraction between masses and remains static. The discovery of 1998 that we mentioned earlier is that the rate of expansion of the universe is accelerating rather than slowing down with time. This is what is meant by the so-called "the accelerating universe". This has earned the Physics Nobel Prize for 2011 to the discoverers Saul Perlmutter, Brian Schmidt and Adam G. Riess. The expansion of the universe is accelerating means there is some sort of repulsion amongst the galaxies. This has given rise to the concept of "dark energy".

Herpes zoster
Return of the Virus

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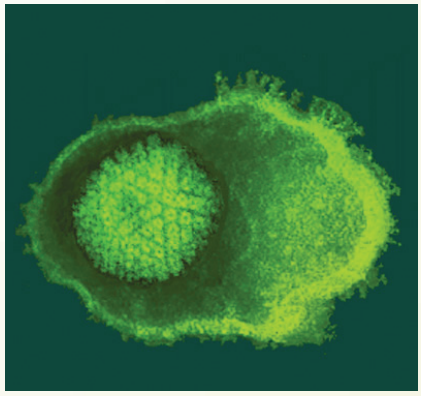
Herpes zoster—also known as shingles—is a viral infection that causes a painful rash. Although shingles can occur anywhere on your body, it most often appears as a single stripe of blisters that wraps around either the left or the right side of your torso.

While it isn't a life-threatening condition, shingles can be terribly painful. Vaccines can help reduce the risk of shingles, while early treatment can help shorten a shingles infection and lessen the chance of complications.



What causes shingles?

Shingles is caused by the *varicella zoster* virus — the same virus that causes chickenpox. Anyone who's had chickenpox may develop shingles. After you recover from chickenpox, the virus can enter your nervous system and lie dormant for years. Eventually—sometimes after many decades, it may reactivate and travel along nerve pathways to your skin — to return as shingles.

The reason for the encore is unclear. But it may be due to lowered immunity to infections as you grow older. Shingles is more common in older adults and in people who have weak immune systems.

What may increase your risk?

Factors that may increase your risk of developing shingles include:

Age

Shingles is most common in people older than 50. The risk increases with age. Some experts estimate that half the people who live to the age of 85 will experience shingles at some point in their lives.

Diseases

Diseases that weaken your immune system, such as HIV/AIDS and cancer, can increase your risk of shingles.

Cancer treatments

Undergoing radiation or chemotherapy can lower your resistance to diseases and may trigger shingles.

Medications

Drugs designed to prevent rejection of transplanted organs can increase your risk of shingles — as can prolonged use of steroids, such as prednisone.

Not the same virus that causes genital herpes

Varicella zoster is part of a group of viruses called herpes viruses, which includes the viruses that cause cold sores and genital herpes. For this reason, shingles is also known as herpes zoster. But the virus that causes chickenpox and shingles is not the same virus responsible for cold sores or genital herpes, a sexually transmitted infection.

Are you contagious?

A person with shingles can pass the varicella zoster virus to anyone who isn't immune to chickenpox. This usually occurs through direct contact with the open sores of the shingles rash. Once infected, the person will develop chickenpox, however, not shingles.

Chickenpox can be dangerous for some groups of people. Until your shingles blisters form dry scab, you are contagious and should avoid physical contact with:

- Newborns
- Pregnant women
- Anyone who has a weak immune system

Preventive care

You must therefore avoid physical contact with others, especially with newborn babies, pregnant women and people with weak bodily defense. Chickenpox in these people can be deadly.

Recognizing the signs

The signs and symptoms of shingles usually affect only a small section of one side of your body. These signs and symptoms may include:

- Pain, burning, numbness or tingling
- A red rash that begins a few days after the pain
- Fluid-filled blisters that break open and crust over
- Itching

Some people also experience:

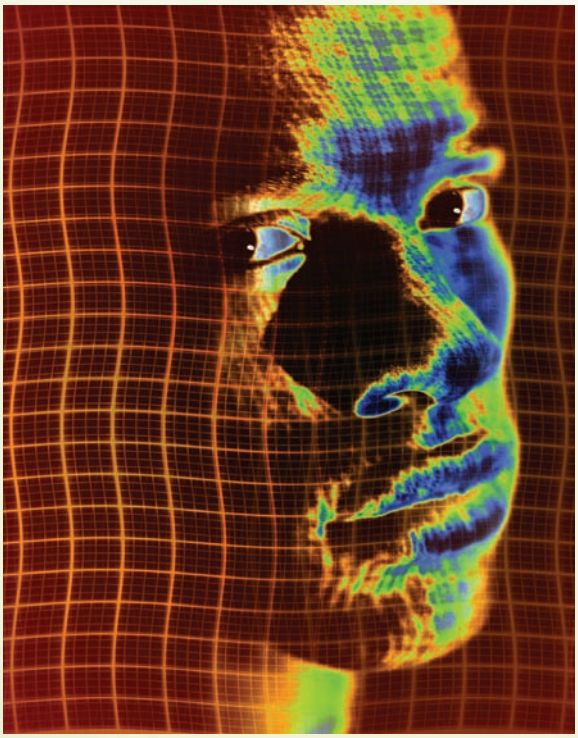
- Fever and chills
- General achiness
- Headache
- Fatigue

Pain is usually the first symptom of shingles. For some, it can be intense. Depending on the location of the pain, it can sometimes be mistaken for a symptom of problems affecting the heart, lungs or kidneys. Some people experience shingles pain without ever developing the rash.

Classically, the pain is limited to a specific area, either the left or right side of your torso or face. The pain occurs as the virus spreads along one of the nerves that spread outward in a band-like pattern from your spine or on the face. This pain or tingling can persist sometimes for days or weeks.

The shingles rash develops as a band or stripe of blisters. It may spread over the next three to five days, often forming a band-like pattern on one side of your torso. Sometimes the shingles rash occurs around one eye or on one side of the neck or face. The blisters usually dry up in a few days, forming crusts that fall off over the next two to four weeks. They may leave scars.

Some people have such mild symptoms of shingles that they don't seek medical treatment. At the other extreme, severe symptoms may result in a visit to the emergency room.



When to see a doctor

Contact your doctor promptly if you suspect shingles, but especially in the following situations:

- The pain and rash occur near your eyes. If left untreated, this infection can lead to permanent eye damage.
- The rash is widespread and painful.
- You're 60 or older, which increases your risk of complications.
- You or someone in your family has a weakened immune system due to cancer, medications or a chronic medical condition.

What to expect from your doctor

You may see your family doctor or a skin specialist. S/he will examine your rash and may ask you a few questions. The diagnosis is usually based on the history, which is classical, along with the telltale rash and blisters. If in doubt, and that's rare, your doctor may take a tissue scraping or culture of the blisters for examination in the laboratory.

There's no cure for shingles, but prompt treatment with prescription antiviral drugs can speed healing and reduce your risk of complications. So if you think you may have shingles, see your doctor right away. Starting any one of the following antiviral medicine right away can help your rash heal faster:

- Acyclovir (Zovirax)
- Valacyclovir (Valtrex)
- Famciclovir (Famvir)

Some people suffer severe pain due to shingles; they may benefit with the following prescription pills:

- Anticonvulsants, such as gabapentin
- Tricyclic antidepressants, such as amitriptyline
- Numbing agents, such as lidocaine, delivered via a cream, gel, spray or skin patch
- Medications that contain narcotics, such as codeine

What You Can Do

Should you be stranded in a place where you can't find a doctor, you may try and find relief with the following:

- Taking a cool bath or using cool, wet compresses on your blisters may help relieve the itching and pain.
- Applying a soothing lotion such as calamine lotion on your blisters.
- Swallowing over-the-counter pain relievers like paracetamol to alleviate pain. Over-the-counter analgesic creams also may alleviate your pain.

Complications from shingles

A few patients may develop complications as a sequel to shingles. They may experience:

Post-herpetic neuralgia

In some 50 per cent people with herpes who are older than 60, shingles pain continues long after the blisters have cleared. This condition is known as post-herpetic neuralgia, and it occurs when damaged nerve fibers send confused and exaggerated messages of pain from your skin to your brain. Such people may benefit with anticonvulsant medications like gabapentin, analgesic pills, acupuncture, and tricyclic antidepressants. Most people become free of pain within the next six months to five years. In a rare severe case, neurosurgery may have to be done.

Vision loss

Shingles in or around an eye (ophthalmic shingles) can cause painful eye infections that may result in vision loss. This calls for immediate help from an ophthalmologist.

Neurological problems

Depending on which nerves are affected, shingles can cause an inflammation of the brain (encephalitis), facial paralysis, or hearing or balance problems.

Skin infections

If shingles blisters aren't properly treated, bacterial skin infections may develop.

Vaccines

Two vaccines may help prevent shingles — the chickenpox (varicella) vaccine and the shingles (varicella zoster) vaccine.

Chickenpox vaccine

The varicella vaccine (Varivax) has become a routine part of childhood immunization to prevent chickenpox. The vaccine is also recommended for adults who've never had chickenpox. Though the vaccine doesn't guarantee you won't get chickenpox or shingles, it can reduce your chances of complications and reduce the severity of the disease.

Shingles vaccine

The US Food and Drug Administration has approved the use of the varicella zoster vaccine (Zostavax) for adults age 50 and older. Like the chickenpox vaccine, the shingles vaccine doesn't guarantee you won't get shingles. But this vaccine will likely reduce the course and severity of the disease and reduce your risk of post-herpetic neuralgia.

The shingles vaccine is used only as a prevention strategy, however. It is not intended to treat people who currently have the disease. The vaccine contains live virus and should not be given to people who have weakened immune systems.

Continued from page 35 (**Why forests are important for our survival?**)

Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura accounts for about 25% of the country's total forest cover. However, forests in those areas are under constant pressure on account of various factors, including the prevalent agriculture system in the area and lack of overall development in the region. *Jhum* (slash and burn) agriculture has been practised in the area for centuries. However, in recent past the *Jhum* cycle has become shorter resulting in destruction of forests. Also, unstable law and order situation contributes in its own way in bringing pressure on the forests in the area.

A positive development in the country is that trees are being grown outside forests in large areas. In recent years the areas under trees have grown substantially, totalling more than nine million hectares. Obviously, they form a major source of timber, pulp, forage, fuel-wood and other similar products, which were earlier obtained from the forests. The trees are helping in their own way in reducing the pressure from the forests. Quite often the farmers select trees which can grow with normal crops in the same areas without substantially interfering with the crops. Thus the trees provide additional income to the farmers.

Conclusion

Continued deforestation is a matter of grave concern, for the entire world and more so for India. On account of deforestation several types of problems are there. Important among them are the increase in greenhouse gases, rising Earth's temperature, changes in climate and weather in different areas, loss of biodiversity, frequent floods, soil erosion, loss of productivity, etc. Indian forests have been victims of serious deforestation. At the beginning of the 20th century 40% of country's area was under high-quality forests. At present, only about 23% of the area is classified as forests and only 50% of the forests are in good health. Rest is degraded forests or only on paper.

We must remember that India has very old tradition of reverence for forests. The Bishnoi community struggled against the ruler of Jodhpur for protection of forests in 18th century. Several people were killed but the forests were protected. A similar movement was launched in the Himalayas in 1973, the 'Chipko' movement. Women took active role in the protest and saved the forests. We know that in colonial time deforestation was done on large scale. Most intense timber exploitation was done between 1850 and 1920. About 33 million hectares of high-quality forests were cleared. During that period we were under alien rule. The tragedy is that the trend continued even after Independence. Forest land has been diverted regularly for other uses. The 1988 National Forest Policy targeted 33% of land under forest cover. In 2002 the Policy was revised and 2012 was identified as the year to achieve the goal. But at present we have only about 23.7% of the land area with forests and not all of it is good forest.

Recent floods and landslides in Uttarakhand and Himachal Pradesh have devastated large areas with heavy loss of life and property. There could be many reasons for the tragedy. But one reason is certainly the devastation of the forest areas in the mountains. The forest cover in the hilly areas is only 38.77% against the goal of 66%. Expanding agriculture and urbanisation are the main factors. Some ray of hope is there in the tribal belts. There the forest cover is substantially high. These areas account for 60.04% of the total forest cover of the country although the tribal areas constitute only 33.6% of the total land of the country.

A positive (if we can call it so) development in recent years is that the danger of Climate Change has come as real. Earlier, climate scientists were discussing ways and means to halt the rise in Earth's average temperature. Now they are discussing possible ways to stop the rise at about 2°C till the year 2040. There are apprehensions that the temperature may rise by 4°C in near future. Obviously, that will be catastrophic. Most of the nations are doing something to counter the imminent threat. India has launched the ambitious National Action Plan on Climate Change. Prime Minister of India is personally interested in the success of the Plan. One of the major components of the Plan is "Green India Mission". The aim is to increase forest or tree cover by about five million hectares and to improve the quality of forests in additional five million hectares. If the goal is achieved, certainly the forests in the country will improve and those dependent or associated with the forests will also be benefitted.

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Recent developments in science and technology

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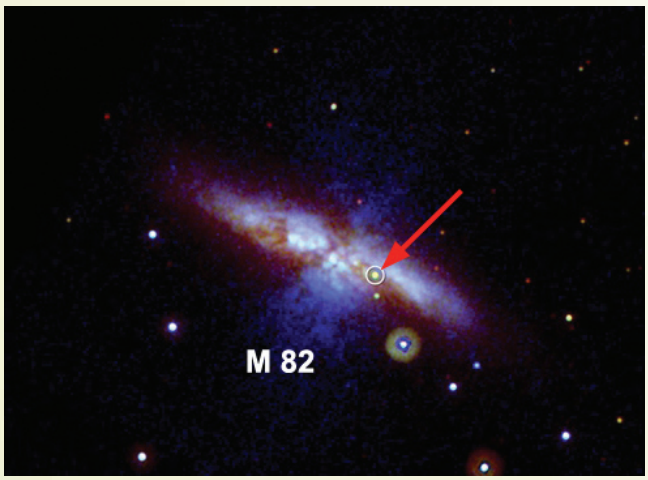
Bright supernova discovered

The stars in the night sky look permanent, but they are not. Stars are born from giant gas clouds and they also die. Some stars die violent deaths when they explode and brighten up millions of times, becoming a supernova. Supernovas are rare occurrences and when one is found astronomers get excited.



The galaxy M82 showing supernova 2014J (red arrow) (Credit: UCL/University of London Observatory)

The latest discovery came on 21 January during a routine observation of the galaxy M82 (also known as the Cigar Galaxy), about 11.4 million light years away. M82 can be seen towards the north-east of the Big Dipper in the northern sky. The supernova was discovered by S.J. Fossey and his astronomy students at University College London using a 35-cm amateur telescope. It was a serendipitous discovery. Noticing that clouds were rapidly closing in, Dr. Fossey decided to skip the formal introduction and simply show the students how a CCD camera is used to image a celestial object. The students chose M82, a galaxy which is an interesting galaxy in the northern skies. Ten minutes later, the group had discovered the new supernova. It was sheer luck!

Designated as SN 2014J, the newly discovered supernova is one of the brightest supernovae seen from Earth since a monster exploded in 1987 just 168,000 light years away in the Large Magellanic Cloud. The new supernova reached its peak brightness of magnitude 10.6 in the first week of February 2014. Said to be the brightest of its kind observed since 1987, it was bright enough to be seen in small telescopes or perhaps in large binoculars. Astronomers the world over quickly recorded spectral information that showed 2014J to be a Type-Ia supernova, which may help reveal how such supernovae form.

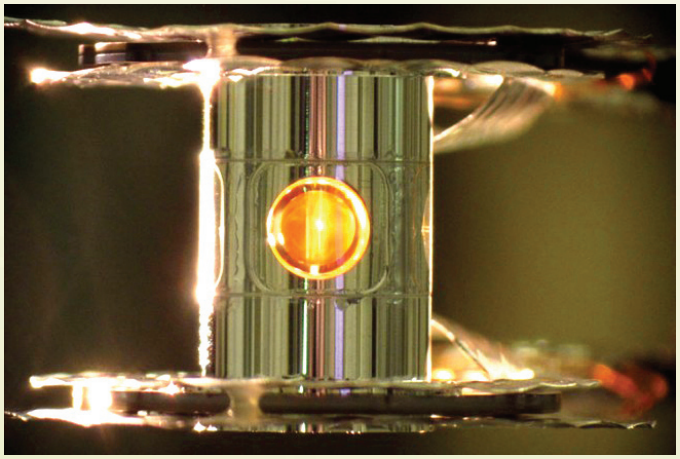
Astronomers classify supernovas broadly into two categories called Type I and Type II. A Type I supernova results when a super-dense white dwarf, a star mainly composed of carbon and oxygen, only about the size of Earth but with the gravitational power of a Sun-sized star, pulls hydrogen gas from a nearby companion star down to its surface where it adds to the star's mass. As soon as the white dwarf's mass exceeds 1.44 times the Sun's mass, also known as 'Chandrasekhar Limit', a runaway nuclear reaction ignites and the white dwarf explodes as a supernova. On the other hand a Type II supernova occurs when a massive star runs out of nuclear fuel and collapses under its own gravity and rebounds explosively. The supernova observed in 1987 was a Type II supernova.

Astronomers use Type 1a supernovas as "standard candles" to measure cosmic distances because all are thought to blaze with equal brightness at their peaks. Moreover, because these supernovae are used as cosmic measuring sticks, understanding them better may help clarify the shape of the universe. SN 2014J was quite a bright supernova and offered amateur astronomers around the world a unique opportunity to look at the explosive death of a star.

US scientists achieve breakthrough in nuclear fusion

There are basically two ways in which nuclear energy can be generated – nuclear fission and nuclear fusion. In nuclear fission a heavy unstable nucleus like uranium or plutonium breaks up when hit by neutrons, releasing tremendous amounts of energy according to Einstein's famous equation $E = mc^2$ where E is the energy liberated, m the mass converted into energy, and c the velocity of light – 300,000 km/s. Fission reaction can be uncontrolled, as in a nuclear bomb, or it can be controlled, as in a nuclear reactor.

Unlike coal- or gas-based power stations, power generation using nuclear fission does not release greenhouse gases, which is a growing environmental problem today. But it leaves behind radioactive waste that poses radiation threat unless handled and stored safely. But nuclear fusion is clean – the only product it leaves behind is harmless helium gas, although the reactor in which the fusion reaction takes place becomes radioactive. Another advantage of power generation by nuclear fusion is that the fuel – hydrogen – is available in plenty in water and more than 70% of the Earth's surface is covered with water. So if it can be controlled,



A metallic case called a 'hohlraum' holds the fuel capsule for the NIF experiments (Credit: Eduard Dewald/LLNL)

nuclear fusion promises availability of almost unlimited clean energy.

The incredible energy of the Sun comes from nuclear fusion in which hydrogen nuclei are being constantly turned into helium nuclei. On Earth, the hydrogen bomb also uses hydrogen fusion. However, despite efforts of several decades, controlled nuclear fusion has remained a distant dream.

The main problem in making a fusion reactor is the extremely high temperature involved – of the order of 100 million degrees Celsius or more, required to start the fusion reaction. It is impossible to hold plasma (ionised gases) at this high temperature as no solid material can withstand such high temperatures. In a fusion reactor, the right pressures and temperatures are created by taking ionised plasma of the hydrogen isotopes deuterium or tritium and squeezing it using magnetic fields or lasers to set off the reaction. The process requires huge amounts of energy to heat the plasma to extremely high temperatures.

Early research on nuclear fusion mainly focussed on confining the plasma using magnetic fields in devices called the Tokamak in which a doughnut-shaped, powerful magnetic field is used to contain the hot plasma without touching the walls of the container. But the Tokamak consumed more energy to trigger the nuclear fusion than it could generate and could not make much headway. Meanwhile an important international magnetic fusion scheme, the $20-billion International Thermonuclear Experimental Reactor (ITER) project in which India is a major collaborator, is under construction in France and is expected to start operation in 2019. The ITER has been designed to produce 500 megawatts of output power. Experiments to study laser triggering of nuclear fusion started in the 1970s, also without much success.

Now a new breakthrough has been announced that can be considered a big step forward towards taming nuclear fusion for power generation. Scientists of the National Ignition Facility (NIF) of the Lawrence Livermore National Laboratory in California, USA, for the first time have managed to release more energy than was required to trigger the fusion reaction. They were able to reach the "ignition" point, where the energy released by the reactor was greater than what was put into it, making the reaction becomes self-sustaining. They did this by using the world's most powerful laser barrage to produce a controlled fusion reaction. The scientists focussed 192 powerful laser beams on a tiny pellet of nuclear fuel containing the hydrogen isotopes deuterium and tritium and were able to extract more energy from the fuel than was put into it (*Nature*, 12 February 2014 | doi:10.1038/nature13008).

Despite this success, currently the experiment is only able to produce of net gain of about one per cent. More work needs to be done and physics problems need to be addressed before controlled fusion can be used for power generation. But some scientists, like Stewart Prager, Director of the Princeton Plasma Physics Laboratory in USA, are hopeful that "in 30 years, we will have electricity on the grid produced by fusion energy."

Hookworm genome decoded

Researchers at Washington University School of Medicine in St. Louis, USA, have decoded the genome of the hookworm, *Necator americanus*, the most common source of soil-borne parasitic infection in humans. Hookworm is a parasitic roundworm of the small intestine that is transmitted through contaminated soil. When hookworm eggs are passed in human faeces, they are shed into the surrounding environment, where the eggs hatch and the worms penetrate through the skin of exposed individuals, especial through feet while walking barefoot. Hookworm infections afflict an estimated 700 million of the world's poor. The disease is also widespread in certain parts of India.

The parasitic worm lives in the soil and enters the body through the feet. After entering the body, hookworms live in the small intestine and feed on blood, causing anaemia and, in children, stunted growth and learning problems. In pregnant women, the worm can cause severe anaemia, leading to maternal deaths and low birth weights that contribute to new-born deaths.

As part of the new research, the scientists tried to understand different aspects of how the hookworm enters the body, feeds on the blood and evades the host's immune system. They mapped the DNA sequence of the hookworm, identifying genes that are responsible for the hookworm's infection of humans and other warm-blooded animals. They also studied genes involved in blood feeding and the worm's life cycle, as well as potential new drug targets (*Nature Genetics*, 19 January 2014 | doi: 10.1038/ng.2875).

As part of their research, the scientists also identified a group of molecules that appears to protect the worm from detection by the host's immune system. As it turned out, hookworms evade detection by the body's immune system by suppressing molecules that promote inflammation. According to the scientists, this same approach may prove valuable in the treatment of autoimmune disorders such as multiple sclerosis, rheumatoid arthritis, pernicious anaemia, Type I diabetes, and many others.

Present therapy of hookworm infection relies mainly on mass treatment with the drug albendazole, but its repeated and excessive use is leading to treatment failures and drug resistance. Decoding of the hookworm genome may help in finding clues to how it infects and survives in humans and to aid in development of new therapies to combat hookworm disease. According to the researchers, the

An estimated 576 to 740 million people worldwide are infected with hookworm, Necator americanus, *according to the Centers for Disease Control and Prevention.*

new research can be used as a springboard not just to control hookworm infections but also to identify anti-inflammatory molecules that have the potential to advance new therapies for autoimmune and allergic diseases.

Why birds fly in 'V' formation explained

Bird flight has been a matter of much research. One particular behaviour of birds, especially migratory birds, that has intrigued ornithologists is their habit of flying in formation during migration. Most migratory birds fly in a 'V' formation, also seen in aircraft flying in formation. Why birds fly in a V formation was a matter of much speculation, with bird intelligence considered to be a key factor, but no evidence was available. Now research has shown that it is indeed so. A recent study has found that migrating birds flying in formation display aviation skills that "dwarf those of human pilots" (*Nature* 16 January 2014 | doi:10.1038/nature12939). The study carried out with birds called ibises by researchers at the Royal Veterinary College of the University of London in UK showed that these big-winged birds carefully position their wingtips and synchronise their flapping, "presumably to catch the preceding bird's updraft – and save energy during flight". The V formation helps them fly more efficiently, staying aloft while expending as little energy as possible. The tiny adjustments to turbulence and each other's positions that birds can make during migrations is far more complex than scientists first realised, the study has found. It has been known that squadrons of planes can save fuel by flying in a V formation, and the new study proves that migrating birds do the same.

The researchers used a microlight plane to guide hand-raised birds to their ancestral migration route from Austria to Italy and studied their course using the latest navigational tools. The birds were studied as they flew alongside the microlight. A flock of 14 juvenile ibises carried data loggers (electronic devices that record data over time) specially built in the lab. The device's GPS determined each bird's flight position to within 30 centimetres, and an accelerometer showed the timing of the wing flaps. Thus the instruments not only tracked their position and speed but also measured every flap of their wings.

From the study of the collected data the researchers discovered that the birds could precisely time the flapping of their wings and adjust their position to make the best of the subtle effects of air turbulence. Each bird took advantage of upward flow of air thrown up by the wings of the flyer in front while avoiding the downward flow of air that would cancel the lift. According to the researchers, "The intricate mechanisms involved in V-formation flight indicate remarkable awareness and ability of birds to respond to the wing path of nearby flock-mates." However, how the birds monitor and react to such complex flight dynamics without the aid of a computer remains a mystery.

New research shows that migrating birds precisely time when they flap their wings and position themselves to make the best of the turbulence produced as a result of flapping of wings.

VP website

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Dream 2047

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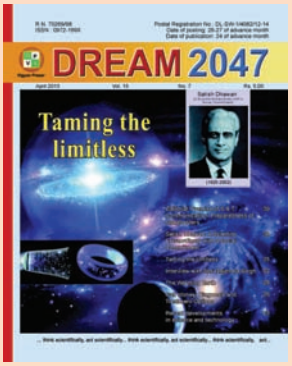

Rashtriya Vigyan Chalchitra Mela and Competition (RVCM) 2014

The fourth National Science Film Festival was organised by Vigyan Prasar in collaboration with National Council of Science Museums (NCSM) at Visvesvaraya Industrial and Technological Museum, Bengaluru from 29 January to 2 February 2014. The competition was also joined for the second time by Open Source Drug Discovery (OSDD) of Council of Scientific and Industrial Research (CSIR) New Delhi for a competition of short video on 'Need of new drug for tuberculosis (TB)' through uploading on YouTube.

The competition had the four categories; (a) Popular science films (duration more than 20 m), (b) Short films on science and technology (duration less than 20 m), (c) Animation/Graphics/Special Effect Film on Science and Technology, and (d) Science & Technology Film made by Student(s). The competition attracted outstanding S&T video film producers of the country. There was overwhelming response to the film festival with 105 entries in all. Out of these, 11 entries in the 'Popular science films'; 12 in 'Short film on science and technology'; five in 'Animation/Graphics/Special Effect Film on Science and Technology' category; and six in 'Science & Technology Film made by Student(s)' category were shortlisted. One of the attractions of the festival was the screening of a film made by young film makers from class VI to IX students of K.R. Mangalam School from Gurgaon. For short video competition on tuberculosis, there were a total of 52 entries of which 24 were shortlisted for screening.

The national jury comprising of prominent personalities from film industry, film recognition authorities, and science communicators from different parts of India selected the winners in different categories. The jury was headed by Mr M. Nasser, eminent personality from film industry. The other members were Mr V. Packirisamy, Regional Officer at Censor Board of Film Certification, Chennai; Mr. Indranil Bhattacharya, Film and Television Institute of India, Pune; Mr. M. Elango, Deputy Director General, Films Division, Bengaluru; Prof. Bindu Bhaskar, Asian College of Journalism, Chennai; Mrs. Kshama Sharma, well-known writer and editor of *Nandan* magazine Delhi; and Dr Arvind C. Ranade, Scientist 'E' Vigyan Prasar.

The Science Film Festival was inaugurated on 29 January 2014 by Prof. Prajval Shastri of Indian Institute of Astrophysics, Mr. K.G. Kumar, Director, Visvesvaraya Industrial and Technological Museum, and Dr. S. Mahanti, Senior Scientist, Vigyan Prasar.

The morning sessions from 29 January to 1 February were devoted to workshops, plenary talks and panel discussions on *Making of Science Documentary Films in India.* Amateur film makers got an insight into the issues related to film making from renowned speakers and panelists including Mr. Nandan Kudhyadi, science film maker from Pune, Dr Mohan Kumar, faculty at Centre for Development of Imaging Technology, Thiruvananthapuram, Mr. K.P. Madhu from Indian Institute of Science Education, Pune, Mr. Sivakumar Mohanan, science film maker, Chennai, Mr. V. Packriswamy from CBFC and Mr. Indranil Bhattachrya from FTII. The post-lunch sessions were reserved for the public screening of shortlisted films. Most of the time auditorium was full, showing the popularity of the science films in public. Short videos of OSDD-CSIR-VP-NCSM competition were screened on 1 February 2014. Dr. T.S. Balganesh, Head, CSIR OSDD Research Unit and Dr. U.C.J. Jaleel, OSDD-CSIR were present for the screening.

The much awaited award presentation ceremony was held on 2 February 2014 in the Main Auditorium of VITM. The Guest of Honour was the prominent film maker Mr. Nasser, and the Chief Guest was Mr. Sudhakar Rao, Former Chief Secretary of Karnataka.

The award winners

Category: 'Popular science films'

'Golden Beaver Award'
Film : 'The Quantum Indians'
Film Director: Mr. Raja Choudhary, New Delhi
Producer: Rajiv Malhotra

'Silver Beaver Award'
Film : 'Chilika-Jewel of Odisha'
Film Director & Producer: Mr. Shekar Dattatri, Chennai

'Bronze Beaver Award'
Film Title : 'Does the Higgs Boson Exists!'
Film Director: Mr. Rajendra Kondapalli, Pulse Media Pvt Ltd, New Delhi
Producer: Vigyan Prasar

Category: 'Short films on science & technology'

'Golden Beaver Award'
Film : 'Stem Cell Therapy for Rejuvenation of Cornea'
Film Director: Rajendra Kondapalli, Pulse Media Pvt Ltd
Producer: Vigyan Prasar

'Silver Beaver Award'
Film: 'True Survivor – Horse shoe Crab'
Film Director: Mr. J.A. Sanjeev Kumar, Pondicherry
Producer: Centre for Electronics Media, Pondicherry University, Pondicherry

'Bronze Beaver Award'
Film : 'Mobile Solar Power'
Film Director: Mr. S. Balamurugan, Pondicherry
Producer: Centre for Electronics Media, Pondicherry University, Pondicherry

Category: 'Animation/Graphics/Special Effect Film on Science and Technology

'Golden Beaver Award'
Film : 'Delhi Safari'
Film Director: Mr. Nikhil Advani, Mumbai
Producer: Mr. Kishore Patil & Mrs. Anupama Patil, Pune

'Silver Beaver Award'
Film : 'Dolly Obesity'
Film Director: Mr. Madhu KS, Hibiscus Digital Media
Producer: Dr. KT Sreelatha Kumari, Thiruvanantapuram

'Bronze Beaver Award'
Film : 'Ocean or Plocean'
Film Director: Mr. Aji Kumar, Kochi
Producer: Monsoon Productions, Kochi

Category: 'Science & Technology Film made by Student/(S)

'Golden Beaver Award'
Film : 'Prism'
Film Director & Producer: Mr. Sandip P Mane, Pune

'Silver Beaver Award'
Film : 'Head in the Stars'
Film Director: Mr. Raghu Kalra, New Delhi
Producer: AJK Mass Communication Research Centre, Jamia Milia Islamia University, New Delhi

'Bronze Beaver Award'
Film : 'Painful Smiles'
Film Director: Ms. Harmeet Kaur and Mr. Harjit Singh, Punjab
Producer: Department of Journalism & Mass communication, Punjabi University

Special Jury Award
Film : 'Maths for Sum or Maths for All'
Film Director: Ms. Chandita Mukharjee, Mumbai
Producer: Comet Media Foundations, Mumbai

OSDD-CSIR-VP-NCSM short video competition

Consolation prizes (Rs. 10.000/) were given to the following individuals:

1. Ms. Neha Gandhi
2. Ms. PriyankaTiwari
3. Dr. Nidhi Sharma
4. Mr. Deepak K Lokwani
5. Mr. Sameer JavidWani
6. Mr. RakeshAndania
7. Dr. JagdaeeshPillai
8. Dr. Parvez Imam

Continued from page 29

(Birth of Modern Cosmology)

will see that other particles making up the object are moving away from it with speeds proportional to their distances from it! Thus the implication of Einstein's general relativity discovered by Friedman that the universe should either be expanding or contracting turned out to be correct! The *first* prediction about the *entire* universe made by a physical theory came out to be correct! (When Einstein became aware of this, he is reported to have described his act of modifying his original equations to get a static universe solution to be the "the greatest blunder" of his life.) Thus took birth cosmology: the science of the universe! The universe became an object of scientific study which was previously only an object of speculation!

Cosmology

Now, as is well known, cosmology is a vast branch of physics having several sub-branches! A large body of knowledge about the universe has been discovered since time of Friedman and Hubble. A large number of cosmologists are busy studying observationally as well as theoretically various aspects of the universe! The Nobel Prize for physics for 2011 has gone to three cosmologists.

Modern cosmology has a *standard* model for the origin and evolution of the universe. Cosmologists use this model to study various aspects of the universe and make predictions. Each of their predictions has so far turned out to be correct. Of course, modern cosmology has many unsolved problems and riddles. But that happens to most branches of science!

It is an amazing and awe-inspiring fact that man, studying a small part of the universe, can make predictions about the entire universe and the predictions turn out to be correct! Those philosophically oriented ask: What are knowable and what are unknowable to man, then? Are there categories of knowable and unknowable for man? Or, will a time come when man will know *everything*? Will the ultimate mystery of existence be solved some day? Nobody knows!

Shri Mishra lives and teaches in Ahmedabad and occasionally writes popular articles on physics and mathematics.