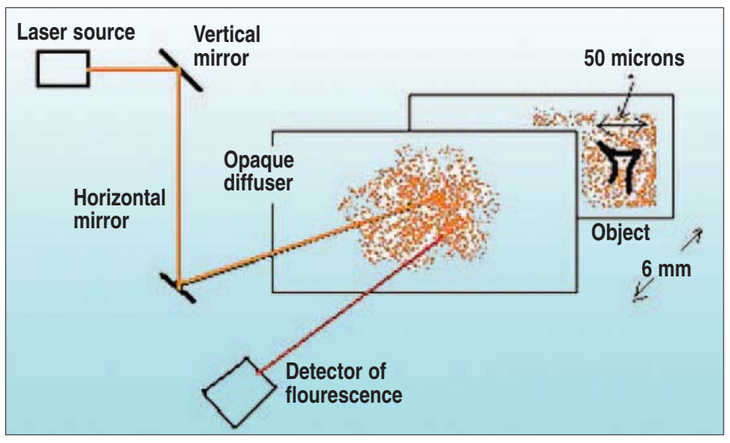
Clear sight in the fog

Unscrambling an obscured image has not been an easy proposition, says
s ananthanarayanan

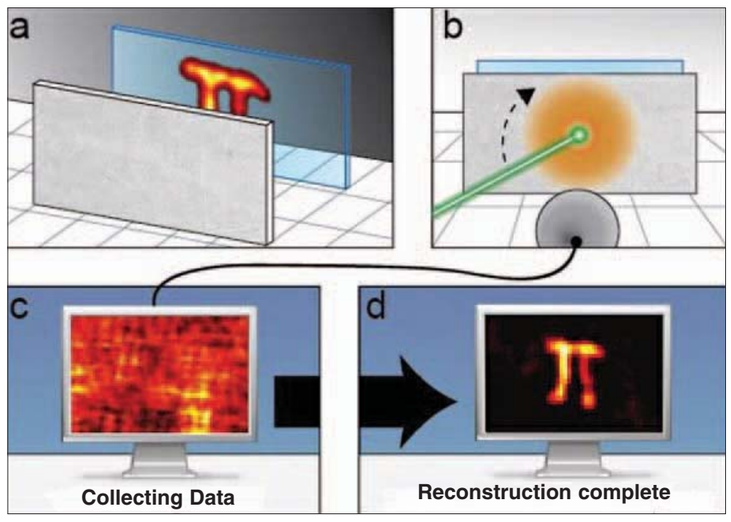
THE light from an object that comes through fog or a ground glass screen gets scattered by innumerable, randomly oriented particles and becomes a general illumination of the dispersing medium, not rays of light that can be focused to throw an image. In theory, all the information about the object is there in the scattered light, but there is no way to identify the scattering points and then to rebuild the image. Jacopo Bertolotti, Elbert G van Putten, Christian Blum, Ad Lagendijk, Willem L Vos and Allard P Mosk, from institutes in the Netherlands and Italy, report a method of getting light to retrace its passage and, using a trial and correction sequence, to recreate the original object, in the journal *Nature*.

A laser beam passing through a scattering medium gets scrambled and emerges as a disordered collection of dark and bright spots, which are known as *speckle*. But the spots in speckle are not really random, they have a pattern and retain some information of both the nature of the original beam of light as well as that of the scattering medium. That this information is there is apparent because slightly changing the angle at which the laser beam strikes the medium is seen to leave the speckle pattern intact, except for a rotation by the same angle. This phenomenon is known as the *memory effect*. Larger changes in the angle do disturb the pattern, but the changes are seen to be gradual and continuous, as the angle is varied.



The way Bertolotti and others linked the changes in speckle with the shape of an object was by illuminating the object with light that diffused through a medium and then viewing fluorescent light from the object, which returns through the medium by the same path as the original illumination.

The return beam can then be treated as "unscrambled", but it is still of little use because all that can be seen is a pattern of spots that make up the speckle. But when the angle of the original beam is varied, the way the pattern of spots changes is not dependent on the nature of the scattering medium, as the effect of the medium has been "reversed" and the nature of the pattern changes can be worked on to reveal the shape of the fluorescing object.



The experimental arrangement was to place a fluorescent target object six millimetres behind a ground glass plate. A laser beam was shone on the plate through an arrangement that allowed variation of the angle of the beam. Light that diffused through the plate, as the speckle, illuminated the object, which fluoresced and beamed light back along the path of light that fell upon it. This return light created the same speckle pattern on plate, to be detected by a sensitive camera as a viewing device.

The pattern that appears in a single assay of fluorescence contains no information of the shape of the object. But when the angle of the incident laser beam is changed, the changed speckle, in conjunction with the first, does contain information. A large number of observations were made to increase the quantity of information, or the *signal*, in the data, as compared to the glare, or *noise*.

Even this information that is gathered cannot, by itself, yield the shape of the object. But there are ways in which this information can refine an approximate shape of the object into a better-defined one. Where we have a low-resolution picture, this can act as the starting point. The computation takes it that the assumed shape would generate a factor that would relate to the variation in the pattern presented. This factor is worked out and applied to the variation of pattern that is actually seen. The result is then reverse computed to arrive at a revised shape of the object. The revised shape is then used in the computation to arrive at further revised shape, and so on, over a large number of cycles, till the shape worked out becomes constant.

As a proof of concept, the team tried it out with a 50-micron fluorescent object, a picture of the Greek letter, pi, hidden six millimetres behind an opaque diffuser. The trial yielded an excellent image of the original. As a real-life trial, the team then used a slice of the stem of a flowering plant and obtained similar, accurate images from six millimetres behind an opaque diffuser. Imaging biological tissue is seen as a major application of this technique. Human skin and flesh is translucent for a reasonable depth, but is so diffusive that no detail can be discerned. But this method of constructing images behind diffusive layers could be developed into a powerful, non-invasive investigation tool for medical use. Imaging from more than one direction could even yield 3D images.

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Using sound for location

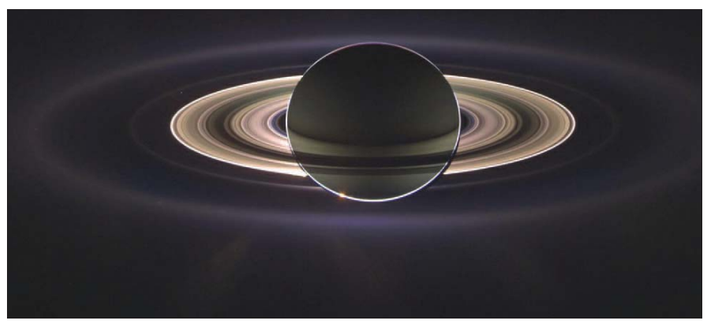
DEMETRI Psaltis and Ioannis N Papadopoulos of Lausanne, writing in *Nature*, have compared the retracing of the light path in and out of the diffusing medium to a golfer driving a ball into the woods and then getting out by driving the ball straight back from the place where it hit the ground.

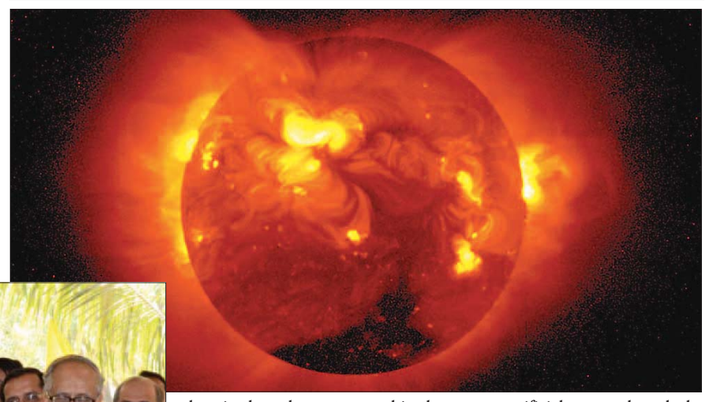
Another instance of making use of a diffused data set was given by Major-General (retd) GD Bakshi, describing an incident during the Kargil conflict where the Indian forces had orders to hold their fire at all costs. As this was known to the enemy, the Indians had often to take cover against shelling and not retaliate and, worse, they had to bear oral mockery from the other side. One moonless night, a Pakistani master of Punjabi expletive, under cover of pitch darkness, was letting the Indians have a verbal barrage. The Indians decided to teach him a lesson and called the regiment "marksman"

But using sound to locate a target can be misleading, both because of echoes and the source of sound getting blurred due to diffusion. Although he knew little of the speckle effect or of iterative algorithms, our marksman listened carefully from different positions and directions till he had sharply located the sound in his mind's eye. And with a single shot, which was followed by a scream, he restored quiet, if not peace, to the valley, a little to the regret of all concerned for literary merit knows no borders.

Looking up and beyond in wonder

An exhibition of photographs at the Birla Industrial and Technological Museum is guaranteed to dazzle one with the visual extravagance of the cosmos, writes
debameeta bhattacharya





AROUND 400 years ago, stargazing was considered practically illegal. The Roman Inquisition sentenced Galileo for supporting Copernican astronomy and most people still believed the earth was flat. Fortunately, science has since come a long way and the National Aeronaurics and Space Administration's jet propulsion lab in Pasadena has made space exploration a viable industry in southern California — on par with film and television. Today, we're still welcome to join the "Flat Earth Society", but most of us accept that we're not the centre of the universe, with perhaps the exception of scientologists.

Very recently, the Birla Industrial and Technological Museum, under the National Council of Science Museums, Union ministry of culture, staged a new travelling exhibition — "The History of Space Photography" – that showcased an extraordinary variety of astronomical photographs taken from the early 19th century through to the present — images of earth from space, our solar system, stars, the Milky Way galaxy, and the universe beyond. With the aim of modernising and upgrading its activities and facilities from time to time, the BITM is constantly developing new galleries and giving the existing ones a facelift.

Early civilisations performed naked-eye observations of the night sky and astronomy – the oldest natural science — was born. As photography was invented and technology advanced, astronomers began to view objects in the heavens in detail in visible light, and in a large number of light wavelengths beyond what the human eye can see. The progress made from ground-based astronomy photographs to producing space-based digital images allows us to look back and learn more and more of our remarkable small, blue world. As a result we get to know more about our place in the solar system and in the universe itself. Jay Belloli from the California/International Arts Foundation and Saroj Ghose, former director-general of the NCSM and chairman of the BITM executive committee curated the exhibition.


Jay Belloli and Saroj Ghose at the inauguration.

Children from around 13 schools participated in various activities, such as a painting competition, a quiz and interactive sessions. The show featured more than 150 images that chronicled the advancement of extraterrestrial photography — from black-and-white images of the moon to incredibly detailed digital photos of galaxies outside our solar system.

History goes back to the '80s. This was the fourth exhibition in collaboration with Nasa and, across these four presenttaions, six astronauts came from the USA and held interactive sessions with students who had a keen astronomical interest. Ghosh vividly discussed a concept of "terraforming" in an interactive session, in the course of which one of the students asked about the possibility of a human colony on Mars. In many respects, Mars is the most earthlike of all the planets though the oxygen level and temperature is much lower than that of earth. The existence of water there is an established fact but the question is, how much? Is there a water table just like earth to sustain survival of the species? Terraforming on Mars is the hypothetical process by which the climate, surface and known properties of the planet would be deliberately changed with the goal of making it habitual for humans and other terrestrial life, thus providing the possibility of safe and sustainable colonisation of large areas.

The concept relies on the assumption that the environment of a planet can be altered through artificial means though the feasibility of creating a planetary biosphere is undetermined. There are several proposed methods, some of which present prohibitive economic and natural resource costs, and others which may be currently technologically achievable. Scientists are diligently trying to process this dream into reality.

Since prehistory, species have been in awe of the cosmos, entranced in the wonder and speculation about the sun and moon by day and overwhelmed by celestial spectacles that banish the darkness of night. With the development of the telescope in the early 17th century, astronomers like Galileo learned, in increasing detail, what wonderful objects the heavens contained. Astronomers who used early telescopes had to document what they observed by hand and created detailed drawings. With the development of photography in the 1830s, they were able to make permanent records of the wide variety of celestial objects and events. These records allowed them to study their own observations and those of their peers, in detail and over time. It was a revolution. The BITM exhibition explored the beauty, mystery, science and meaning of images depicting earth and the world beyond.

The museum authorities are doing a remarkable job by filtering knowledge down to young inquisitive minds. Belloli was at his explanative best and he seemed to have all the patience in the world while running children through the wonders of the universe. One can but express the thought that if millions of people took time off to contemplate the images exhibited, perhaps politics could take a rest for a moment and allow compassion, social justice — the very dignity of humankind – to advance an inch.

Checking out the mini-collection of photos from "The History of Space Photography" is well worth the time. This travelling exhibition will remain open daily from 10.00 am to 5.30 pm till 9 December at the BITM, after which it will shift to another science centre under the NCSM.

Unnaturally warm

tapan kumar maitra **explains the consequences of global warming and provides solutions to mitigate the problem**

'IN nature there is no punishment and reward, only consequences are there." None of us are aware of our environment. Every now and then we are responsible for its condition in some way or another. In the long run, we face intolerable hazards like green house effects and ozone depletion. The fact that we have reached laudable heights in scientific advancement has been established. Yet we do not know how to control alarming environmental phenomena rationally and with judiciousness.

We have the capacity to devise ways that help our mind and body only to better our own standards of living but we care two hoots about adhering to certain rules and regulations for the betterment of our society and nation. Because of our ignorance, our haphazard actions have gradually disrupted dwindling homeostatic conditions of our environment. Some congenial factors responsible for the environment's degeneration include pollution, rapid urbanisation, industrialisation, felling of trees, automobiles and burning fossil fuels. Global warming is presently one of the biggest warning signals concerning the future of flora and animals in their habitats.

The concentration of carbon dioxide maintained by the energy balance of sunrays that reach Earth that is then radiated back into space is what helps moderate temperatures. However when the concentration of carbon dioxide increases, it creates a hick blanket that prevents heat from radiating back into space. Sunrays, with a narrower wavelength have highly penetrative energy and once they reflect off of the earth, they turn into infrared rays with lower energy. The thick blanket of carbon dioxide prevents these rays from going back out and temperatures exceed the global normal temperature through the process of resonance. Other gases like sulphur dioxide, methane and water vapour also play a pivotal role in global warming. These gases are also known as greenhouse gases.

So what are the consequences of global warming? Many. These include:

- Rising temperatures that disturb the earth's delicate thermal balance may cause glaciers and ice caps to melt making sea levels rise and flooding coastal and low-lying regions.
- Heavy rainfall causes soil to erode – topsoil in particular. When the soil's salinity is drastically changed, this causes the vegetation of that area to change as well. This imbalance in the hydrosphere

leads to changes in seasonal periods which consequently affect agriculture.
- Increasing temperature will increase the rate of water evaporation resulting in higher humidity. It also causes changes in food production.
- Because of an excess of carbon dioxide, there are higher chances of cyclones and hurricanes.
- Though there may be more rain, the problem of desertification and drought will only increase.
- Plants will become nitrogen deficient and will be less resistant to pests.
- There also may be a problem in the food web.
- There would be tremendous setbacks in the world's economy.

To check "Global Warming" some remedial measures should be taken into consideration. Green plantation programmes should be implemented to act as a pollution sink. Chlorofluorocarbon compounds should be banned. Human activity should be checked in order to control the discharge of particulate matter. The Montreal Protocol should be implemented on certain fuel gases and diesel.

Hydrogen can be used instead of chlorofluorocarbon. Greenpeace, an international level NGO, should be given more importance so that they can check violation of environmental laws. Advertisements, meetings, seminars, conferences, exhibitions and science fairs should be organized to help educate people about environmental hazards. Carbon dioxide should be rationed and budgeted emphatically.

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