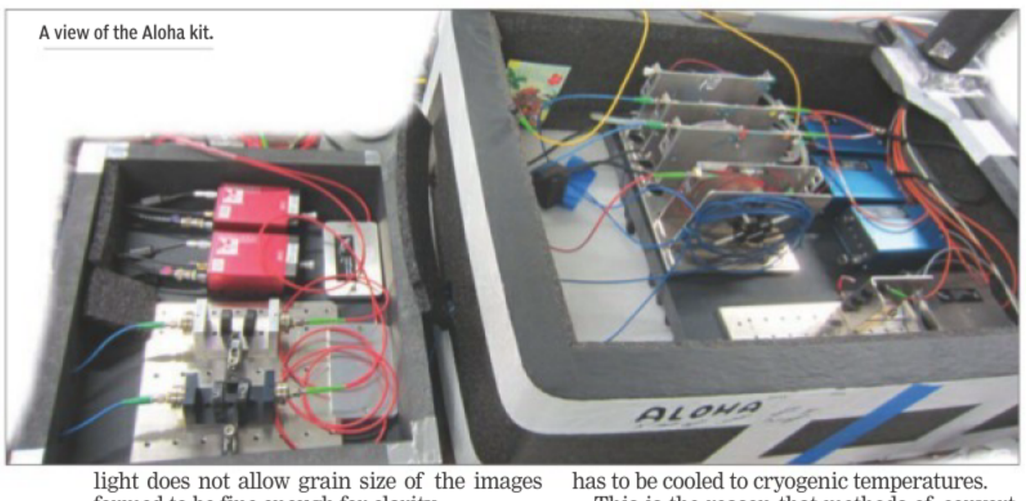
Changing the colour of starlight

BEING ABLE TO SEE IN THE INFRARED WOULD GIVE US A CLEARER VIEW OF FAR-OFF WORLDS, WRITES **S ANANTHANARAYANAN**

A large part of information about the distant universe comes to us in the form of infrared radiation. This is because many bodies in outer space are covered by clouds that are opaque to light in the visible part of the spectrum. Apart from that, it is only in the infrared that any light can reach us over very large distances, as light of higher frequencies is scattered more than that in the infrared.

The trouble with seeing in the infrared, however, is that images, even in telescopes with very large lenses or mirrors, cannot bring out the details of the objects being seen. That is because the longer wavelength of infrared light does not allow grain size of the images formed to be fine enough for clarity.



A view of the Aloha kit.

The solution is hence to form images not with the help of large lenses or mirrors, but by mimicking a very large light collecting area with separate telescopes placed hundreds of metres apart. The different signals then need to be brought together and analysed, a process that presents many challenges, compared to dealing with visible light.

P Darré, R Baudoin, J-T Gomes, NJ Scott, L Delage, L Grossard, J Sturmann, C Farrington, F Reynaud, and TA Ten Brummelaar, of a group of labs in the National Centre for Scientific Research at Limoges, in France and the Mount Wilson Observatory, California, have reported in the journal, *Physical Review Letters*, an effective method of converting infrared light into light in the visible spectrum, without loss of essential features, which enables more efficient retrieval of information.

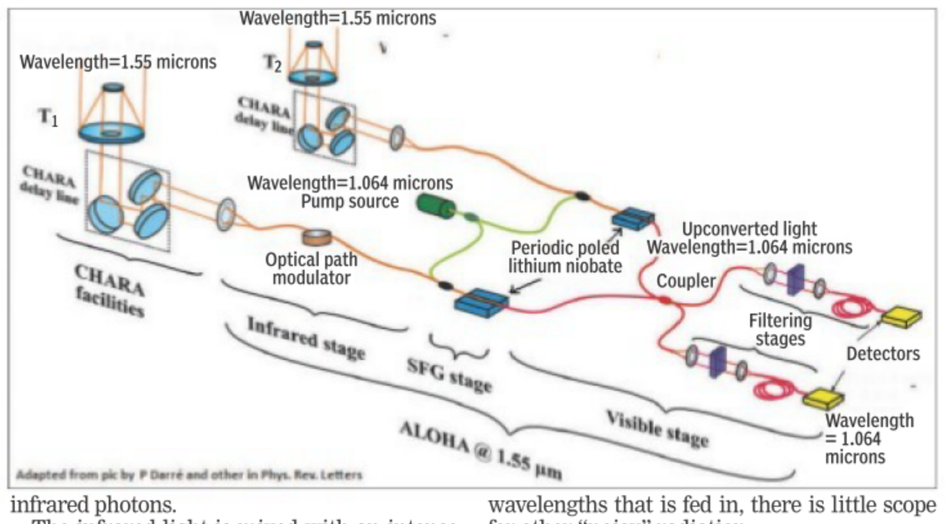
In the method of using widely-separated telescopes, the waves striking different telescopes in the array arrive at slightly different stages of vibration when they are brought together. The different stages of vibration of the waves, known as "phase", causes them to interfere, and that results in a series of bright and dark fringes, from which phase information can be inferred and managed.

Working with infrared, however, calls for special optics that is transparent to light in that area and what's more challenging is keeping the signal free from unwanted radiation because all warm objects radiate in the infrared. Much of the arrangement, therefore, has to be cooled to cryogenic temperatures.

This is the reason that methods of converting infrared radiation to visible light — without destroying the information of "phase" or the stage of vibration and which enables the structure of the distant object to be assembled — has been of great interest.

Handling signals in visible light, both for transmission as well as for detection, is much easier, as photons of visible light affect photo sensors more powerfully. Extremely efficient and low-noise detectors are hence available for identifies visible light. And it is not only in astronomy, but also in chemical analyses and detecting minute gas concentration for environmental monitoring that mid-infrared conversion has now become important.

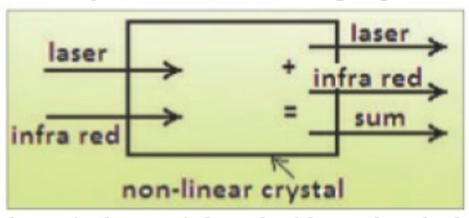
The possibility of the process, or "up-conversion", arose with the development of lasers, which can provide the intense beam of coherent light or a beam of light waves that are all in phase, which is used to combine with incident infrared photons.



The infrared light is mixed with an intense laser beam that is in the near infrared or visible region. The mixing is carried out in a cell made of a material in which the effect of the absorption of photons is not only the emission of equal photons, but can also be the emission of a photon with the sum of the energy of two, a process called sum frequency generation.

One of the methods used is with crystals of such a material, which shows special properties while passing light, in the form of slivers that are arranged one on the other, with opposed optical properties, a process called periodic poling. This kind of arrangement, known as a non-linear crystal, brings about the adding together of the energy of a far or mid-infrared photon and the near infrared or visible photon from the laser, to give rise to a photon with the sum of the two frequencies, in the visible region.

The team writing in *Physical Review Letters* made use of crystals of periodically poled lithium niobate and passed an infrared beam of wavelength 1.55 microns, and a "pump" laser



beam, in the near infra red, with wavelength of 1.064 microns through the crystal stack.

The result was light at a combined, shorter wavelength of only 0.631 microns, or 631 nanometres, visible, red-orange region photons with exactly the sum of the energy of the two mother photons.

The principle of the conversion is that as the pump photons are in phase, while the product photons in the visible region retain the phase of the converted, original infrared photons.

In the case of photons that arose from two telescopes imaging a distant, stellar object, we would now have a pair of visible light photons, with which to carry out manipulation but with the more powerful tools that we have for the visible region.

As the final light is in the visible region and arises only from the combination of specific wavelengths that is fed in, there is little scope for other "noisy" radiation.

The arrangement used by the researchers is called astronomical light optical hybrid analysis, or ALOHA, and consists of a pair of one metre diametre infrared telescopes, 34 metres apart, at the Center for High Angular Resolution Astronomy of Georgia State University, located at the Mount Wilson Observatory, California.

The infrared signals were then channelled to the 22 mm-long lithium niobate cells in a laboratory adjacent to the telescopes. The visible light signals that emerged were then brought together and filtered, to eliminate left over pump laser light and also its harmonics, before being passed on to the detectors.

The paper goes on to describe the corrections and refinements applied, resulting in confirmation that the infrared signals from the northern-most of the two "pointers" in the Great Bear constellation, had been effectively up-converted into the visible region , with phase intact, as the interference of the signals in visible light was detected.

Apart from this being a proof of principle result, the papers says even fainter sources have been detected with results comparable with the best so far. In the implementation of Aloha, the up-conversion stage could be kept even much closer to the telescope focus, which would eliminate all extraneous signals from the equipment, the paper says.

Even the optical path regulating equipment, which was used before the up-conversion stage (see picture) could be placed after the up-conversion, as phase information was maintained in the up-conversion process, the paper says.

The development, in opening the possibility of the use of efficient visible light optics to the infrared, is a seminal one, the paper says, and this would extend the utility of great advances already made in visible light optics and detectors, to sensitive investigation of low energy processes.

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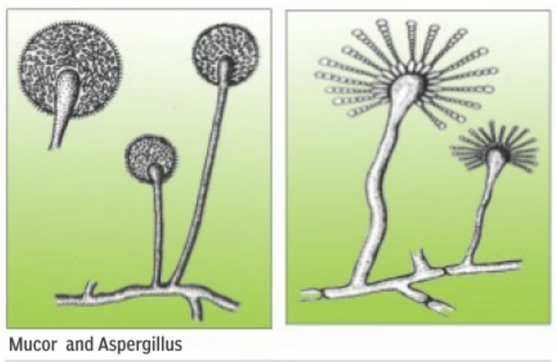
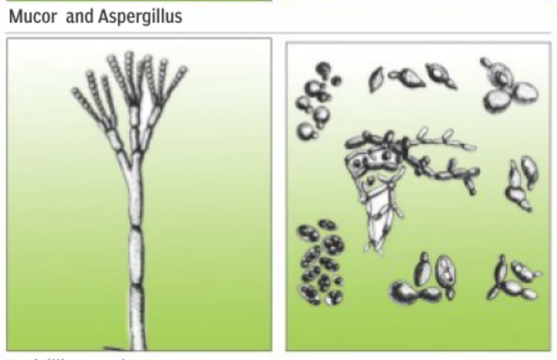
UNIQUE VEGETATIVE BODIES

TAPAN KUMAR MAITRA EXPLAINS THE MORPHOLOGY AND STRUCTURE OF FUNGI

Fungi belong to plant heterotrophic organisms (eukaryotes) devoid of chlorophyll. The cells of fungi have a differentiated nucleus and many of them multiply by sporulation. They differ greatly from bacteria and are marked by various morphological properties. The main structural component of the vegetative body is the mycelium, which is composed of branching colourless filaments (hyphae).

In some species the mycelium is non-septate or formed of a single cell (Mucor mould) while in others (higher fungi) it is poly-cellular (septate). Yeasts are oval or rounded and lack mycelium.


Mucor and Aspergillus


Penicillium and Yeasts

The fungus Claviceps purpurea forms a sclerotium, which is a firm network of mycelial hyphae.

Fungi resemble algae in structure — they have a firm membrane consisting of cellulose, pectin substances, and carbohydrates. Various inclusions are found in the cytoplasm like glycogen, volutin and drops of fat.

The cells of fungi may be mono-nucleate or poly-nucleate and the nuclei undergo both direct and indirect division. Fungi reproduce by rupture of the mycelium into pieces capable of germinating, by means of chlamydospores and conidia, by sporulation, and by the sexual way. The group of fungi includes saprophytes, parasites, and facultative parasites of plants, animals, and humans. Here's a look at some of them.

Chytridiomycetes are a species that inhabit water reservoirs. They lack mycelium or it is present in a rudimentary state and they move by means of pseudopodia. The cells are poly-nucleate. When occurring on a moist substrate, the spores of these fungi absorb water, swell, rupture the membrane, and divide with the production of amoeboid-like cells some of which coalesce and form zygotes that divide and develop into a poly-nucleate mucous mass. Some species, which are pathogenic for plants induce, in particular, cabbage disease and wart disease of potatoes.

On the other hand, oomycetes are fungi with non-cellular (non-septate) mycelium. Some species live in water, others in the soil. Water inhabiting oomycetes cause diseases among fish and destroy the roe of fish and frogs while others parasitise on plants and cause phytophtorosis of potatoes and the fruit of grapes and peronosporosis of sugar beet.

The genus Mucor or bread mould belongs to the class Oomycetes. Pathogenic species of this mould may cause infections of the lungs and middle ear, and a general severe infectious process in humans.

Moving on, zygomycetes are soil fungi with a non-cellular mycelium. They reproduce by means of sporangiospores and less frequently, by means of conidia. Enzymes secreted by these fungi are used for clarifying juices and preparing alcoholic beverages. The class zygomycetes includes the order entomophiles, parasites of insects — they cause the death of the larvae of mosquitoes and flies and are used as insecticides.

Ascomycetes or sac fungi (35,000 species) have a multicellular mycelium. They reproduce sexually by means of ascospores (spores which develop in special spore cases called asci). The organisms reproduce asexually by means of conidia (exospores which bear the function of asexual reproduction in many fungi).

The genus Aspergillus belongs to the class Ascomycetes. Microscopic investigations have revealed that the fruiting part of the aspergillus (arrangement of endospores) resembles a jet of water from a watering can, and hence the name "sprinkler" mould is used. Certain species may cause aspergillosis of the lungs, ear, and eye in humans or may infect the whole body.

The genus penicillium belongs to the class ascomycetes. The mycelium and conidiophore are multi-cellular while the fruiting body is in the shape of a brush. The conidiophore branches towards its upper part and terminates in sterigmata from which even-rowed chains of conidia are pinched off. This genus of fungi is widespread in nature. It is found in fodder, milk products, ink and jam, on moist objects, and old leather.

Certain species like penicillium notation and penicillium chrysogenum, among others, are used for producing penicillin which is widely employed in treating many infectious diseases. Some species of this genus of fungi are pathogenic for humans — they cause infections of the skin, nails, ears, upper respiratory tract, lungs, and other organs.

Next up, to the class ascomycetes, the order saccharomycetales (primary sac fungi) belong the yeasts which are large, oval, round, and rod-shaped cells. Yeast cells have a double-cell wall and a well-defined nucleus.

Yeasts multiply by budding, fission and sporulation while some species reproduce sexually. Daughter cells produced by budding from the parent cell transform into independent individuals.

The groups of asporogenic yeasts include species pathogenic for humans, which cause severe diseases such as thrush in infants and blastomycosis.

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Filling the seventh row

THE PERIODIC TABLE HAS OFFICIALLY EXPANDED TO MAKE WAY FOR FOUR BRAND NEW ELEMENTS. **ANDREW GRIFFIN** REPORTS

The periodic table is now just a little bit bigger.

Perhaps the most fundamental chart in all of science officially has four extra elements listed. The new elements have now been given official names and will be included in the grid. The four new elements include nihonium, the first ever to be found by Japanese scientists. That element — which until recently was referred to as 113 — got its proper name from the word for Japan in Japanese — *nihon*, literally "the land of the rising sun".

"The element, named for the first time by Japanese and in Asia, will occupy a place in the periodic table — an intellectual asset of mankind," Kosuke Morita, who led the team that created the element, said in a statement. Two of the other three new elements take their name from a place. The other gets it's from a pioneering scientist.

The periodic table, pored over by science students the world over, arranges chemical elements in the order of their atomic number. Some elements, such as hydrogen, carbon or magnesium, are found in nature while others, including nihonium — official symbol Nh — are synthesised in laboratories. All the discovered elements after 104 are synthetic ones produced through laboratory experiments.

Tradition dictates that newly discovered elements be named after a place, geographical region, or scientist, according to the International Union of Pure and Applied Chemistry, which made the announcement on the names last week.

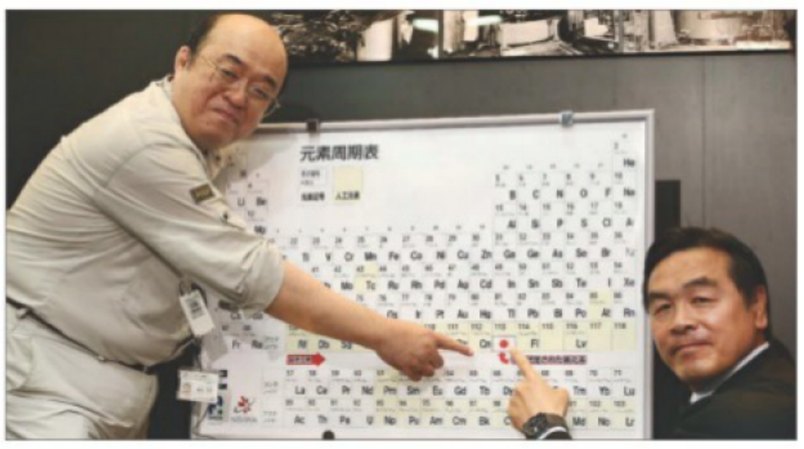
A joint team of Russian and US scientists named element 115 moscovium — symbol Mc — after the Russian capital, where much of the relevant research was conducted. For similar reasons, they also named element 117 tennessine — symbol Ts — after the US state of Tennessee.

The third one they discovered, element 118, was named oganesson — symbol Og — in homage to Russian nuclear physicist Yuri Oganessian, in recognition of his "pioneering contributions" in elements research.

North Carolina-based IUPAC said that the names were officially accepted after a five-month public review period.

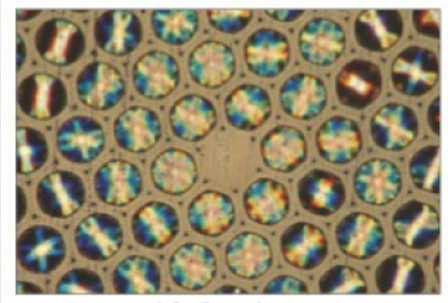
"The names of the new elements reflect the realities of our present time," IUPAC president Natalia Tarasova said on its website, citing the "universality of science" as well as "the pivotal role" of Oganessian. With the latest discoveries, the periodic table is now complete down to the seventh row. Underscoring the importance of the discoveries, the scientists behind the four new elements had been seen as strong candidates for this year's Nobel Chemistry Prize.

Japan has a proud research tradition and its citizens have won about 20 Nobel prizes in science and medicine, including Yoshinori Ohsumi who won the Nobel Medicine Prize this year.


Kosuke Morita (left), who led the team at Riken institute that discovered the superheavy synthetic element, and Hiroshi Hase, minister of education, culture, sports, science and technology, pose with a board displaying the new element 113 at Riken's research centre in Wako, Saitama prefecture, Japan.

THE INDEPENDENT

PLUS POINTS



Beautiful science

This photograph was taken by illuminating a piece of "photonics bandage fibre" under a white-light microscope. The fibre is formed by stacking rods of germanium — a shiny grey semi-metal — doped in silica in a hexagonal pattern. The centre rod is replaced with just silica to form the fibre's core. The colourful patterns pictured arise from the silica guiding white light through the structure. This microstructure acts as a filter for certain wavelengths.

University of Bath physicists say they have developed a technique to more reliably produce single photons that can be imprinted with quantum information, which will help in processes such as quantum computing, secure quantum communication and precision measurements at low light levels. Photons — particles of light — can be imprinted with information that can be used for things like carrying out calculations and transmitting messages. To do this, individual photons need to be created — a difficult process, says the university.

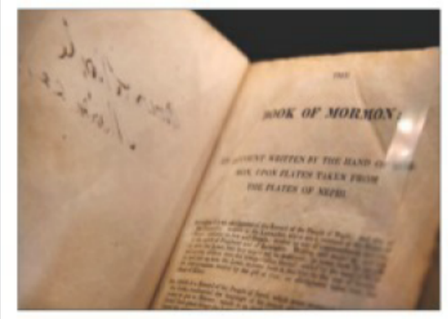
Researchers from its Centre for Photonics and Photonic Materials have implemented a new way to improve the performance of single-photon sources using fibre optics and fast optical switches. They combined several individual sources of photons using optical switches, a technique called multiplexing, using fibre optics fabricated at the university. The resulting device not only makes generating single photons more reliable but also allows the control of properties of the photons created, including their colour.

THE STRAITS TIMES/ANN

Feeling the spirit

Religious experiences have a similar effect on the brain as taking drugs, according to a new study.

Scientists at the University of Utah, US, used MRI scans to monitor the brain activity of 19 devout Mormons while they carried out a variety of tasks including resting,



watching a church announcement about financial reports, praying, reading quotations from non-Mormon religious leaders, and reading the Bible.

The researchers specifically choose young Mormons — seven women and 12 men — who had all carried out the one to two years of missionary work that most members of their faith are expected to undergo.

During the tasks the participants were told to press a button when they "felt the spirit". When studying the brain scans, the researchers noted certain brain regions consistently lit up when the participants reported spiritual thoughts.

These are the same parts of the brain which have lit up when participants in previous studies have listened to music, experienced feelings of love and taken recreational drugs.

This section of the brain, the nucleus accumbens, is known as the brain's "reward centre", which controls addiction and plays a role in the release of dopamine — one of the chemicals which control a person's mood.

Dr Jeffrey Anderson, the neuroradiologist who led the study, said, "These are areas of the brain that seem like they should be involved in religious and spiritual experience.

"But yet,religious neuroscience is such a young field — and there are very few studies — and ours was the first study that showed activation of the nucleus accumbens, an area of the brain that processes reward.

"Billions of people make important decisions in life based on spiritual and religious feelings and experiences. It's one of the most powerful influences on our social behaviour."

CAROLINE MORTIMER/THE INDEPENDENT