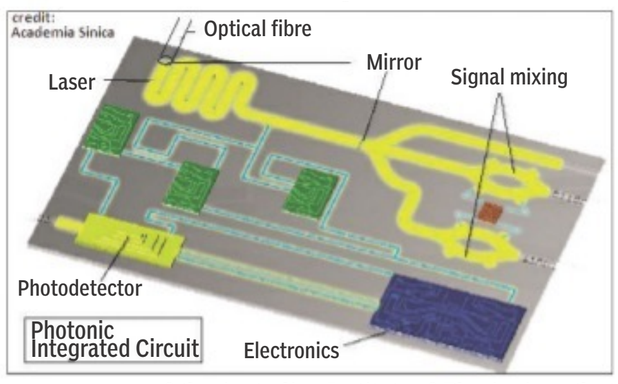
The light from worlds far away

SLIVERS OF GLASS THAT WORK LIKE MICROCHIPS MAY HELP ASTRONOMERS GET PAST THE GLARE OF DISTANT SUNS, WRITES **S ANANTHANARAYANAN**

There has been an explosion in the discovery of planets in solar systems other than our own during the last few decades. While a brace of methods have been devised to glimpse these specks of light hidden by the brightness of their parent stars, there are challenges in viewing images in the mid infrared, where information about the atmosphere of the planet can be found. A team of researchers in Australia have reported to have created a miniature optical arrangement that could help sight a planet in that region of the light spectrum as if the parent star were not there.

H-D Kenchington Goldsmith, N Cvetojevic, M Ireland, P Ma, P Tuthill, B Eggleton, JS Lawrence, S Debbarma, B Luther-Davies and S J Madden from the Australian National University, the Australian Astronomical Observatory, the University of Sydney and Macquarie University, reported their success in manipulating light from a distant planetary system with the help of a device made of a special glass that is transparent to relatively longer wavelength infrared radiation. It was presented at the Congress of the Australian Institute of Physics in Brisbane recently.



As the glare of the parent star prevents a planet's dim, reflected light from being seen by observers, the first method of detecting exoplanets has been indirect and "in the blind". The movement of the planet in orbit results in a definite, if lesser, movement of the mother star too. This back-and-forth movement of the luminous star can be detected on earth because of the Doppler shift in the colour of the light that comes from the star. The extent of the shift, and also the frequency of its reversal, enables an estimate of the orbit and the size of the planet.

The next method devised was watching for a slight dip in the intensity of the light from the star when a planet went between the star and the earth. As we now have very sensitive instruments, which can measure a drop in intensity, this method reveals the time a planet takes to go around its parent star and also provides an estimate of its size.

A more fancy method of seeing exoplanets is by blanking out the light from the star. One proposal was to launch a large, circular screen into orbit around the earth and then positioning it in a way that it exactly covers the disk of the star to block the glare. The surrounding planets could then be expected to burst into view as the background falls dark. This plan, unfortunately, was still-born, as there is a property of light waves that prevents a circular disk from acting like a screen. The outer rim of the disk that is lit acts as a circular source of light and focuses the starlight along the line where the telescope lies, and the brightness is not abated. A work-around has been to provide the opaque disk with a scalloped rim, so that half the light waves arriving at the centre travels a greater or shorter distance and finds itself "out of phase" and therefore, cancels the other half. The method, however, is yet to be tried.

While these are methods in respect of visible light, a great interest, in the case of distant heavenly bodies and exoplanets, is to view them in long wavelength radiation like infrared. It is of interest for two reasons. One is that it is often the longer waves alone that survive because light of shorter wavelength gets scattered. The other — more to the point in the quest for more proximate exoplanets — is that the chemical signature of gases in the atmosphere of the planets lies in the infrared, particularly the mid infrared region of the spectrum of light. A serious interest is to look for signs of the ozone in the planets' atmosphere, as its presence indicates the possibility that the planet harbours living organisms and even intelligent life.

A major issue while dealing with long wavelength light is that getting images of good resolution calls for huge light collection, in the form of a very large objective mirror of the telescope. For the longer infrared waves, the only way is to use multiple telescopes separated by large distances and then combine the images to mimic a large collection area. With these techniques, however, the phase, or stage of vibration of the light waves at different telescopes needs to be managed. Very sensitive devices that integrate light of shorter wavelengths, like visible light, with micro-electronics have been developed but it has not been possible with infrared light, mainly because most materials are opaque to it. In fact, a method — just reported by a group in Limoges, France — comprises converting mid infrared waves to near infrared or visible radiation, without disturbing the phase.

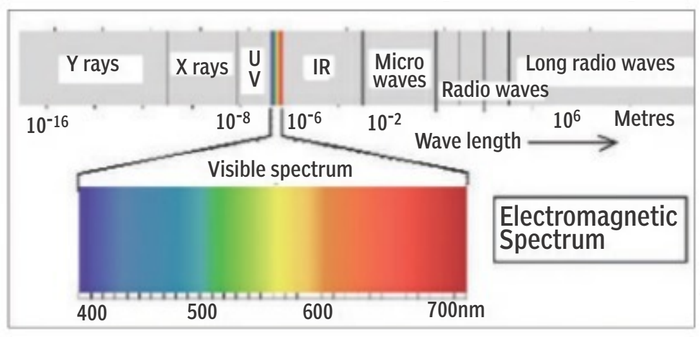
This is the context in which the researchers in Australia announce their work of fabricating photonic integrated circuits — they are self-contained assemblies that take in, process, compare and combine infrared light signals and works in the same way that large computing ability is built into electronic ICs. With the help of the photonic IC, in fact, the group is able to implement yet another way of blocking out the glare of the mother star and hence see the image of the exoplanet in infra red light more clearly.


Ronald N Bracewell

The method used is similar to the adaptive optics, which optical telescopes use to make out a dim star in visible light. The feeble light wavefront from a dim source gets distorted by variations in the composition of the earth's atmosphere before the light gets down to the telescope. What is then done is that a bright, nearby star is also sighted and the distortion of its otherwise strong image, measured. A low intensity light signal that is the exact opposite of the distortion is then generated and added to the feeble signal. This cancels the distortion and the feeble image can be correctly formed. Team member S J Madden explained that this is similar to what is done in noise-cancelling headphones.

In the case of sighting exoplanets, the infrared signal of the mother star is the dominating signal that is received. The faint signal from the exoplanet is also there, and invisible, but that signal is generally out of phase with the main one, both because of its position and the fact that the exoplanet is in motion. Now, if a signal, which is the inverse of the received signal, is generated and comes from the image formed by neighbouring telescopes, it will blank out the light coming from the mother star but not the faint light from the exoplanet, which would then become "visible" in infrared light. This is the process, which was proposed by Ronald N Bracewell of Stanford University in 1978 and it has now been implemented by the new photonic integrated circuit.

While silica-based photonic chips have been useful in integrating photonic optics, these are opaque beyond the near infrared. A material called chalcogenide glass — glass which contains the elements, sulphur, selenium and tellurium — has been found to be transparent well down to the mid infrared region. The group of researchers thus constructed optical units of chalcogenide glass and integrated the functions of phase-shifting the main infrared image for superimposition and blanking out the strong, stellar signal. During trials, the new "multi mode interference" coupler demonstrated effective "nulling" of stellar glare thereby revealing the weaker, reflected signal, in the mid infrared. It opens up a great, new research area of investigation of the atmosphere or surface of exoplanets, many of which have been found to be "earth-like".



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PLUS POINTS

Shooting for the stars

Nasa researchers have joined forces with Stephen Hawking to build a nano-starship that can travel at one-fifth the speed of light. If successful, the ship called "star-chip" could reach Earth's closest star system, Alpha Centauri, in 20 years.

Hawking announced the Breakthrough Starshot project in April, for which he is joined by a team at the Korea Institute of Science and Technology. But whether the craft could survive a two decade-long trip remained in question.

That's where Nasa can help. According to their researchers, high-energy radiation in space could cause the ship to cease functionality well before the 20-year trip was over, according to *Science Alert*.

Nasa proposed a number of options to pursue in the development stages of the project. They presented their findings at the International Electron Devices Meeting in San Francisco last week.

First, adjust the route of the flight to avoid those high-radiation areas. But that could add years to the voyage and would not necessarily protect the ship from degradation. Second, they proposed the ship could be built with protective shielding on the electronics. But adding shielding to the ship would add to the size and weight and thus slow down the remarkable speed of the craft. Third, Nasa researchers proposed a silicon chip that would automatically repair itself.

"On-chip healing has been around for many, many years," Nasa team member Jin-Woo Han said in the presentation.

Still the research is only theoretical and scientists have significant work to do to address other major problems in interstellar travel.

"The limit that confronts us now is the great void between us and the stars," Hawking said in April. "But now we can transcend it. With light beams, light sails, and the lightest spacecraft ever built, we can launch a mission to Alpha Centauri within a generation.

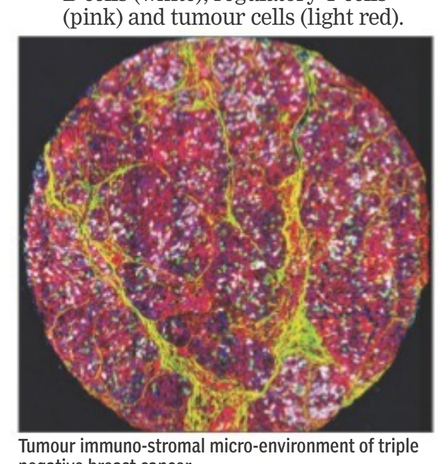
"Today, we commit to this next great leap into the cosmos because we are human, and our nature is to fly."

FELIKS GARCIA/THE INDEPENDENT

Photographing a tumour

Cancer is a multi-faceted disease generally caused by normal human cells, which turn cancerous because of defects, an imbalance of immune-cell response and the re-modelling or destruction of surrounding normal tissue, which is called stroma.

Pictured here is the tumour immuno-stromal micro-environment of triple-negative breast cancer. It comprises CD8 T-cells (green), CD20 B-cells (white), regulatory T-cells (pink) and tumour cells (light red).


Tumour immuno-stromal micro-environment of triple negative breast cancer.

The green fibres running across the image are tissue collagen.

It was captured using a novel imaging method that integrates multi-photon pathology imaging technology — a laser-based technique that allows 3D and 2D assessment of tissue samples — with the immune-fluorescent staining technique.

It identifies different cells and their characteristics, said Joe Yeong, a visiting scientist at the Singapore General Hospital's department of anatomical pathology.

The technology was developed by SGH, A*Star's Singapore Immunology Network and the Institute of Molecular and Cell Biology, and optical medical imaging equipment company HistoIndex.

It provides a tool to visualise and quantify the spatial distribution and "cross-talk" among different immune cells, which may attack or promote cancer; different immune and cancer markers and the pattern of collagen fibres, said Yeong.

THE STRAITS TIMES/ANN

WEED TERMINATORS

TAPAN KUMAR MAITRA EXPLAINS HOW HERBICIDES WORK ON PLANTS

Herbicides are chemicals employed to kill weeds. The major part of herbicides relate to organic compounds characterised by a high physiological activity and effectiveness at relatively low rates of use. Some inorganic compounds are also used as herbicides.

Depending on their properties, selective and non-selective herbicides are distinguished. Non-selective herbicides are used for killing all plants on areas where no plant growth is desired — on the shoulders of highways and railways and on railway tracks, on drainage and irrigation canals, along power transmission lines, on sports grounds, et al. Selective herbicides kill or inhibit weed growth without harming crop plants and can be used on plantings of almost all crops. Many weeds can be killed without harming the crop plants upon the proper choice of a type of herbicide, its rate of use, the time and way of treatment.

Selectivity depends on the anatomical, morphological, and physiological features of the plants, and also on the chemical composition and physio-chemical properties of the herbicide and its physiological activity. Many selective herbicides kill a considerable number of weed species. For instance, the herbicides 2.4-D and MCPA eradicate numerous dicotyledonous weeds in grain fields. Derivatives of 1, 3, 5-triazine – atrazine and simazine – kill many di-and monocotyledo-nous weeds on corn fields. Conversely, some herbicides kill a very limited number of weed species or even one weed. For example, barban used for treating wheat, barley, pea, and corn fields against wild oats acts on this weed a very short time (only in the stage of one or two leaves). Propanil used to kill Japanese barnyard millet on rice fields has a very weak effect on other weeds. Some other herbicides such as dalapon, TCA, and chlorpropham are also characterised by a narrow selectivity.

Topographical selectivity is due to the differences in the anatomical and morphological structure of plants. For example, plants with dense ground tissues, cuticle, a wax coating, and also with dense nap are more resistant to herbicides because their dense ground tissues prevent the penetration of herbicides. Plants with leaves directed vertically upward are also more resistant to herbicides because a considerable part of the herbicide solution drips down from these leaves.

Plants with a deep root system exhibit resistance to soil herbicides. For example, Canadian (creeping) thistle, field sow thistle, Russian knapweed, field bindweed, and common horsetail are resistant to atrazine and simazine because these herbicides remain in the top 10-centimetre layer of soil and do not reach the zone of the active roots. These features explain the use of the above-mentioned herbicides in fruit growing and forest nurseries. They kill many weeds whose roots are concentrated in the top layer of the soil, but do not harm the fruit plants and tree seedlings whose root systems are at a considerable depth.

The resistance and sensitivity of plants to herbicides are associated with biochemical selectivity. The herbicides penetrating into plants undergo various transformations. In some cases this leads to their decomposition and inactivation, in others, to a greater phytocidal activity. Quite often a considerable part of herbicides penetrating into the leaves are excreted through the root system without harming the plant.

Selective herbicides enter plants in different ways — some via the leaves and move along the vessels of the phloem, while others enter via the roots from the soil solution. This explains why they are applied in different ways — herbicides entering via the leaves are used to spray the green organs of plants, while those entering via the roots are incorporated into the soil. It must be noted that such a division is arbitrary because many herbicides (like 2,4-D, MCPA, dicamba, piclo-ram, dalapon, etc) may penetrate into plants via both the leaves and the roots.

During their translocation within a plant, herbicides are partly inactivated because of reaction with the contents of the cells — absorption by the cells, decomposition by enzymes, and the formation of complexes. They move along the phloem into the root system, the generative organs, accumulate in the zones of active growth and in the meristematic tissues, which is just where they induce deep disruptions of the physiological processes leading to perishing of the plants.

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100 million-year-old tail

SCIENTISTS HAVE FOUND AN 'ASTONISHING' DINOSAUR FOSSIL ~ WHICH WAS WRAPPED IN AMBER ~ FROM A MARKET IN MYANMAR. **JOHN VON RADOWITZ** REPORTS

A piece of feathered dinosaur tail has been found trapped in amber and perfectly preserved for almost 100 million years. Despite the yawning gulf of time, individual feather fronds can easily be identified and the specimen has even retained signs of its original colour and traces of blood. Scientists believe the tail belonged to a small juvenile cousin of


The chunk of amber — fossilised resin — that was spotted by a Chinese scientist in a market in Myitkyina.

Tyrannosaurus Rex that lived in Asia, 99 million years ago. The 3.6cm lump of amber, which is hardened tree resin, was discovered in a market in Myitkyina, Myanmar, last year where it had been offered for sale as a curiosity or item of jewellery. The fossil within it, described as "astonishing" by researchers, was originally mistaken for plant material. Microscopic examination and computed tomography X-ray scans confirmed that the tail had come from a flightless dinosaur and not an early species of bird.

Mike Benton, from the school of earth sciences at the University of Bristol, said, "It's amazing to see all the details of a dinosaur tail — the bones, flesh, skin and feathers — and to imagine how this little fellow got his tail caught in the resin, and then presumably died because he could not wrestle free.

"There's no thought that dinosaurs could shed their tails, as some lizards do today." The Bristol team joined colleagues from China and Canada to carry out the analysis, reported in the journal *Current Biology*.

The specimen consists of eight vertebrae, but is thought to be just a fragment of a complete tail that may have been three times longer. By looking at the structure of the bones, scientists were able to discount any possibility that it was from a bird.

Ryan McKellar, from the Royal Saskatchewan Museum in Canada, said, "We can be sure of the source because the vertebrae are not fused into a rod, or pygostyle, as in modern birds and their closest relatives. Instead, the tail is long and flexible, with keels of feathers running down each side.

"In other words, the feathers definitely are those of a dinosaur, not a prehistoric bird."

Chemical analysis showed that the soft tissue layer around the bones retained traces of ferrous iron — residue from the animal's blood. The dinosaur was a "theropod", the large family of mostly carnivorous two-legged beasts to which T-Rex belonged.

Writing in the journal, they concluded,"The theropod tail reported here is an astonishing fossil, highlighting the unique preservation potential of amber."

THE INDEPENDENT


An artist's impression of what might have happened.