

Seeking out the error

GETTING IT RIGHT IS NO GOOD. IT'S WHEN WE GO WRONG THAT WE LEARN, SAYS S ANANTHANARAYAN

The trouble with the current theories of physics is that they work so well. And yet, the different theories tell only part of the story. Alternate, comprehensive, proposed explanations of nature bring in a new element, which can be tested to say whether there is something missing in the current view.

The current theories of physics are the quantum theory and the General Theory of Relativity. Quantum theory starts from the discovery that at the very fine scale changes of energy are not smooth changes but always in minute steps, like a staircase as opposed to a bannister railing. The theory then deals with the forces between very small objects, like atomic particles or small groups of atoms, at very small distances, like between nearby atoms or within the atom. At this limit of matter, quantum physics has got it right to incredible accuracy — expressed as “one part in 100 billion”, which translates into being right to a hair's breadth over 3,000 miles! But quantum mechanics deals with minute particles that interact through forces that exist only at very small distances, or through the electric force. As the particles are small, there is no reference to the force of gravity.

Einstein's Theory of Relativity takes a new look at the nature of space and time. The theory shows that both these measures depend on the way the observer is moving. Time and distance, hence, appear to be slower and shorter to a moving observer, only providing, fortunately, that the difference is noticeable only when the motion is near that of the speed of light. And out of this comes the proof that mass and energy are forms of the same thing, related by the speed of light, the legendary $E=mc^2$ relation.

Refinement of the theory then leads to considering the quality of mass to be the same as the curve in the dimensions of space and time — again an intuitively incomprehensible idea but one which has been verified by sighting stars during an eclipse that should have been hidden behind the sun, which shows that the mass of the sun has bent the path of light round to reach the earth! The gravitational effects predicted by the theory have again been verified in stellar and planetary dynamics and there is no reason to think that it is anything but exact.

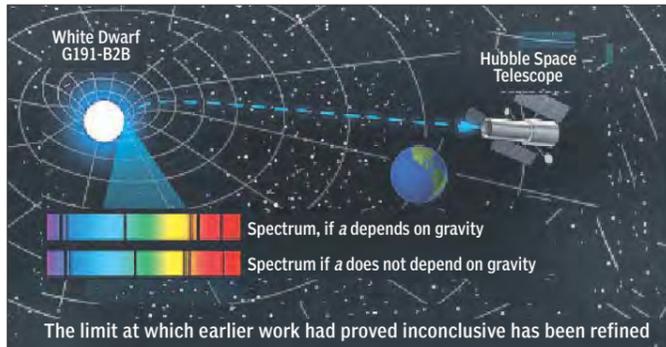
And yet the two theories have no meeting ground; one reigns supreme at the limit of the very small, the other is unquestioned at the scale of the cosmos. Yet neither is good to explain the domain of the other. Scientists have, hence, striven to develop a “unified theory” which would take into account the forces at the atom scale and also the force of gravity. All these theories, however, need to reduce, at the very small and the very large limits, to the existing theories, which are seen to work. A common feature of most of these theories, fortunately, provides a test, albeit difficult, by which we could tell if quantum mechanics is actually not the whole truth, even at the atomic level.

The assumption

All matter is found to consist of fundamental particles containing at least the negatively charged electron and the positively charged proton. With estimates of the masses of these particles and the value of the charge they carry, a comprehensive model of “elementary” particles has been developed, which, with the help of a discipline called *quantum electrodynamics*, has given us the marvels of the modern world. Another observed feature of nature is that when energy is converted to light or vice-versa, there is a proportionality, which is constant, expressed as “h” or Planck's constant, after Max Planck who first proposed it.

Now, while working out interactions of atomic particles and exchanges of energy there are two factors, connected with the masses of the particles and the energy and frequency of light, that recur in the calculations — the *fine structure constant* denoted as “ α ”, which relates the charge on the electron, Planck's constant and the speed of light; and the *ratio of the masses of the electron and the proton*, denoted as “ μ ”. The value of these relationships is, thus, central to the structure of fundamental particles as created by the theory and the values, being derived from observation, are assumed to be constant.

But the alternate theories, which seek to bring gravitation and also discoveries like the expansion of the universe and the existence of dark matter, and quantum electrodynamics into a single theory, generally relate the value of the fine structure constant and



The limit at which earlier work had proved inconclusive has been refined

the electron-proton mass ratio to the time, position or the density of matter at the place.

If any of these theories are the correct explanation of nature, then the values of α and μ would not be constant and the currently accepted model of the particle physics may not be valid in the ancient past or at point deep within space. Scientists have thus gone to great lengths to verify if α and μ remain unchanged in the remotest places — in the hope of finding a difference that would be a lead out of the impasse, of nature being explained so well, but in part only, by a pair of theoretical systems.

Put to the test

S Truppe, RJ Hendricks, SK Tokunaga, HJ Lewandowski, MG Kozlov, Christian Henkel, EA Hinds and MR Tarbutt, of London, Colorado, Gatchina in Leningrad, Bonn and Jeddah, report in the journal *Nature* their latest assessment of the values of α and μ in distant places of space, which shows that any variability is less than the order of one and a half to three parts in 10 million.

A natural way of testing the value of the constants is to measure the energy levels within atoms and molecules, as these levels arise from the values of the constants. α , the fine structure constant, is so named because its value is involved in the splitting of energy levels in atoms, or in molecules, which also depend on the value of μ . Study of the spectral lines, which arise from transitions between energy levels in atoms and molecules, could hence detect variation in the values of α or μ .

The work done so far had detected no variation, but only to the extent of the accuracy of the experiments, which are of the order of a few parts in a million, and there is tentative support for changes at a finer scale. Hence the need for more sensitive measurement and better astronomical observations.

The authors of the present study note that the transitions of a normally short lived molecule, CH, or an atom of carbon and an atom of hydrogen, which is found in low pressure environment in distant places in space, has a pair of transitions with emission in the microwave region, which is notably sensitive to the values of α or μ . The team developed a device to generate and excite these molecules with a reference microwave signal, yielding accuracy down to the units in frequency of the order of 10 million. The frequencies have been compared with emissions from sources in parts of the Milky Way where the density of matter is a tenth of a billionth twice over (10^{19}) of what it is on earth. But as there is inherent uncertainty in the estimates of the radiation from the distant sources, any variation is taken as limited to 1.4 to three in 10 million.

What has been done is to overcome the existing limits of the comparison frequencies and push the accuracy of the assessment to the quality of the signal from the distant source of emission. With dedicated astronomical measurements, using facilities we already have, even higher precision could be reached, the authors say.

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PLUS POINTS

A water world ~ far, far away

The remnants of a lost water world of rocks and oceans has been discovered by astronomers who say they've found the basic ingredients for a habitable planet beyond our Solar System. Astronomers believe the tiny blip on their telescope screens some 150 light years from earth was once a rocky planet with huge amounts of water — the first time rocks and water were found together in one place outside the Solar System.

Water and a rocky surface are assumed to be vital for the origin of life and the discovery of both substances in deep space indicates that the basic building blocks for habitable planets may be widely distributed throughout the cosmos, scientists said. The rocky planetary body or asteroid is an orbiting star called GD 61, a “white dwarf”, where its nuclear fuel has been exhausted.



The asteroid is believed to be the remnant of a small, watery planet that was knocked out of its original orbit and pulled so close to its sun that it was shredded in the process.

Scientists said that the original planet was at least 90 km in diameter, making it a minor entity in terms of size, and that it was once composed of 26 per cent water — by contrast, earth is just 0.023 per cent water. “At this stage in its existence, all that remains of this rocky body is simply dust and debris that has been pulled into the orbit of its dying parent star,” said Professor Boris Gänsicke of the University of Warwick.

“However, this planetary graveyard swirling around the embers of its parent star is a rich source of information about its former life. In these remnants lie chemical clues which point towards a previous existence as a water-rich terrestrial body,” he said. “Those two ingredients — a rocky surface and water — are key in the hunt for habitable planets outside our Solar System, so it's very exciting to find them together for the first time otherwise,” he said.

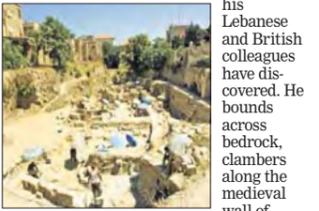
The study, published in the journal *Science* used observations from the Hubble Space Telescope and the giant Keck telescope at Mauna Kea in Hawaii, and was based on the observation that the asteroid contained a large amount of oxygen but little or no carbon — suggesting the presence of water.

“The finding of water in a large asteroid means the building blocks of habitable planets existed — and maybe still exist — in the GD 61 system, and likely also around a substantial number of similar parent stars,” said Dr Jay Farihi of Cambridge University's Institute of Astronomy, the study's lead author. “These water-rich building blocks, and the terrestrial planets that they build, may in fact be common. A system cannot create things as big as asteroids and avoid building planets, and GD 61 had the ingredients to deliver lots of water to their surfaces. Our results demonstrate that there was definitely potential for habitable planets in this exoplanetary system.”

STEVE CONNOR/THE INDEPENDENT

Deadly history

Across the ruins of ancient Sidon, Matt Williams darts like one of the stick-like figures on the Mycenaean pottery he and his



Lebanese and British colleagues have discovered. He bounds across a bedrock, clammers along the medieval wall of Sidon, his hands gesticulating at still-damp wells and Roman columns inserted into Crusader walls. “This is the most exciting excavation I've ever worked on in my career,” he says. “And it will have been the best excavation I will ever work on in the future.”

If dog owners look like their pets, Williams can look slightly like the warriors he has helped unearth, or perhaps the 500 BC shard of Hermes receiving a “suppliant”. Hermes was a messenger of the gods and the god of roads and commerce — as well as cunning and theft, of which the freelance British archaeologist from Cambridge is innocent. With his Lebanese companion Enas Saleh, who has spent 15 years on this wonderful site in the very centre of old Sidon, Williams has spent a mere six years digging through the cult life and feast days and violence of the peoples who live in what is still, from time to time, a dangerous city.

And lest you think this is academic waffle, just listen when he describes the Crusaders' human remains, buried hastily in a mass grave beneath the medieval walls some time around 1250. Some of the Crusaders had been beheaded. “There was some kind of attack and they probably died fighting,” he says.

ROBERT FISHER/THE INDEPENDENT

PLATOON OF PROTECTANTS

TAPAN KUMAR MAITRA DWELLS ON THE FUNGICIDES USED FOR TREATING SEEDS AND PLANTING STOCK

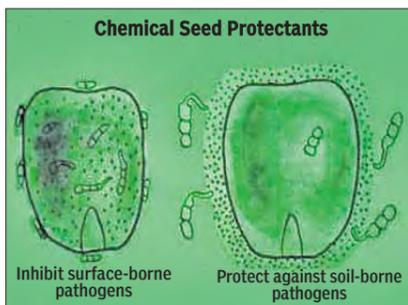
The disinfection of seeds and planting stock by chemical substances is aimed at protecting plants against pathogens that are on the surface of seeds (common bunt of wheat, covered smut of barley, flag smut of rye, loose smut of millet, etc), in and under the hull of seeds (loose smut of oats, leaf blight of wheat, polysporiosis of flax, white rot of sunflowers) and also inside seeds in the embryo (loose smut of wheat and barley).

Seed protectants, as their name implies, protect plants from diseases whose pathogens are in the soil (mould of corn seeds, fusarial wilt and root rots of grain crops, fusarial wilt of flax, black root of beets, root rot of cotton). With respect to their chemical structure, nature of action and designation, the fungicides used for seeds and planting stock can be divided into a number of groups. Mercury-containing protectants are distinguished by the universal nature of their action, they kill the primary infecting organisms on the surface of seeds and in their hulls but are not effective against internal infection. Mercury formulations, however, are very toxic and dangerous to humans and warm-blooded animals and this restricts their use. Seed protectants not containing mercury include formulations of various chemical compositions. These are less toxic to warm-blooded animals but are inferior to mercury-containing formulations in the universal nature of their action.

The greatest favour in agricultural practice has been found by *thiram*. It is highly effective against mould fungi, less effective against bunts and smuts, and has a slight bactericidal action. *Thiram* penetrates poorly under the hulls of seeds, which is why it is only slightly effective as a seed protectant of oat, barley and millet seeds. Mercury-containing formulations or formalin should be used to treat these seeds.

Hexachlorobenzene and quitozene are used to control external infections with smut and bunt. Among the group of organic copper-containing formulations, which are distinguished by their strong bactericidal action, copper trichlorophenolate is used. It is 10 times more toxic to the pathogens of bacterial blight of cotton than *thiram*.

The seed protectant EF-2 is highly effective in controlling the pathogens of seed mould and also of common



on the seeds, the prolonged contact thereof with the seeds intensifies its action and makes it possible to lower the rate of use of the formulation by 20-30 per cent in comparison with pre-planting disinfection.

The regular disinfection of seeds makes it possible to reduce the losses due to many diseases (common bunt, covered smut, root rots, cotton bacterial blight, black root of beets, etc) to virtually imperceptible amounts. Some of the fungicides that are used for the treatment of plants during their vegetation period are also employed for treating seeds and planting stock in addition to the formulations intended only for seed protection.

Benzimidazole derivatives characterised by a broad spectrum of fungicidal action are used for treating the seeds of grain and pulse crops.

Benomyl (a 50 per cent wettable powder) is recommended for dressing the seeds of wheat and barley at rates of two-three kg/tonne of seeds against loose and covered smut, and also the pathogens of mould and root rots. To prevent lodging of the crops, treatment with benomyl may be combined with dressing of the seeds with a 60 per cent solution of chlormequat chloride (six litres per tonne of seeds).

To dress soybeans and lupine, it is recommended to combine treatment with a 50 per cent wettable powder of carbendazim, benomyl (three kilograms per tonne of seeds) with nitrogenising. The treatment with the fungicide is performed not earlier than two weeks before planting, and with the bacterial fertiliser nitragin on the day of planting.

Derivatives of dithiocarbamic acid in addition to quitozene and formalin are used to treat potato tubers against scab, late blight and brown patch. Metiram (a 75 per cent wettable powder) is used for treating seed potato tubers at a concentration of 3.7-3.8 per cent and a rate of 70 litre/tonne of tubers. Metiram is also used for treating sugar beet seeds against black root at a rate of 5 kg/tonne.

Cuprozin-1 is used for treating seed potato tubers in a one per cent concentration at a rate of the formulation of 0.5-one kilogram/tonne. Cuprozin is used in a 0.5 per cent concentration at a rate of 0.25-0.5 kg of the formulation per tonne of tubers. Seed potato tubers may also be treated with benomyl. For this purpose, a 0.5 per cent suspension is used on the day of planting at a rate of 70 litres per tonne of tubers.

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Some nets & sunshine

M SUCHITRA REPORTS ON HOW FISHERS IN A TAMIL NADU VILLAGE SAVE COSTS AND IMPROVE CATCH WITH SOLAR PANEL-FITTED BOATS

Little Flower doesn't look different when viewed from outside. Even the interior of this fishing boat is no different from the others anchored nearby. It has a diesel engine, a wheelhouse, a cabin for storing fish, tools of the trade, modern gadgets like GPS, sonar fish-finder, a wireless set and, of course, a television, a grinder and a dozen CFL bulbs.

“Please have a look there,” insists M Sahayaraj, proud owner of the boat, pointing at the rooftop of the wheelhouse, which is fitted with four solar panels. “These panels help me save a good amount on diesel and get a good catch,” he says with a wide smile.

Sahayaraj lives in Thoothoor, a small fishing village along the western coast of Tamil Nadu's Kanyakumari district. Thoothoor fishers are traditional shark hunters. “They are adventurous and enterprising,” says J Vincent Jain, chief executive officer of the Association of Deep Sea Going Artisanal Fishermen, a non-profit organisation in Thoothoor. “More than that, they are innovative.”

Praise the Lord is another boat that runs its gadgets on solar power and Jain says Thoothoor's fishers are probably the first in the country to use solar energy in commercial fishing boats. Over the past few decades, Thoothoor's artisanal fishers have shifted to boats fitted with diesel engines and other modern equipment, leaving behind their traditional rowing boats and rafts. Now there are about 500 diesel-powered boats in the village, all capable of venturing up to 400 nautical miles into the sea, enabling their owners to fish across the country's two million square kilometres of territorial waters, called the Exclusive Economic Zone.

“We stay out at sea for 30 to 40 days if we find a good fishing ground,” says Sahayaraj. “Each boat employs 10 to 15 people, so we have to carry everything along with us — food, water, diesel and ice blocks — to last for more than a month.”

“We carry about 10,000 litres of water, 7,000 litres of diesel and 800 blocks (one block weighs about 40 kg) of ice along with us,” says A Sil Verian, another fisher from

Thoothoor. “A month-long fishing trip costs us about Rs 5 lakh. Diesel accounts for a major part of the expense, say about 70 per cent.”

One of the reasons for such high fuel consumption is that most boat owners buy used truck engines to save money. Besides, though engines can be turned off while fishing, fishers run it continuously to avoid restarting troubles and to recharge batteries that are the main source of power for lighting the boat and operating navigational and other safety equipment. “The cost of fishing has increased in tandem with diesel prices but the catch remains the same,” says V Romane, secretary of the association. As a result, many fishers in Thoothoor are now facing losses and are in the grip of moneylenders.

Heavy losses prompted the community to pool ideas on how to reduce diesel consumption. “Cutting down fuel was necessary to earn profits from fishing while curbing greenhouse gas emissions from burning of diesel as the gases affect fish stocks,” says Jain. The association organised workshops to create awareness among the community about clean, renewable sources of energy. Many fishers preferred solar energy as an alternative.

“It was a challenge for us,” says Kichu Krishnan, managing director



Little Flower, the first fishing boat in Thoothoor, Tamil Nadu, to use solar power.

of Sirius Controls. “We had never worked for the fishing sector.” Jagath Jothi worked on *Praise the Lord* and Sirius Controls on *Little Flower*. It took months before the boats could be fitted with solar panels. Four panels each with a capacity of 250 Watts were fitted on the rooftop of the wheelhouse. Together the panels generate about one kilowatt, sufficient to light the boat and run the gadgets. “But the power generated is too little to propel the engines of commercial fishing boats,” Ravisunthar says.

The cost of fitting solar panels, control board and wiring on *Little Flower*, the bigger boat, was Rs 3.75 lakh. Sirius Controls did it for free. For *Praise the Lord*, the cost was Rs 1.80 lakh.

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