Zeroing in on a distant planet

THE outermost in the Solar System, Pluto has been in the spotlight. s ananthanarayanan **elaborates**

SEVEN major planets were discovered by the ancients while gazing at the night sky and noticing specks of light that changed position. In modern times, the masses of these planets were worked out, their orbits plotted by the laws of physics. When discrepancies were noticed in the observed orbits, this suggested the existence of other planets. In the 1940s, discrepancies in the orbit of Uranus suggested the existence of Neptune, which was discovered later in the century. But the orbits still did not fit and the search continued for yet another planet.

Percival Lowell, a wealthy benefactor who founded the Lowell Observatory in Arizona, started a vigorous hunt for this elusive planet. The effort was stalled for some years after his death, in 1915, but was resumed in 1929. A young astronomer called Clyde Tombaugh was assigned the task of comparing photographs of the night sky, taken two weeks apart, to spot any movement. After a year of painstaking comparison, a possible moving object was identified and, after confirmation, on 13 March 1930, the discovery of the ninth planet, later named Pluto, was announced. Pluto does not quite fit into the extra planet predicted by calculations earlier in the century, but after refining all the data available there is no longer need for that.

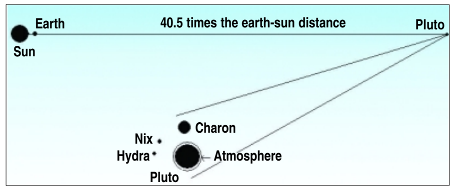
One part of the new data available is the mass of Pluto itself, which became available with accuracy when Charon, Pluto's largest moon, was discovered. Further studies of Pluto and Charon blocking out stars, as they pass before them, has helped us work out the size and shape of the planet. We now know that Pluto has less than one per cent of the mass of earth and about 66 per cent of the diameter of the moon.

Occultation

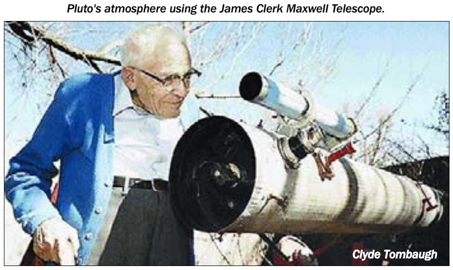
The method of watching starlight which gets blocked by an object, for studying the shadow, is called *occultation*. Faint objects, like Pluto and its moons, are good candidates for such study. While the complete blocking of starlight shows the physical limits of the object, a gradual dimming of starlight shows the partial absorption by an *atmosphere* of the occulting object. Studies of both Charon and Pluto show that the former has no atmosphere, but the latter does. Pluto's atmosphere has been studied through a series of occultations for the last 25 years. The Royal Astronomical Society in the UK recently announced results culled from observations the world over, for the last two decades.

In the controversy of whether Pluto should be regarded as a planet in view of a more massive object – *Eris* was discovered in the outer Solar System – it was relegated to the status of a *minor* and thereby *dwarf* planet.

But among the handful of "dwarf" planets, Pluto is still the only one to have an atmosphere that is understood to arise from the evaporation or sublimation of frozen gases on its surface as it warms when it approaches the sun. Why other dwarf planets do not show an atmosphere is a question demanding an answer, but Pluto's atmosphere has displayed features that make it a subject of great interest.



Pluto's atmosphere using the James Clerk Maxwell Telescope.



Clyde Tombaugh

After its discovery through occultation in 1985, and again in 1988, a study in 2002 showed that the atmosphere had become more dense than before. An important factor of Pluto's atmosphere is the planet's elongated orbit. The planet spends long periods much further away from the sun than when swiftly turning past, when it is closest. The gases in the atmosphere freeze during the long, cold period and the ices begin to sublime when Pluto warms on nearing the sun. The subliming of ice again causes cooling, somewhat like we cool down when we perspire. This effect, which is called *anti-greenhouse*, has recently been confirmed by accurate temperature measurements that, incidentally, confirm the source of the atmosphere. When the planet pulls away from the vicinity of the sun, heat gained is retained, depending on the quantities of greenhouse gases, and it is not necessary that the last gases to sublimate will be the first ones to condense and freeze.

New results

The 15-metre James Clerk Maxwell Telescope at Hawaii has thrown up twin, unexpected results. One is that the atmosphere is now 3,000 km deep, against earlier observations of only about 100 km. This distance of 3,000 km is nearly a quarter of the way to the moon, Charon. Pluto made its closest approach to the sun in 1989, which is not so long ago, as the planet takes 248 years for each orbit. But since 1989, Pluto has been receding and what is being seen is perhaps the result of a warm period. The extended atmosphere is exceedingly cold, at more than 220? Celsius below freezing and tenuously held by the tiny planet. Expansion of the atmosphere typically causes loss of atmosphere to outer space.

"The height to which we have seen carbon monoxide agrees well with models of how the solar wind strips Pluto's atmosphere," says team member Dr Christiane Helling of the University of St Andrews.

The other unexpected result is that the atmosphere is rich in carbon monoxide. Pluto's atmosphere is known to be largely nitrogen, with traces of methane, a greenhouse gas, and carbon monoxide. Carbon monoxide is the reverse of a greenhouse gas.

It warms fast and radiates heat back to space, unlike carbon dioxide, or methane, which warms slowly and retains heat. The balance between the levels of methane and carbon monoxide would thus affect the temperature graph during the long winter in the decades to come. The discovery of carbon monoxide may imply cooling and less loss of atmosphere. But too much cooling would cause nitrogen snowfalls and all the gases freezing to the ground. The cycle of freezing and sublimation, and the ratio of the gases, may have settled into a pattern, or it may still be varying from season to season.

"Seeing an example of extraterrestrial climate change is fascinating," says team leader Dr Jane Greaves, also from St Andrew's. "This cold, simple atmosphere that is strongly driven by the heat from the sun could give us important clues to how some basic physics works and act as a contrasting test-bed to help us better understand the earth's atmosphere."

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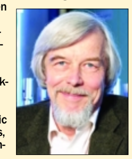
Small numbers

Hadron chief admits that 'we may not have found the God particle after all'. steve connor **reports**

FEVERED speculation about the discovery of the so-called "God particle" by physicists at Europe's underground atom-smasher experiment is premature, according to the director-general of the European Organisation for Nuclear Research (Cern) near Geneva. Professor Rolf Heuer says his scientists had detected "intriguing fluctuations" in the data gathered by Cern's Large Hadron Collider, which is searching for the elusive Higgs boson, a subatomic particle predicted by Professor Peter Higgs of Edinburgh University in the 1960s but so far never detected.

He cautions that the data fluctuations detected by Cern scientists may turn out to have nothing to do with the Higgs boson and could even be random statistical "noise" generated when beams of protons are crashed together within the LHC at velocities just short of the speed of light.



Professor Rolf Heuer.

The Higgs, mischievously nicknamed the "God particle" by one physicist, is predicted to confer mass to other subatomic particles and matter. If it exists, the LHC — a 27-km circular tunnel that straddles the Swiss-French border — is powerful enough to detect it, but researchers have first to eliminate any random fluctuations that could interfere with their observations, which is why they are urging caution about these early results.

"Don't expect too much too quickly," Professor Heuer told an international meeting of physicists in Grenoble to review the LHC's first few months of gathering data. "You have to be careful about combining small numbers because you can easily be fooled. I hope the first big discovery will come next year, namely the discovery of the Higgs boson. I have learned in life to be patient, something will come."

It is still possible that the particle does not actually exist, but that would mean physicists would have to abandon the Standard Model, their fundamental theory of how the many different subatomic particles interact with one another. Two experiments attached to the LHC, called Atlas and CMS, are both detecting interesting fluctuations in the "low mass" region of energy levels where the Higgs could exist, according to Professor Heuer. However, so far the evidence is still equivocal and is unlikely to be strong enough to confirm or refute the existence of the Higgs until the end of 2012.

"I think towards the end of next year we'll have the answer. The Higgs is not like any other subatomic particle. The difference is that with the Higgs we know everything about it, but whether it exists," says Professor Heuer. "(Its discovery) will come slowly. In the meantime you will hear what I can only call rumours, but slowly the right signal will be creeping up, and we need to see it creeping up in both experiments. We are really living in exciting times for particle physics. To a large extent it's due to the LHC. It's working really well, beyond my expectations.

"Now it's bringing us into unchartered territory. We are still missing the Higgs boson, the key particle of the Standard Model. If we find it, the Standard Model is complete, and if we don't find it then the Standard Model has a problem," he said. "If we fail to find the Higgs, the Standard Model is no longer valid as we know it today."

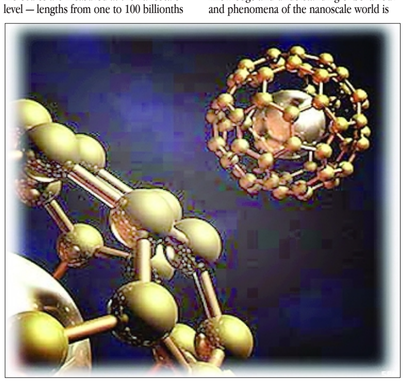
The Independent, London

Nature's toy box

Nanotechnology holds forth the promise of surprising discoveries in the near future, says shiva sharma

NANOTECHNOLOGY is an innovation in the world of science and technology which has made us realise that "there are spaces in the world too small to be seen with even the most powerful optical microscopes, where atoms and molecules are measured at the nanoscale level — lengths from one to 100 billionths of a metre". This fact was first conceived by scientist Richard Feynman whose 1959 speech "There's Plenty of Room at the Bottom" shed light on the term nanotechnology, which has now become an umbrella term for a wide range of technologies. It is rightly said by Horst Stormer, "Nanotechnology has given us the tools to play with the ultimate toy box of nature — atoms and molecules. Everything is made up of it and possibilities to create new things appear limitless"

Nanotechnology emerged by the implementation of nanoscience, the science of building materials and devices using single atoms and molecules. Thus knowledge and understanding of behaviour and phenomena of the nanoscale world is nanoscience and when we study, observe, experiment and build materials from the individual atoms and molecules we deal in nanotechnology. It has been already been observed that everything is made up of molecules which in turn are made up of atoms; customisation at these levels to get a useful product is what nanotechnology helps us to achieve.



Nanoscopic machines, called assemblers, can be programmed to manipulate atoms and molecules at will.

What is it all about?

Nanotechnology has been understood by different scientists in different ways and so we can have many definitions, but what is more significant is that it can be utilised in different fields with great benefit. Nanoscience is an interdisciplinary subject and is used in many fields for achieving desired results.

In the early years, when K Eric Drexler popularised the word nanotechnology, he was talking about building machines on the scale of molecules, a few nanometers wide — motors, robot arms and even computers smaller than a cell. Thus the evolution of nanotechnology was divided into four stages: "passive nanostructures", "active nanostructures", "systems of nanosystems" and "molecular nanostructures". The prefix "nano" in both science and technology refers to the unit of 10-9, which means really small. It has been observed in research that at nanoscale (10^{-9}m), the physical, chemical and biological properties of material differ in fundamental and valuable ways from the properties of individual atoms and molecules of bulk matter. Materials at nanoscale can behave very differently from when they are in larger form. Nanomaterials can be stronger or lighter, or conduct heat or electricity in different ways. Moreover, by changing just the molecular structure of a material it is even possible to control fundamental properties of materials like their melting temperature, magnetic properties, charge capacity and even colours without changing their chemical compositions. Particles of gold can appear red or blue, depending on their size. Building something out of these materials is difficult but can produce tremendous results. Although nonmaterial processes occur at the nano scale level, the objects and result scan can be much larger.

Nano robots are extensively used to destroy cancer cells.

Applications

Nanotechnology is not just a concept of material science but it has implementations in physics, chemistry, biology, computer science, mechanical and electrical engineering. Nanotechnology is distinguished by its interdisciplinary nature. A lot of work has already been done in nanotechnology and there is tremendous scope for improvement. Scientists have already applied it in various fields and it holds forth the promise of surprising discoveries in the near future. Let us take a quick look at the various ways it has been applied with success.

In IT and electronics nanotechnology has worked miracles. It is used in the miniaturisation of devices in the semiconductor industry and is behind major inventions in computer science for example, nanochips. Nanotechnology offers tools to understand/transform silicon technology. It is behind the improvement in display screens and electronic devices. (Replacement of CRT by electron-producing carbon nanotubes, for instance). High resolution Recordable Compact Discs with progressive scans are built with nanotechnology that displays the best in picture quality. And only because of nanotechnology, nonvolatile random access memory cards have been designed that are almost 10 times better compared with similarly-sized regular Ram. The wireless laser mouse is just right for medical offices, libraries and schools as well as mobile professionals, gamers and desktop users. As there is nano coating in the mouse it contains anti-microbial properties, which protect the device from bacteria. Nano robotics is a technology for creating machines at, or close to, a microscopic scale of nanometers. Researchers the world over are working to produce designs of nanocomputers (DNA and quantum computers).

Demand for better surface finish and accuracy has increased rapidly in recent years. Nano surface finish has become an important parameter in the semiconductor industry, too Chemical nanotechnology is no longer a new field. Chemical catalysts coating, alloys, abrasives and glues are typical examples of the use of nanotechnology in the domain.

Nanobiotechnology or biomedical nanotechnology studies elements to produce new devices. In the life sciences this technology is used in nanocells (Globblebot — an artificial white blood cell.) It is used in biomedicines and the diagnosis and therapy of cancer. For example, nanotubes, nano medicines and nanogels. Tiny machines (nano robots) inserted in the body can be used to cure cancer, as cancer cells can be killed without painful side effects of chemotherapy. Tumors, too, can be destroyed in a similar fashion without killing healthy cells. Using nanotechnology in biometric sensors for medical therapies has been rendered possible. Carbon tubes are already helping deliver drugs. Scientists have microscopic robots floating in the blood fighting cancer cells, the Aids virus, genetic disorders or even ageing. Nanotechnology has revolutionised the pharmaceutical industry by changing the ways drugs are produced and delivered.

Nanotechnology is now extensively used in defence to manufacture secure, lighter and accurate sensors. As nanotechnology is replacing conventional material the quality of weapons is improving and more rigid and lighter material is being manufactured. Nanotechnology has contributed towards the betterment of human life and the environment by significantly reducing the production of waste; it no longer impossible to create devices to convert household waste into fresh food, diamond rings or antique works of art!

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