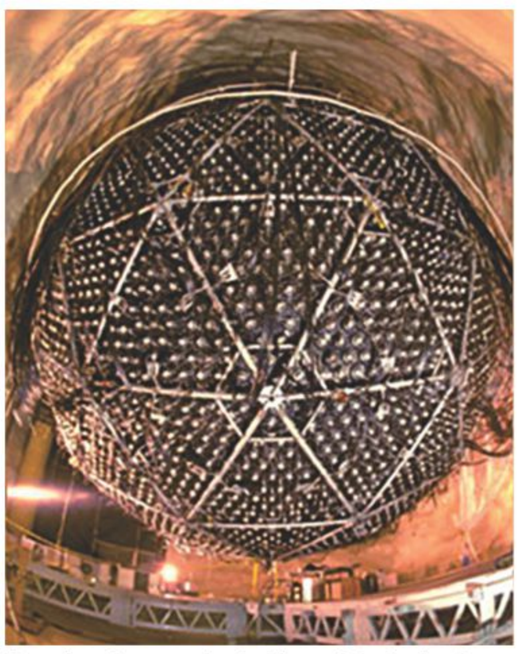
Neutrino - gate keeper of the Universe

QUAMRUL HAIDER, *Ph.D*

OUT of the hundreds of elementary particles floating around in the Universe, surprisingly the elusive neutrino holds clues to some of the most profound questions in astronomy. These chargeless, near-massless, structureless particles zipping around at nearly the speed of light have lately been in the headlines for violating the cosmic speed limit of 300,000 kilometers per second. Neutrinos (Italian for "little neutral ones") come in three "flavors": electron neutrino, muon neutrino, and tau neutrino.

The number of neutrinos moving freely throughout the Universe since the Big Bang is staggering, about 300 million in every cubic meter. The Sun and supernovae (exploding stars that have reached the end of their life) are the primary sources of neutrinos reaching us. Every second over 500 trillion solar neutrinos enter every square meter of the Earth's surface exposed to the Sun. By the time you finish reading this paragraph, about trillion neutrinos will pass through your body. But don't panic, they are inert and harmless; just "little bits of spin-energy that have got detached," according to astrophysicist Arthur Eddington.

Why should we care about these furtive particles? Strange as it may seem, the intrinsic properties of neutrinos make them an influential player in the field of cosmology. They carry a wealth of information of great cosmic significance, about the high-energy events that produced them, deep secrets of the cosmos from distant galaxies and the remote past. They are essential in understanding what happened in the briefest moments after the Big Bang. They can tell us why the Universe contains more matter than anti-matter. If they have mass, even if it is miniscule, it will be the dominant form of matter in the Universe.



Neutrino detector buried in a nickel mine in Sudbury, Canada.

Neutrinos act as telescopes and allow us to take a peek into the interior of the Sun. They are critical in understanding stellar evolution and dynamics of supernovae where heavy elements are produced. They are living witnesses of star birth and their violent death. Just like red shift and cosmic microwave background radiation, neutrinos have a tale to tell about the Universe of which they are part. Detection of neutrinos, therefore, is crucial if we want to have a handle on all of these and other aspects of cosmology.

It is notoriously difficult to detect these ephemeral particles. They announce their presence only through weak interaction associated with the radioactive break-up of a nucleus.

Occasionally neutrinos do interact with matter making it possible to capture a few of them if the detectors are large enough. Also known as "neutrino telescope," the detector is a huge tank filled with large amount of liquid such as chlorine-rich cleaning fluid or heavy water. The liquid increases the chances for particle interaction. The detectors must be placed deep underground, beneath a mountain or inside a mine, so that only neutrinos can reach them. All other particles coming from outer space that could befuddle the detectors are blocked by the thick layers of overlying rocks.

The earliest detector built in 1967 is buried nearly a mile deep in a gold mine at Homestake, South Dakota. It was expected that out of the trillions of neutrinos that will reach the detector, the capture rate would be at least one per day. After more than two decades, it was found that on the average it trapped only one neutrino every three days. A more recent detector buried in a nickel mine in Sudbury, Canada revealed that the neutrinos on their way to the Earth can change flavor. The Homestake detector was tuned for only one flavor, the electron neutrino; hence the low count rate.

Clearly, the problem of detecting neutrinos is of immense proportions. We still have "miles to go" before we can say we are on the verge of solving the neutrino puzzle. However, the detection in 1987 of more than the expected number of neutrinos from a supernova explosion 168,000 light years away by underground telescopes in Japan and Ohio has infused new life into neutrino physics. Physicists are now more than ever inspired to build some of the most sophisticated detectors to find and unmask the guise of this gate keeper of the Universe.

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SPACETRAMP

Free-floating planet

NOT all planets are content to dutifully circle a star. A new rogue planet has been spied roaming free among a pack of young stars about 115 to 160 light-years from Earth.

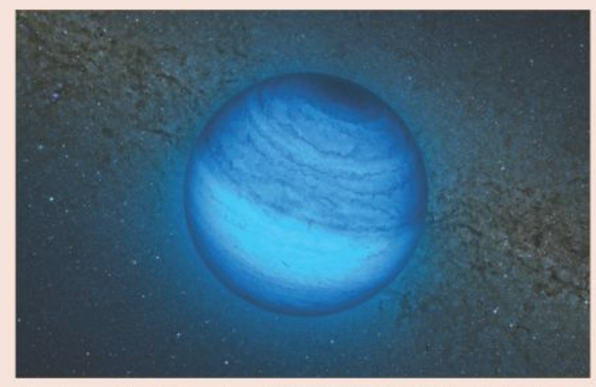
It's not a planet in the conventional sense, because it doesn't orbit a star. Yet it's between four and seven times the mass of Jupiter, well within planetary size range. The object appears to be a young, cold planet in a cluster of about 30 stars moving together called AB Doradus, astronomers report in the December Astronomy & Astrophysics. The free-floating planet is the closest to Earth yet discovered, scientists say.

"It's quite a nice discovery probably the clearest example of a planetary mass object that's very young like this," says astrophysicist Philip Lucas of the University of Hertfordshire in England, who was not involved with the study.

Other potential free-floating planets have been detected before, but their ages weren't as well known. Astronomers couldn't be sure the objects were planets and not brown dwarfs, failed stars too small to sustain fusion reactions in their cores.

The newfound object, dubbed CFBDSIR2149, lies in the southern constellation Dorado. Scientists estimate the planet is between 20 million and 200 million years old, based on the assumption that it was formed around the same time as the stars that it accompanies.

Source: **Science News**



The free-floating planet CFBDSIR2149 (artist's illustration shown) is the nearest planet-like object found not orbiting a star.

LIGHT & GENETICS

Neurons from Stem Cell

Researchers have found a way to stimulate stem cell-derived neurons to direct cognitive function after transplantation.

RESEARCHERS and patients look forward to the day when stem cells might be used to replace dying brain cells in Alzheimer's disease and other neurodegenerative conditions. Scientists are currently able to make neurons and other brain cells from stem cells, but getting these neurons to properly function when transplanted to the host has proven to be more difficult. Now, researchers at Sanford-Burnham Medical Research Institute have found a way to stimulate stem cell-derived neurons to direct cognitive function after transplantation to an existing neural network.

The study was published November 7 in the Journal of Neuroscience.

"We showed for the first time that embryonic stem cells that we've programmed to become neurons can integrate into existing brain circuits and fire patterns of electrical activity that are critical for consciousness and neural network activity," said Stuart A. Lipton, M.D., Ph.D., senior author of the study. Lipton is director of Sanford-Burnham's Del E. Webb Neuroscience, Aging, and Stem Cell Research Center and a clinical neurologist.

The trick turned out to be light. Lipton and his team -- including Juan Piña-Crespo, Ph.D., D.V.M., Maria Talantova, M.D., Ph.D., and other colleagues at Sanford-Burnham and Stanford University -- transplanted human stem cell-derived neurons into a rodent hippocampus, the brain's information-processing center. Then they specifically activated the transplanted neurons with optogenetic stimulation, a relatively new technique that combines light and genetics to precisely control cellular behavior in living tissues or animals.

Source: **Science Daily**

NANO CONVERTER

Power from light and heat

A University of Texas at Arlington physics professor has helped create a hybrid nanomaterial that can be used to convert light and thermal energy into electrical current, surpassing earlier methods that used either light or thermal energy, but not both.

A new hybrid nanomaterial can be used to convert light and thermal energy into electrical current.

Working with Louisiana Tech University assistant professor Long Que, UT Arlington associate physics professor Wei Chen and graduate students Santana Bala Lakshmanan and Chang Yang synthesized a combination of copper sulfide nanoparticles and single-walled carbon nanotubes.

The team used the nanomaterial to build a prototype thermoelectric generator that they hope can eventually produce milliwatts of power. Paired with microchips, the technology could be used in devices such as self-powering sensors, low-power electronic devices and implantable biomedical micro-devices, Chen said.

"If we can convert both light and heat to electricity, the potential is huge for energy production," Chen said. "By increasing the number of the micro-devices on a chip, this technology might offer a new and efficient platform to complement or even replace current solar cell technology."

In lab tests, the new thin-film structure showed increases by as much at 80 percent in light absorption when compared to single-walled nanotube thin-film devices alone, making it a more efficient generator.

Copper sulfide is also less expensive and more environment-friendly than the noble metals used in similar hybrids.

In October, the journal Nanotechnology published a paper on the work called "Optical thermal response of single-walled carbon nanotube-copper sulfide nanoparticle hybrid nanomaterials." In it, researchers also say also found that they could enhance the thermal and optical switching effects of the hybrid nanomaterial as much as ten times by using asymmetric illumination, rather than symmetric illumination.

Coauthors on the Nanotechnology paper from Louisiana Tech include Yi-Hsuan Tseng, Yuan He and Que, all of the school's Institute for Micromanufacturing.

"Dr. Chen's research with nanomaterials is an important advancement with the potential for far-reaching applications," said Pamela Jansma, dean of the UT Arlington College of Science. "This is the kind of work that demonstrates the value of a research university in North Texas and beyond."

Chen is currently receiving funding from the U.S. Department of Defense to develop nanoparticle self-lighting photodynamic therapy for use against breast and prostate cancers. In 2010, he was the first to publish results in the journal Nanomedicine demonstrating that near infrared light could be used to heat copper sulfide nanoparticles for photothermal therapy in cancer treatment, which destroys cancer cells with heat between 41 and 45 degrees Celsius.

Next month, the Journal of Biomedical Nanotechnology will publish Chen's work successfully coupling gold nanoparticles with the copper sulfide nanoparticles for the photothermal therapy. Such a material would be less costly and potentially more effective than using gold particles alone, Chen said.

Source: **Science Daily**

IT'S THERETOO

Carbon at the core

A tiny fraction of carbon helps account for the oddly light density of Earth's iron core, a new computer simulation finds.

Though the core is only 0.1 percent to 0.8 percent carbon, the iron ball is the largest reservoir of carbon on the planet, the study authors said.

An impenetrable 1,790 miles (2,890 kilometers) below the planet's surface, the core is a compelling mystery. The density of pure iron is heavier than the core's observed density, which is calculated from seismic and laboratory studies.

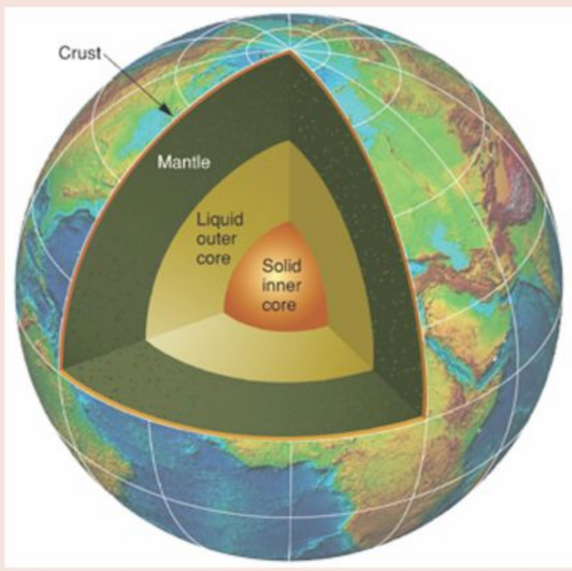
Even though the bulk of the core is iron, scientists have surmised it must contain a small amount of lighter elements such as oxygen and sulfur. Using computer simulations, researchers from the University of California, Davis, and the Chinese Academy of Sciences in Beijing tested whether Earth's most common element, carbon, also hides in the core.

"We knew the density of the core, and we knew that metal iron and nickel alone couldn't account for that density," said Qing-Zhu Yin, UC Davis geology professor and study co-author. "You need something lighter."

Previous estimates of the carbon content of the core have differed by a factor of 20, Yin wrote in the study.

In the computer model, carbon was one of the major missing light element candidates; others included silicon, oxygen, phosphorus, magnesium, hydrogen and nitrogen. An accurate knowledge of carbon's influence can help pinpoint the exact timing of the core's formation.

Source: **Live Science**



Different layers inside the Earth. Scientists think carbon in the core may account for its light density.

LUST FOR WARMTH

Penguins in a colony pack extremely tightly together, but still shuffle around without crushing anyone.

Cozy penguin huddle

Source: **Live Science**

Greed is good for penguins that huddle together to avoid Antarctica's icy weather.

According to a new study, penguin groups can maximize everyone's heat when individual birds act selfishly, huddling in ways that keep them toastiest.

"Even if penguins are only selfish, only trying to find the best spot for themselves and not thinking about their community, there is still equality in the amount of time that each penguin spends exposed to the wind," study researcher Francois Blanchette, a mathematician at the University of California, Merced, who normally studies fluid dynamics, said in a statement.

DID YOU KNOW?

What is the Rio Hamza?

It is name of an underground river that flows 4 Kilometres below the Amazon.

An aerial view ... the Amazon river.

THE Amazon basin covers more than 7 million square kilometres in South America and is one of the biggest and most impressive river systems in the world. But it turns out that - until now - we have only known half the story.

Brazilian scientists have found a new river in the basin - around four kilometres underneath the Amazon River. The Rio Hamza, named after the head of the team of researchers who found the groundwater flow, appears to be as long as the Amazon but up to hundreds of times wider.