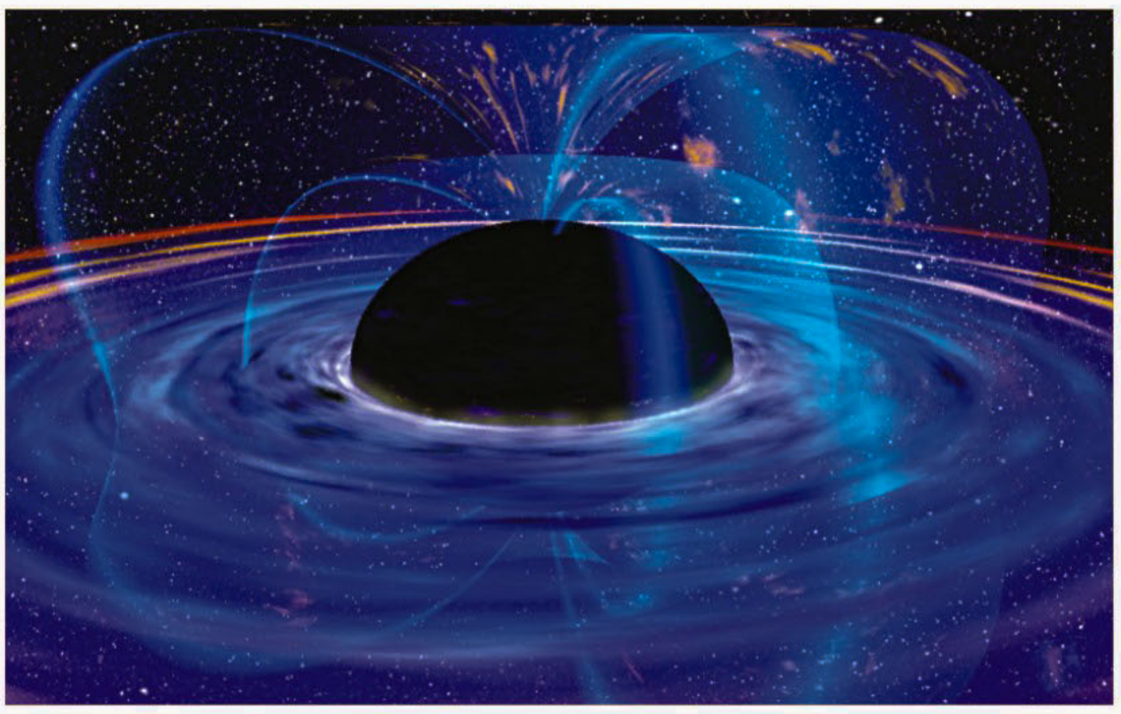
Black holes and string theory

DEBASHISH CHAKRABORTY

RECENT astrophysical measurements have revealed the existence of a supermassive black hole at the centre of our galaxy, the Milky Way. These measurements also show that black holes are ubiquitous in our Universe. Thus, black holes do not just represent exotic solutions to Einstein's theory of General Relativity: they really exist in Nature.

A black hole possesses a surface, called the event horizon, which separates the interior of the black hole from the outside region. The area of this surface determines the thermodynamic Bekenstein-Hawking entropy of the black hole. This entropy should, according to Boltzmann, have a statistical interpretation in terms of microstates of the system, i.e. of the black hole. Thus, any candidate theory for a consistent theory of quantum gravity has to be able to identify these microstates, and their subsequent counting has to reproduce the thermodynamic entropy of the black hole.

String theory is a leading contender for a consistent theory of quantum gravity. With the pioneering work of Strominger and Vafa, it has become evident that it is possible to identify and to count black hole microstates in the context of string theory. At the current juncture, the black holes that are best understood are those that arise as solutions to theories of gravity with a certain amount of supersymmetry. Supersymmetry is a symmetry that relates bosons and fermions, and the amount of supersymmetry is calculated by the number of generators of this symmetry. These generators are called supercharges, and the black holes arising in string theory that are best understood are those with eight supercharges. Black holes of this type are supported by scalar fields, and this exhibit an interesting flow mechanism termed the attractor mechanism. This mechanism states that as one moves towards the event horizon of the black hole, the scalar fields flow to specific values at the event horizon, thereby losing all memory of their initial values far away from the horizon.



Artist's rendition of a black hole

The attractor mechanism is at the heart of the recent progress in string theory in reproducing the thermodynamic black hole entropy by microstate counting. The latter exhibits fascinating connections with topological string theory and with the theory of automorphic forms. Topological string theory is a simplified topological version of full-fledged string theory that appears to capture the microstates of super symmetric black holes. Automorphic forms are an extension to several complex variables of the concept of analytic functions on the upper half-plane satisfying a certain functional equation.

In addition, the microstates should also be captured by the enigmatic AdS2/CFT1 correspondence. The AdS/CFT correspondence, discovered by Maldacena, describes a deep connection between gravitational theories in d-dimensional spacetimes and field theories in one dimension lower. It states that quantum gravity (closed string theory) in anti-de Sitter spacetimes has an equivalent (dual) description in terms of conformal field theories (open string theory) in one dimension lower, living at the boundary of anti-de Sitter spacetime. The AdS2/CFT1 correspondence is a poorly understood example of this duality.

Despite much work in this area, our understanding of black holes with eight supercharges is far from being complete, and it is likely that many more surprises will emerge. Ultimately the goal is to obtain an understanding of realistic black holes, i.e. of black holes with no super symmetry at all.

The writer is a student at the Dept. of Computer Science and Engineering, BRAC University

WATER OF HOPE

Largest, oldest mass of water

This artist's concept illustrates a quasar, or feeding black hole, where astronomers discovered huge amounts of water vapour

ASTRONOMERS have discovered the largest and oldest mass of water ever detected in the universe a gigantic, 12-billion-year-old cloud harboring 140 trillion times more water than all of Earth's oceans combined.

The cloud of water vapor surrounds a supermassive black hole called a quasar located 12 billion light-years from Earth. The discovery shows that water has been prevalent in the universe for nearly its entire existence, researchers said.

"Because the light we are seeing left this quasar more than 12 billion years ago, we are seeing water that was present only some 1.6 billion years after the beginning of the universe," said study co-author Alberto Bolatto, of the University of Maryland , in a statement. "This discovery pushes the detection of water one billion years closer to the Big Bang than any previous find."

Studying a distant quasar

Quasars are the most luminous, most powerful and most energetic objects in the universe. They are powered by enormous black holes that suck in surrounding gas and dust and spew out huge amounts of energy.

The research team studied a particular quasar called APM 08279+5255, which harbors a black hole 20 billion times more massive than the sun and produces as much energy as one quadrillion suns.

The astronomers used two different telescopes, one in Hawaii and one in California , to detect and confirm the water vapor surrounding the quasar.

Scientists think water vapor was present even in the early universe. So finding this old cloud of the stuff doesn't come as a shock.

"It's another demonstration that water is pervasive throughout the universe, even at the very earliest times," said study lead author Matt Bradford of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

However, the sheer size of the vapor cloud may surprise some scientists. APM 08279+5255 contains 4,000 times more water vapor than our own Milky Way galaxy, researchers said. That may be because much of the Milky Way's water is locked up in ice rather than vapor.

Learning about the quasar

The water vapor in the quasar is distributed around the massive black hole in a region spanning hundreds of light-years. The cloud has a temperature of minus 63 degrees Fahrenheit (minus 53 degrees Celsius), and it's 300 trillion times less dense than Earth's atmosphere.

Source: Live Science

YOUNG INVENTORS

Spark-proof switch

EUGS students at the spark-proof switch project

RAFIQUL ISLAM

TENTH grade students, Hasna Hena Mou and Jinia Akter Arianna, of the Engineering University Girls School (EUGS) have designed a 'spark proof electric switch.'

The `spark-proof switch' they designed can be used both for AC and DC power lines. This switch is safer than the usual electric switches available in the market. Mercury has been used to make the switch more convenient to design.

The main part of the switch, which resembles a tube, is coated in glass as insulator. The positive and negatives poles of the switch remain within the glass coating. Any spark created is absorbed by the Mercury. The 'spark-proof switch' project won the 3rd place at a Science Fair held on the BUET premises.

The writer is a student of Rajuk Uttara Model College

LIFE GETS WIDER BASE

New bases of DNA found

FOR decades, scientists have known that DNA consists of four basic units -- adenine, guanine, thymine and cytosine. Those four bases have been taught in science textbooks and have formed the basis of the growing knowledge regarding how genes code for life. Yet in recent history, scientists have expanded that list from four to six.

Now, with a finding published online in the July 21, 2011, issue of the journal Science, researchers from the UNC School of Medicine have discovered the seventh and eighth bases of DNA.

These last two bases -- called 5-formylcytosine and 5 carboxylcytosine -- are actually versions of cytosine that have been modified by Tet proteins, molecular entities thought to play a role in DNA demethylation and stem cell reprogramming.

Thus, the discovery could advance stem cell research by giving a glimpse into the DNA changes -- such as the removal of chemical groups through demethylation -- that could reprogram adult cells to make them act like stem cells.

"Before we can grasp the magnitude of this discovery, we have to figure out the function of these new bases," said senior study author Yi Zhang, Ph.D., Kenan Distinguished Professor of biochemistry and biophysics at UNC and an Investigator of the Howard Hughes Medical Institute. "Because these bases represent an intermediate state in the demethylation process, they could be important for cell fate reprogramming and cancer, both of which involve DNA demethylation."

Much is known about the "fifth base," 5-methylcytosine, which arises when a chemical tag or methyl group is tacked onto a cytosine. This methylation is associated with gene silencing, as it causes the DNA's double helix to fold even tighter upon itself.

Newly discovered seventh and eighth bases of DNA -- called 5-formylcytosine and 5 carboxylcytosine -- are actually versions of cytosine

Last year, Zhang's group reported that Tet proteins can convert 5 methylC (the fifth base) to 5 hydroxymethylC (the sixth base) in the first of a four step reaction leading back to bare-boned cytosine. But try as they might, the researchers could not continue the reaction on to the seventh and eighth bases, called 5 formylC and 5 carboxyC.

The problem, they eventually found, was not that Tet wasn't taking that second and third step, it was that their experimental assay wasn't sensitive enough to detect it. Once they realized the limitations of the assay, they redesigned it and were in fact able to detect the two newest bases of DNA. The researchers then examined embryonic stem cells as well as mouse organs and found that both bases can be detected in genomic DNA.

The finding could have important implications for stem cell research, as it could provide researchers with new tools to erase previous methylation patterns to reprogram adult cells.

It could also inform cancer research, as it could give scientists the opportunity to reactivate tumor suppressor genes that had been silenced by DNA methylation.

The research was funded by the Howard Hughes Medical Institute and the National Institutes of Health.

Study co-authors from UNC include Shinsuke Ito, Ph.D.; Li Shen, Ph.D.; Susan C. Wu, Ph.D.; Leonard B. Collins and James A. Swenberg, Ph.D

Source: Science Daily

ULTIMATE 'CURIOSITY'

Mission to Gate Crater

NASA's six-wheeled Mars rover Curiosity now has a destination on the Red Planet: Gale Crater, an ancient, 150-kilometer-wide depression with a large mountain in the middle. The car-sized robot will spend at least two years wheeling around the rocky basin, collecting information about martian history and looking for signs of habitable environments.

NASA announced the landing site for the $2.5 billion rover on July 22. Scheduled to launch later this year for an August 2012 landing, Curiosity and its payload of instruments will wheel around examining rocks, snapping photos and eating dust. There are 17 cameras on board; one on its belly will capture the probe's dramatic descent to the surface. A laser will help Curiosity identify intriguing rocks to study; when it finds one, the rover will approach the rock and drill into it, producing a powder that it will then ingest and analyze.

Gale Crater's central mound is a 5-kilometer-tall stack of sediments that scientists can read like chapters in a history book. The rocky pages will reveal Mars' geologic and environmental history, including how much water may have drenched the basin once upon a time. The crater also features canyons and fissures that may once have been habitable.

Source: Science News

The Mars rover Curiosity will touch down in Gale Crater (above) at the landing site outlined in yellow

LUST FOR GREATNESS

Writing in sand visible from space

Source: Live Science.

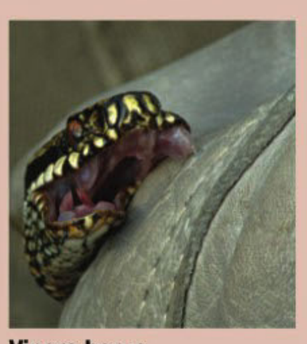
Hamad bin Hamdan al Nahyan, a billionaire Sheikh and member of Abu Dhabi's ruling family, has had his name carved into the sandy surface of an island he owns in the Persian Gulf. It is no lackadaisical sand-scrawling, though: At half a mile tall and 2 miles long altogether, the letters HAMAD are visible from space.

Satellites captured these images of al Futaisi Island, stamped with the name of its owner, back in 2009. They can be accessed on Google Maps and Google Earth.

While, under normal circumstances, words written in sand wash away, The Daily Mail explains that these letters are large enough to "form waterways that absorb the encroaching tide." Indeed, at the time the satellite photographs were taken, said tide can be seen flowing through the letters all the way to the M.

DID YOU KNOW?

What is Zootoxin?



Vipera berus

A toxic substance of animal origin, e.g., venom of snakes, spiders, or scorpions.

Venom is the general term referring to any variety of toxins[1] used by certain types of animals that inject it into their victims by the means of a bite or a sting.[2] Unlike poison, which is ingested or inhaled into the victim's tract, administration of venom is usually directed into the lymphatic system itself for faster action.