Source : www.thehindu.com Date : 2019-04-05

FOSSILS PINPOINT DAY ASTEROID HIT EARTH, CAUSING MASS EXTINCTION

Relevant for: Geography | Topic: The Earth, its Evolution and Origin of Life on Earth

A file photo of a model of a T. rex at the New Mexico Museum of Natural History and Science | Photo Credit: AP

New research released on Friday captures a fossilised snapshot of the day nearly 66 million years ago when an asteroid smacked the earth, fire rained from the sky and the ground shook far worse than any modern earthquake.

It was the day that nearly all life on the earth went extinct, including the dinosaurs.

The researchers say they found evidence in North Dakota of the asteroid that hit Mexico, including fish with hot glass in their gills from flaming debris that showered back down on the planet. They also reported the discovery of charred trees, evidence of an inland tsunami and melted amber.

Hell Creek which spans Montana, both Dakotas and Wyoming is a fossil treasure trove that includes numerous types of dinosaurs, mammals, reptiles and fish trapped in clay and stone from 65 to 70 million years ago.

Separately, University of Amsterdam's Jan Smit disclosed that he and his colleagues even found dinosaur footsteps from just before their demise.

Mr. Smit said the footprints one from a plant-eating hadrosaur and the other of a meat eater, maybe a small Tyrannosaurus Rex is "definite proof that the dinosaurs were alive and kicking at the time of impact... They were running around, chasing each other" when they were swamped.

"This is the death blow preserved at one particular site. This is just spectacular," said Purdue University geophysicist and impact expert Jay Melosh, who wasn't part of the research but edited the paper released on Friday by the journal *Proceedings of the National Academy of Sciences*.

Mr. Melosh called it the field's "discovery of the century." But other experts said that while some of the work is fascinating, they have some concerns.

Kirk Johnson , director of the Smithsonian National Museum of Natural History who also has studied the Hell Creek area for 38 years, said that the work on the fish, the glass and trees "demonstrates some of the details of what happened on THE DAY. That's all quite interesting and very valid stuff." But Mr. Johnson said that because there is restricted access to the site, other scientists can't confirm the research. Mr. Smit said the restrictions were to protect the site from poachers.

For decades, the massive asteroid crash that caused the Chicxulub crater in Mexico's Yucatan Peninsula has been considered the likely cause of the mass extinction, often called the "KT boundary" for the division between two geologic time periods. But some scientists have insisted that massive volcanic activity played a role.

Mr. Johnson and Mr. Melosh said this helps prove the asteroid crash case.

There were only a few dinosaur fossils from that time, but the footsteps are most convincing, Mr. Smit said.

The researchers said the inland tsunami points to a massive earthquake generated by the asteroid crash, somewhere between a magnitude 10 and 11.

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ISRAEL UNVEILS WORLD'S LONGEST SALT CAVE

Relevant for: Geography | Topic: Various Landforms, Changes Therein and the Effects of Such Changes

Israeli researchers say they have discovered the world's longest salt cave near the desert site where, according to the Bible, Lot's wife was turned into a pillar of salt.

The 10-km long warren of underground passages and chambers in Mount Sodom, overlooking the Dead Sea, was mapped out over two years by cavers from nine countries, led by the Hebrew University of Jerusalem. The cave is called Malham.

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HUMANS CAN DETECT THE EARTH'S MAGNETIC FIELDS

Relevant for: Geography | Topic: The Earth and the Solar System

An artist's rendering of Earth's magnetic field

Scientists have long known that turtles, birds, honeybees and even bacteria can sense the earth's magnetic field and use them for navigation. But this magneto-reception has hardly been tested in humans and many studies have been inconclusive.

Now a team of researchers from California Institute of Technology, U.S. and the University of Tokyo has shown that humans do indeed unconsciously respond to the changes in the earth's magnetic fields. But they are yet to decode what our brains may be using this information for. How did they find this?

They selected 34 volunteers, who sat with their eyes closed in a dark room. The room was wrapped with electrical coils, which helped simulate the earth's natural magnetic field.

The participants were connected to an EEG set-up and their brain activity was monitored. In the one-hour session, for a few minutes, the magnetic field around the chamber was shifted. They noticed that during this period, the alpha power of the brain began to drop.

"When a human brain is unengaged, the alpha power is high. When something catches its attention, consciously or unconsciously, its alpha power drops.," explains a release from Caltech.

The most interesting find was that the participants' brain responded only to changes when the magnetic field pointed toward the floor. This may be due to the fact that the study participants were people who live in the Northern Hemisphere. In this region, the natural geomagnetic field points downwards to the North. "There are many studies needed. First and most important is independent replication. Second, the drop in alpha-wave power is only one expression of the brain's receiving magnetic information... There may be many more magnetic fluctuations that trigger brain response, including variations in the total strength of the field," Prof. Joseph Kirschvink, the corresponding author, said .

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BLACK HOLE DISCOVERED

Relevant for: Geography | Topic: The Earth and the Solar System

Astronomers on April 10 unveiled the first photo of a black hole, one of the star-devouring monsters scattered throughout the Universe and obscured by impenetrable shields of gravity. The image of a dark core encircled by a flame-orange halo of white-hot gas and plasma looks like any number of artists' renderings over the last 30 years. But this time, it's the real deal. The supermassive black hole now immortalised by a far-flung network of radio telescopes is 50 million lightyears away in a galaxy known as M87.

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Source : www.thehindu.com Date : 2019-04-12

HOW CAN A BLACK HOLE BE IMAGED?

Relevant for: Geography | Topic: The Earth and the Solar System

This image released on April 10, 2019 by Event Horizon Telescope shows a black hole. Scientists revealed the first image ever made of a black hole after assembling data gathered by a network of radio telescopes around the world. Photo: Event Horizon Telescope Collaboration/Maunakea Observatories | Photo Credit: AP

At a press conference held simultaneously in six places around the world, the Event Horizon Telescope revealed the first ever photograph of the shadow of a black hole.

Decades of effort and bringing together scientists resulted in the world's first glimpse of the shadow of the supermassive black hole at the centre of the galaxy Messier 87 (M87).

This is 55 million light years away from the Earth. Telescopes from eight centres across the world worked as one unit to piece together this image.

The stunning image looked like an uneven gold ring, heavier at the lower end than the upper.

Analysis revealed that what was within the dark inner circle was rotating clockwise. This could either be the black hole itself or matter that was falling into it. The mass of this black hole was calculated to be 6.5 billion times the mass of the Sun and its diameter is 100 billion kilometres.

Though the Event Horizon Telescope set out to image both M87 and Sagittarius A* the black hole at the centre of the Milky way, they have succeeded only in imaging the former, despite its being much further away.

"This is a marvelous discovery because it is the first time we have actually seen the shadow of a black hole. But it is not surprising that M87 was imaged and not Sagittarius A* because the brightness of the material around M87. Since Sagittarius A* is not as heavily accreting, any small variation in the light from the material around the black hole will make it much harder to image," says Professor Prajval Shastri, Senior Associate at International Centre for Theoretical Physics and an expert in this field.

"If immersed in a bright region, like a disc of glowing gas, we expect a black hole to create a dark region similar to a shadow — something predicted by Einstein's general relativity that we've never seen before," explained chair of the EHT Science Council Heino Falcke of Radboud University, the Netherlands, in a press release given out by the Event Horizon Telescope. "This shadow, caused by the gravitational bending and capture of light by the event horizon, reveals a lot about the nature of these fascinating objects and has allowed us to measure the enormous mass of M87's black hole." The results are published in six papers in a special issue of The Astrophysical Journal.

How can one image a black hole when it is known that even light – the fastest object in the universe – does not have a high enough velocity to escape its gravitational pull? The fact is, the black hole itself cannot be seen, but at a definite distance from the black hole lies its event horizon, which marks an important boundary. Any object including light that falls within its event horizon is sucked into the black hole. However, if something that orbits the black hole outside the event horizon shines as it usually does, the black hole can be seen in silhouette against this shine.

Normally stars and other massive objects close to the black hole orbit it and slowly spiral into it. Gas falling into the black hole swirls around it, forming an “accretion disc”. In the accretion disc, the gas gets get heated and emits radiation, or light. Given its powerful gravitational power, the black hole acts as a lens, bending this light. This light can escape and even reach the Earth and be detected. The light coming from M87, a giant elliptical galaxy in Virgo A constellation, was in fact measured by the Event Horizon Telescope earlier. M87 has a black hole at its heart which, at 6.5 billion times the Solar mass, is one of the most massive blackholes known. The effort in effect mapped out the shape of the event horizon.

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LIFE ON EARTH MAY HAVE BEGUN IN PONDS: STUDY

Relevant for: Geography | Topic: The Earth, its Evolution and Origin of Life on Earth

A NASA image of the earth. File | Photo Credit: AFP

Challenging a common perception, a new study suggests primitive ponds may have provided a suitable environment for creating the earth's first life forms, more so than oceans.

The findings published in the journal *Geochemistry, Geophysics, Geosystems* showed shallow water bodies could have held high concentrations of what many scientists believe to be a key ingredient for jump-starting life on the earth: nitrogen.

"Our overall message is, if you think the origin of life required fixed nitrogen, as many people do, then it's tough to have the origin of life happen in the ocean," said lead author Sukrit Ranjan from Massachusetts Institute of Technology (MIT). "It's much easier to have that happen in a pond," Mr. Ranjan said.

Nitrogenous oxides were likely deposited in water bodies, including oceans and ponds, as remnants of the breakdown of nitrogen in earth's atmosphere.

Atmospheric nitrogen comprises two nitrogen molecules, linked via a strong triple bond, that can only be broken by an extremely energetic event — namely, lightning.

Scientists believe there could have been enough lightning crackling through the early atmosphere to produce an abundance of nitrogenous oxides to fuel the origin of life in the ocean.

But the new study found that ultraviolet light from the Sun and dissolved iron sloughed off from primitive oceanic rocks could have destroyed a significant portion of nitrogenous oxides in the ocean, sending the compounds back into the atmosphere as nitrogen.

In the ocean, UV light and dissolved iron would have made nitrogenous oxides far less available for synthesising living organisms.

In shallow ponds, however, life would have had a better chance to grow, mainly because ponds have much less volume over which compounds can be diluted. As a result, nitrogenous oxides would have built up to much higher concentrations, the study said.

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Source : www.thehindu.com Date : 2019-04-14

BLACK HOLE SNAPPED: HOW THE PICTURE OF ONE OF THE UNIVERSE'S MOST SECRETIVE OBJECTS WAS CLICKED

Relevant for: Geography | Topic: The Earth and the Solar System

The story so far: In 2017, a consortium of institutions around the world decided to pool the scanning abilities of eight telescopes — from Hawaii to the South Pole — and focus on getting a picture of a black hole. By definition, a black hole can't be seen. As a cosmic gobbler of all matter on its periphery, these sinkholes have gravitational fields so powerful that even light cannot escape them, rendering its contents invisible. Because the concept of black holes (the cemeteries of spent stars above a certain mass and massive cosmic objects) followed from Einstein's theories of general relativity, scientists have had intricate mathematical descriptions and speculation of how they look, how many of them exist, how they behave, where they might be located and their relationship to the universe. Based on this, there have been a plethora of visual and artistic descriptions of black holes. However, there has never been visual confirmation of their existence, until now.

On April 10, astronomers shared an image, now christened on Indian Twitter as a 'giant *meduvada* in the sky,' from the black hole at Messier 87 or M87. It was a blurred, yellowish orange frame surrounding a black centre. While this wasn't vastly different from how astronomers and artists have visualised black holes for decades, it's still great to see reality correspond to imagination. The black hole measures 40 billion km across — three million times the size of the earth — and is 55 trillion light years from earth. (A light year is about 9.46 trillion km). It is bigger than our entire solar system and a scientist described it to the BBC as "the heavyweight champion of black holes in the Universe." The image has been analysed in six studies co-authored by 200 experts from 60-odd institutions and published on Wednesday in *Astrophysical Journal Letters*.

Since the 1970s, astronomers have known that there are 'super massive' black holes (about a billion times heavier than the sun) in the Milky Way or galaxies close to it. While black holes themselves are invisible, the region around them — the luminous frenzy of charged particles from matter in their vicinity — is, in theory, 'visible'. The bigger a black hole, the greater the odds of it having a massive event horizon — the fiery periphery of a black hole — and the better our chances of observing wisps of radiation from it. After the discovery of a super massive black hole in M87 (a 'neighbouring' galaxy about 55 trillion light years away) and one in our Milky Way, astronomers formed a network of ultra-sensitive telescopes — called the Event Horizon Telescope — to dedicatedly train their sights towards trying to capture some radiation from them and hopefully, snap a real picture from the black hole's periphery.

Because black holes are the result, mostly, of heavy stars collapsing in on themselves, radiation emitted by particles within the disc are heated to billions of degrees as they swirl around the black hole at close to the speed of light, before vanishing into them.

The astronomers used a technique known as interferometry, which combines radiation from eight telescopes from around the world in a way that it appears as one single telescope capture. What this virtual telescope would capture were traces — electromagnetic radiation — from jets of particles spewed from the event horizons of the black hole. This faint radiation, in the form of mostly radio waves, would have travelled trillions of kilometres and for the telescope to observe them would be the equivalent of trying to snap a picture of an ant from the moon.

The EHT team observed M87 and Sagittarius A (Sgr A), the black hole at the centre of our Milky Way, over five nights in April 2017, using eight radio telescopes that are sensitive to the wavelengths of a millimetre. The telescopes they used stretched from Hawaii to Arizona, Mexico to Spain, and Chile to the South Pole. The data generated were so voluminous that they couldn't be transmitted on the internet and had to be recorded on disk and shipped to the Massachusetts Institute of Technology, Boston. It took nearly a year for data from the South Pole to be shipped because of inclement weather. A total of 4 petabytes were recorded — the equivalent of 8,000 years of MP3-format music played non-stop — and was crunched in supercomputers by teams of scientists working 16-18 hour shifts. A report in *Science* said four independent teams duplicated the data processing to eliminate biases and over four days of observations of M87, the shape and size of the shadow was consistent with theoretical expectations. The team did not report results from Sgr A because the picture quality from M87 was better.

Coupled with the momentous discovery of gravitational waves, generated by two black holes, in 2015 by the Laser Interferometer Gravitational-Wave Observatory, the black hole image of M87 is a testament to engineering skills. It will help to form international collaborations to pool the capabilities of disparate scientific instruments and perceive phenomena that cannot be comprehended by individuals. It also underlines that international scientific collaboration is now essential to scientific advancement. The image and the data generated could better illuminate black holes, how they work, how the jets of luminosity that enabled us to see them, actually behave. An actual image also confirms a century of theoretical work that has built up over the years, premised on the assumption that black holes are indeed real objects and not the fantasy fallout of abstruse mathematical equations. It allows scientists greater confidence to proceed with more involved questions such as the surface of the regions around black holes, how they rotate, how quickly their characteristics vary and how earthlings need to shift and shape their instruments accordingly to learn more about them.

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WILL THE EL NINO FACTOR IMPACT THE MONSOON?

Relevant for: Geography | Topic: Climate and Weather & Changes in Climate

The story so far: The forecast of a below average monsoon in 2019 on the back of a prospective El Nino that is often associated with less rainfall has come from a private agency, Skymet. Its managing director Jatin Singh says the Pacific Ocean has become strongly warmer than average. Even as things may get clearer after the India Meteorological Department's forecast, we look into the weather phenomenon called El Nino and its impact on the monsoon.

El Nino is synonymous with the Pacific Ocean that covers as much as one-third of the planet. There is no bigger stage for it to unfold in which the vast ocean and the atmosphere combine perfectly, only to send out associated bad tidings half a world away and even beyond.

El Nino is a phenomenon in the equatorial Pacific, in which sea-surface temperatures rise over a threshold of +0.5 degree Celsius (and cools by the same margin during alter ego La Nina). These are averaged over five, three-month sessions on a trot across a stretch of water designated as the Nino 3.4 region (see graphic) to arrive at the Oceanic Nino Index (ONI). There are a few other acronyms which one comes across while tracking El Nino. For instance, the Southern Oscillation Index, or SOI, that gives an indication of the development and intensity of El Nino or La Nina. The SOI is calculated on the basis of the atmospheric pressure differences between Tahiti (South Pacific Ocean) and Darwin (Australia), separated by 8,569 km. Sustained positive SOI values are indicative of La Nina conditions while negative values suggest El Nino conditions. Another acronym is the ENSO (El Nino Southern Oscillation) which refers to the oscillation between the El Nino and the La Nina. ENSO shifts irregularly back and forth between El Nino and La Niña every two to seven years. Each phase triggers predictable disruptions of temperature, precipitation, and winds disrupting large-scale air movements in the tropics, triggering a cascade of global side effects. Under 'normal' conditions, though, the west tropical Pacific is warmer than its eastern basin. The warmer area of the ocean is also a source for convection and is associated with cloudiness and rainfall. During El Nino years, the warmth shifts to Central and East Tropical Pacific (Nino 3.4 region), and along with it, cloudiness and rainfall.

El Nino was observed as far back as in the late 1800s when South American fishermen noticed the warming up of coastal waters around Christmas. They referred to it as "El Nino" (Spanish for the boy child), since it appeared around Christmas. Sir Gilbert Walker, a British mathematician, discovered the Southern Oscillation (SO), or large-scale changes in sea level pressure across Indonesia and the tropical Pacific. However, he did not recognise that it was linked to changes in the Pacific Ocean or El Nino. It wasn't until the late 1960s that Norwegian-American meteorologist Jacob Bjerknes and others realised that the changes in the ocean and the atmosphere were connected. This was how the coinage 'ENSO' came into existence.

As already mentioned, El Nino has been found to impact almost half the world triggering droughts in Australia, India, southern Africa and floods in Peru, Ecuador, the United States, the Gulf of Mexico, and the Colorado River basin. If Sir Gilbert found in the 1920s that many global climate variations, including monsoon rains in India, were correlated with the SO, the credit of linking it with El Nino as part of ENSO involving both the ocean and atmosphere, goes to Bjerknes. But it took until the 1980s or later for 'La Nina' or even the 'neutral phase' (neither El Nino or La Nina) to gain currency.

India has not had a particularly productive monsoon since 2014 (save a tolerable 2017), with weak El Nino events unfolding on either side of the strong 2015-16 El Nino, a trend forecast to

continue into this year. This comes on the back of a deficient post-monsoon season last year. After all, the south-west monsoon (June-September) accounts for over 70% of the country's annual rainfall and irrigates over half of the crop land. The rain-fed kharif crops are heavily dependent on the monsoon and the quantity of rainfall determines agricultural production. Agriculture accounts for around 15% of the GDP and normal rains rejuvenate the farm sector and help the government deal with rural stress. Normal rains can boost sentiments, raise farm production, perk up rural demand, and tame inflation to some extent.

But what perplexes scientists and researchers is that no direct correlation between the ENSO events and the monsoon has been established yet. From 1950 to 2012, there were 16 La Nina years, with the monsoon rains ending up above or around average nearly every time. El Nino brought in five droughts during this period but on 14 other occasions, monsoon performance ranged from being well below-average, average, or even above-average. To top it all, the 1997-98 El Nino, among the century's strongest, went on to stand conventional logic on its head; far from heralding a drought, it generated above-average rain. Likewise, 2002 proved to be one of the driest monsoons despite it being a weak to moderate El Nino year. It only helped bust another myth: the strength of an individual El Nino event may not necessarily have its imprint on monsoon performance.

El Nino has been generally known to suppress monsoon rainfall in India while La Nina increases it. El Niño years tend to be drier than average, but one of the strongest El Nino of the century (1997-98) produced a monsoon season with above-average rainfall for India (see table). Researchers also believe that even the location of the warming in the Pacific may possibly have an influence on the monsoon. Anomalous warming in the Central and East Pacific (Nino 3.4 region) could have a more profound adverse impact on the monsoon than when the warming shifts to the adjoining far east Pacific (Nino 3. region). Current conditions (March, 2019) suggest that the warming is pronounced (+0.98 degree Celsius) in the Nino 3.4 region than the far east Pacific (+0.74 degree Celsius), which could suggest a weaker monsoon this year. Already, a couple of private forecasters as well as a few international agencies have sounded out the possibility. The official forecast from the India Meteorological Department (IMD) is eagerly awaited. Scientists claim there may be other factors that combine with the prevailing Pacific conditions to decide the fate of the monsoon. Progressive heating of the land during April-May-June is one. The extent of the Himalayan/Eurasian snow cover is another. Less snow cover means a warmer subcontinent, which can help to intensify the monsoon circulation and bring more rain. It is worthwhile in this context to recall that north India has had an extended winter earlier this year. Last but not the least is the 'dipole' effect nearer home, wherein the Indian Ocean mimics El Nino-La Nina in which the western and eastern basins warm up relative to each other every few years with associated impact on the monsoon. Warming up of the west Indian Ocean boosts a prevailing monsoon, and *vice-versa*. International and domestic weather agencies expect that this year, the Indian Ocean dipole could be either 'neutral' or weakly positive. It remains to be seen how this could reflect in the monsoon's performance.

Most places in India's southern States – Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana experienced a hotter February and March this year

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SEEING DARKNESS: THE FIRST IMAGE OF A BLACK HOLE

Relevant for: Geography | Topic: The Earth and the Solar System

On April 10, the Event Horizon Telescope collaboration showed the world the ‘unseeable’: **the very first image of a black hole**. Of course, the black hole itself cannot be seen, because light cannot escape its intense gravitational attraction. The so-called event horizon that envelops the black hole is the point of no return and any object transgressing this boundary is lost. Just outside is a region where a photon (light quantum) can orbit the black hole without falling in. This is called the ‘last photon ring’, and this is what the EHT imaged, seeing in effect the silhouette of a black hole. About a hundred years after the black hole made its way into physics through Albert Einstein’s general theory of relativity, soon after the LIGO collaboration first directly observed the gravitational waves made by the merging of two black holes, the ‘dark star’ had finally been imaged. The Higgs boson was detected 50 years after it had been postulated, and gravitational waves were observed a century after Einstein predicted them. Visual proof of the existence of black holes comes a century after they appeared in scientific literature. In a collaborative effort, eight telescopes around the world were used for the experiment. The challenges included making each observe the same broad range of wavelengths around 1.3 mm and having precise atomic clocks at each location, so the data could be combined.

A black hole marks the end of spacetime as commonly understood, and nothing that enters it can escape from the tremendous gravitational attraction. However, this is no real danger, as black holes are located at distances that humans do not have the power to scale. The EHT set out to image two candidate supermassive black holes — Sagittarius A*, which is 26,000 light years from the earth, at the centre of the Milky Way, and another which is 55 million light years away at the centre of the Messier 87 galaxy in the Virgo galaxy cluster. But the first image was of the more distant one. The very long baseline interferometry technique linked radio dishes of telescopes across the world to produce a virtual telescope the size of the earth. This was needed to obtain the high resolution required for this measurement. Combining data from telescopes, each with different characteristics, was a separate challenge. Cutting-edge developments from computer science related to image recognition were used. As Katie Bouman, Assistant Professor at the California Institute of Technology, who led the efforts to develop an algorithm to put the data together and create the image, said in a TEDx talk, projects such as the EHT succeed owing to interdisciplinary expertise that people bring to the table. This experiment endorses the diversity of collaboration just as much as it does unrelenting patience and good faith in the power of science and reason.

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BLACK HOLE NAMED ‘POWEHI’ BY HAWAII UNIVERSITY PROFESSOR

Relevant for: Geography | Topic: The Earth and the Solar System

This image released on April 10, 2019 by Event Horizon Telescope shows a black hole. Scientists revealed the first image ever made of a black hole after assembling data gathered by a network of radio telescopes around the world. Photo: Event Horizon Telescope Collaboration/Maunakea Observatories | Photo Credit: AP

A language professor has given a Hawaiian name — Powehi — to the black hole depicted in an image produced in a landmark experiment.

The Honolulu Star-Advertiser reported Thursday that University of Hawaii-Hilo Hawaiian Professor Larry Kimura named the cosmic object.

The world’s first image of a black hole revealed on Wednesday was created using data from eight radio telescopes around the world.

The newspaper reports the word meaning “the adorned fathomless dark creation” or “embellished dark source of unending creation” comes from the Kumulipo, an 18th Century Hawaiian creation chant.

Astronomers say giving it a Hawaiian name was justified because the project included two telescopes in Hawaii.

Jessica Dempsey, a co-discoverer of the black hole, says the word is an excellent match for the scientific description she provided to Kimura.

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UNIVERSE’S FIRST MOLECULE DETECTED IN SPACE

Relevant for: Geography | Topic: The Earth and the Solar System

Image of planetary nebula NGC 7027 with illustration of helium hydride molecules. In this planetary nebula, SOFIA detected helium hydride, a combination of helium (red) and hydrogen (blue), which was the first type of molecule to ever form in the early universe. This is the first time helium hydride has been found in the modern universe. | Photo Credit: NASA/ESA/Hubble Processing: Judy Schmidt

Scientists have detected the most ancient type of molecule in our universe in space for the first time ever.

Helium hydride ion (HeH+) was the first molecule that formed when, almost 14 billion years ago, falling temperatures in the young universe allowed recombination of the light elements produced in the Big Bang.

At that time, ionised hydrogen and neutral helium atoms reacted to form HeH+, said researchers from The Max Planck Institute for Radio Astronomy (MPIfR) in Germany.

Despite its importance in the history of the early Universe, HeH+ has so far escaped detection in astrophysical nebulae — cloud of gas and dust in outer space.

Operating the GREAT far-infrared spectrometer onboard the flying observatory SOFIA, an international team reported unambiguous detection of the molecule towards the planetary nebula NGC 7027.

During the dawn of chemistry when the temperature in the young universe had fallen below 4000 Kelvin, the ions of the light elements (hydrogen, helium, deuterium and traces of lithium) produced in Big Bang nucleosynthesis recombined in reverse order of their ionisation potential.

Helium combined first with free electrons to form the first ever neutral atom, according to the study published in the journal *Nature*.

At that time hydrogen was still ionised or present in form of bare protons. Helium atoms combined with these protons into the helium hydride ion HeH+, the universe’s first molecular bond.

As recombination progressed, HeH+ reacted with then neutral hydrogen and created a first path to the formation of molecular hydrogen — marking the beginning of the modern universe.

Despite its unquestioned importance in the history of the early Universe, the HeH+ molecule has so far escaped detection in interstellar space, researchers said.

Studied in the laboratory as long ago as 1925, dedicated searches during the last decades have been unsuccessful, thereby challenging our understanding of the underlying chemical networks, they said.

“The chemistry of the universe began with HeH+. The lack of definitive evidence of its very existence in interstellar space has been a dilemma for astronomy for a long time,” said Rolf Gusten from the MPIfR.

In the late 1970s, astro-chemical models suggested the possibility that HeH+ might exist at detectable abundances in local astrophysical nebulae, and would be most easily observed in so-called planetary nebula, ejected by Sun-like stars in the last stage of their lifetime.

The hard radiation field produced by the central white dwarf star with a temperature of more than 100,000 degrees drives ionisation fronts into the ejected envelope, where HeH+ is predicted to form.

The molecule will emit its strongest spectral line at a characteristic wavelength of 0.149 mm.

However, Earth's atmosphere is opaque at this wavelength for ground-based observatories, requiring this search to be performed from space or a high-flying observatory like SOFIA cruising above the absorbing layers of the lower atmosphere.

"With recent advancements in terahertz technologies it has now become possible to perform high-resolution spectroscopy at the required far-infrared wavelength," said Mr. Gusten.

Operating the GREAT spectrometer aboard SOFIA the team now reports the unequivocal detection of HeH+ towards the envelope of the planetary nebula NGC 7027.

"The discovery of HeH+ is a dramatic and beautiful demonstration of nature's tendency to form molecules," said David Neufeld from the Johns Hopkins University in the US.

"Despite the unpromising ingredients that are available, a mixture of hydrogen with the unreactive noble gas helium, and a harsh environment at thousands of degrees Celsius, a fragile molecule forms," Mr. Neufeld said.

"Remarkably, this phenomenon can not only be observed by astronomers but also understood using theoretical models that we have developed," he said.

The detection of this special molecule brings a long search to a happy ending, and eliminates doubts that we might not understand the underlying formation and destruction as well as we thought, researchers said.

The data generated will help scientists understand how the jets of luminosity that enabled us to see the black holes actually work and behave.

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LAKES FILLED WITH LIQUID METHANE SPOTTED ON SATURN'S MOON TITAN

Relevant for: Geography | Topic: The Earth and the Solar System

Ligeia Mare, the second largest known body of liquid on Saturn's moon Titan, shown in data obtained by NASA's Cassini spacecraft, is pictured in this NASA handout image released January 17, 2018. | Photo Credit: NASA

Scientists on April 15 provided the most comprehensive look to date at one of the solar system's most exotic features: prime lakeside property in the northern polar region of Saturn's moon Titan - if you like lakes made of stuff like liquid methane.

Using data obtained by NASA's Cassini spacecraft before that mission ended in 2017 with a deliberate plunge into Saturn, the scientists found that some of frigid Titan's lakes of liquid hydrocarbons in this region are surprisingly deep while others may be shallow and seasonal.

Titan and Earth are the solar system's two places with standing bodies of liquid on the surface. Titan boasts lakes, rivers and seas of hydrocarbons: compounds of hydrogen and carbon like those that are the main components of petroleum and natural gas.

The researchers described landforms akin to Mesas towering above the nearby landscape, topped with liquid lakes more than 300 feet deep comprised mainly of methane. The scientists suspect the lakes formed when surrounding bedrock chemically dissolved and collapsed, a process that occurs with a certain type of lake on Earth.

The scientists also described "phantom lakes" that during wintertime appeared to be wide but shallow ponds — perhaps only a few inches deep — but evaporated or drained into the surface by springtime, a process taking seven years on Titan.

The findings represented further evidence about Titan's hydrological cycle, with liquid hydrocarbons raining down from clouds, flowing across its surface and evaporating back into the sky. This is comparable to Earth's water cycle.

Because of Titan's complex chemistry and distinctive environments, scientists suspect it potentially could harbor life, in particular in its subsurface ocean of water, but possibly in the surface bodies of liquid hydrocarbons.

"Titan is a very fascinating object in the solar system, and every time we look carefully at the data we find out something new," California Institute of Technology planetary scientist Marco Mastrogiuseppe said.

Titan, with a diameter of 5,150 km, is the solar system's second largest moon, behind only Jupiter's Ganymede. It is bigger than the planet Mercury.

"Titan is the most Earth-like body in the solar system. It has lakes, canyons, rivers, dune fields of organic sand particles about the same size as silica sand grains on Earth," Johns Hopkins University Applied Physics Laboratory planetary scientist Shannon MacKenzie said.

The research was published in the journal *Nature Astronomy*.

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A BRIEF HISTORY OF BLACK HOLES

Relevant for: Geography | Topic: The Earth and the Solar System

In the album *A Farewell to Kings* (1977), Canadian rock band Rush tells the story of a cosmic voyager who is trapped in the event horizon of a black hole called Cygnus X-1. It seems initially that he has not survived, but he is found later in a parallel dimension resembling the Olympus of Greek mythology.

And in the film *Interstellar* (2014), a wormhole — a portal in the fabric of space and time — leads to a supermassive black hole called Gargantua, located 10 billion light years from earth, with a mass approximately 100 million times that of the sun.

Our cosmos has long been a source of fascination for artists, writers and theologians, and it's not hard to see why — our sun is just one tiny point of light among the hundreds of billions of stars swirling around the Milky Way galaxy. So vast is the distance between the outer edges of the galaxy, it would take a vessel moving at the speed of light 100,000 years to cross it.

Our very own Milky Way has a black hole the size of 4 million solar masses at its core. It would take us 27,000 years to reach it travelling at the speed of light.

Einstein's singularity

In his general theory of relativity, Einstein conceived of stars and planets as weighted spheres that stretch the fabric of space much like a bowling ball stretches a rubber sheet, causing it to sag, and drawing lighter bodies to the heavier object in the centre.

Basically, time appears to move more slowly near massive objects because the object's gravitational force bends space-time, a phenomenon called gravitational time dilation.

Thus, gravity was not a 'force' as Isaac Newton had envisaged it, but the result of a distortion in the fabric of *spacetime* — a continuum that extends throughout the known universe.

Einstein's equations further suggested the existence of a spatial entity that scientists now refer to as a 'naked singularity': the centre of a spherical gravitational field — a *black hole* — that sucked in everything — matter, information and light — that crossed its 'event horizon,' or the point of no return.

A couple of weeks ago, scientists released a breakthrough image of a black hole at the centre of Messier 87, a galaxy 55 million light years away from our own, finally proving Einstein's theory correct. The golden ring of light shown in the image is that of the event horizon, the boundary encircling the black hole.

Try to picture this: our sun is 330,000 times the mass of earth. Now visualise an entity 6.5 billion times more massive than our sun. That is the estimated size of the *Virgo A* black hole captured in the now iconic image.

Furthermore, the image we are looking at is 55 million light years old, because that is how long it would take for light to travel from that region of space to our own.

Awe and reverence

When we consider that ours is just one out of hundreds of billions of galaxies in the universe, it is not difficult to see how contemplation of the cosmos can lead to feelings of religious awe and reverence.

There are many striking parallels between Eastern thought and modern astrophysics, especially in their imagining of space, time and the birth of the universe.

Another name for the Hindu god Shiva is Mahakala, the lord of time. He represents the void at the dissolution of the universe and has the power to subsume even time and space into himself.

Mahakala is typically visualised as black in colour. Just as all colours are absorbed and dissolved into black, all names and forms are said to merge into Mahakala — symbolising his all-encompassing nature.

Black can also represent total stillness or the complete absence of light, much like a black hole. Again, in this case, it signifies the nature of Mahakala as the primordial source of creation known as *Bindu* in Yogic terminology, conceptually identical to the singularity in astrophysics.

The idea of blackness as the primordial state of the universe can also be found in the *Rig Veda*:

At first there was only darkness wrapped in darkness.

All this was only unillumined cosmic water.

That One which came to be, enclosed in nothing,

arose at last, born of the power of heat. (Nasadiya Sukta)

Mystics and moderns

It has taken a cosmic minute, but modern science is finally beginning to see eye-to-eye with mystics who have long held the view that everything is interconnected with consciousness as the glue that binds it all together.

“As we penetrate into matter, nature does not show us any isolated ‘building blocks’, but rather appears as a complicated web of relations between the various parts of the whole,” wrote theoretical physicist Fritjof Capra. “These relations always include the observer in an essential way. The human observer constitutes the final link in the chain of observational processes, and the properties of any atomic object can be understood only in terms of the object’s interaction with the observer.”

Scientists now believe that black holes are not just central to the existence of the universe as we know it but crucial to our very own existence. This new understanding has led cosmologists to indulge in some dizzying speculations. Could it be possible that the cosmos we inhabit came out of a universal black hole that consumed all the matter of a previous universe, collapsed into itself, then vomited everything out in a colossal explosion that resulted in our present universe?

Hindu, Buddhist and Taoist adepts would simply nod in recognition, as these ideas mirror their worldview. Hindu mythology is undergirded by the notion of the One — *Brahman* — multiplying into the many, manifesting as the world, then collapsing back into itself. This cycle of cosmic creation and destruction is called *Lila*, the play of god.

Or, as Carl Sagan said, “The cosmos is within us. Some part of our being knows this is where

we came from. We long to return. And we can, because we're made of star stuff. We are a way for the universe to know itself."

The filmmaker, columnist and scholar likes to hang out with his cats, toucans and pet iguana.

The data generated will help scientists understand how the jets of luminosity that enabled us to see the black holes actually work and behave.

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