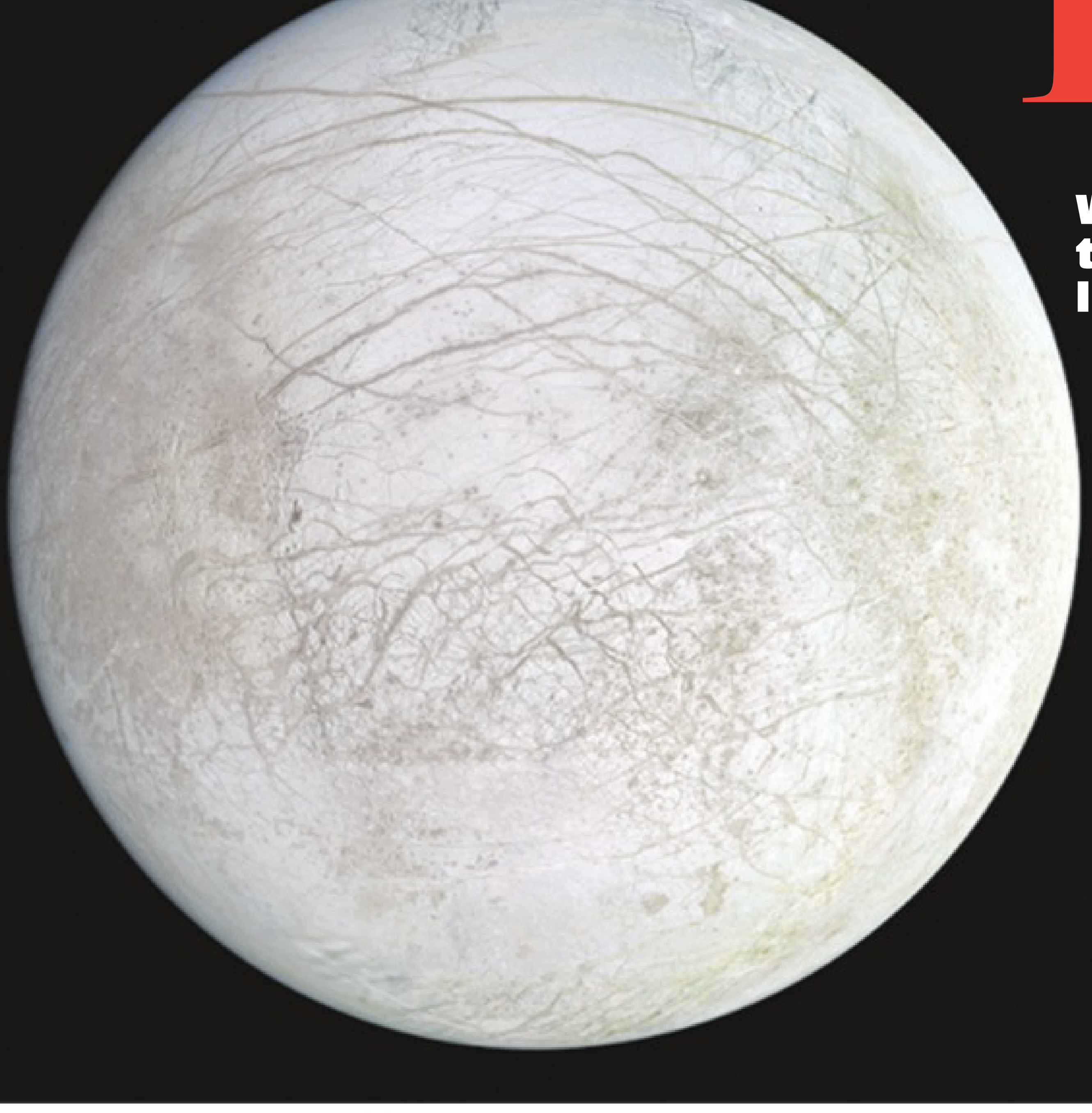
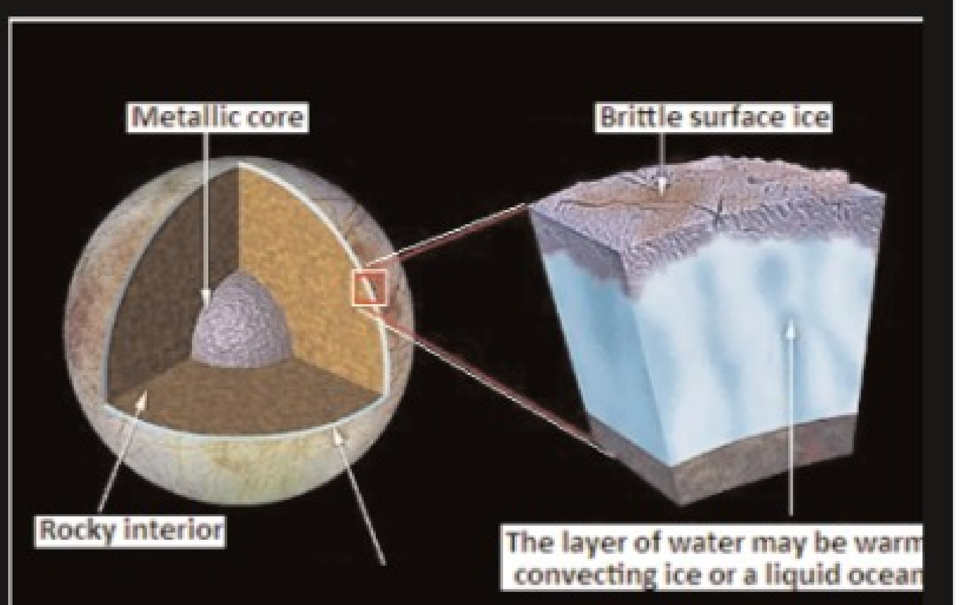
Under Europa's skin

We may not need to go far to find extra-terrestrial life after all





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The motivation for the quest for exoplanets, or planets that orbit distant suns, is to find one that has the conditions to support life. The conditions that we look for in such planets are mainly the presence of water and a temperature range where there could be life as we understand it. Even if we did find such a planet, however, it may not be of practical value for some time, as the distances are in multiples of light years.

A report in the journal, *Nature Astronomy*, suggests that we may still find signs of extra-terrestrial life much closer home, on Europa, one of the moons of Jupiter. However, as the surface of Europa, a likely host for life forms, is battered by intense radiation, it has been feared that any signs of life may not survive till deep below the surface. TA Nordheim, P Hand and C Paranicas, from the California Institute of Technology and Johns Hopkins University, describe a study that suggests that life forms could be there at a depth of just a centimetre.

Europa is one of the four moons of Jupiter that Galileo discovered in 1610 when he used a telescope for the first time. Europa is a little smaller in size than our own moon, has practically no atmosphere and the temperature is more than 160°C below freezing. As the surface shows high reflectivity, it is believed that it is covered with ice. Observations by the Hubble Space Telescope in 2012, and again in 2014 and 2016, have detected what appear to be plumes of water emerging from different parts of the moon. This indicates that there is a large body of liquid water below the ice and the plumes are possibly the result of volcanic activity.

There is evidence, in fact, that there may be more water on Europa than all the water in the Earth's oceans. While volcanic activity may be a source of heat to keep the water liquid, it is also considered that tidal forces, because of the gravity of Jupiter and the other three moons, also creates pressures within the mass of Europa.

These would have the effect of warming the water body to keep the volume below the outer crest in the liquid state. This tidal activity may also be raising matter from the bottom of the ocean to the surface. Surface features that have been observed from orbiting missions also suggest that there is matter welling up.

These conditions — apparently warmer temperatures and the rich chemical makeup below the surface — constitute a medium in which life forms could flourish. Europa has hence been considered a prime candidate to be host of extra-terrestrial life. The space missions sent out to Europa have all had the detection of signs of life as part of their objectives.

While it was thought that the plumes of water could bring with them living things or their constituents from deep within the moon, it has been understood that nothing would be able to survive on the surface because of the onslaught of radiation. This blast of radiation is a result of a gale of charged particles that whips around the mother planet.

Jupiter's magnetic field is 14 times stronger than Earth's and the planet has a rotation period of nine hours. The strong and rapidly changing magnetic field reacts with the charged particles, mainly electrons, protons and alpha particles that stream forth from the sun, the solar wind. These, along with the rich outpouring of charged particles from Io, Jupiter's volcanic moon, create the planet's rotating torus of charged particles. This region, which is called the magnetosphere of Jupiter, extends seven million kilometres towards the sun and another seven million kilometres, almost to the orbit of Saturn, in the opposite direction. This is the largest magnetosphere in the Solar System and its existence was first inferred from strong radio signals that come from Jupiter, as a rotating radio beacon.

The result is that the moons of Jupiter (there are 79 in all, including the large four discovered by Galileo) are blasted with radiation. In fact, even spacecraft that were sent near Jupiter and to fly past Europa needed special shielding and could remain in the radiation only for short periods.

The effect of this radiation would be so scorching on the surface of Europa that it was believed that no living thing, or even amino acids, as evidence of proteins, could last long enough to be detected. It was believed that if ever a lander craft were sent to the surface of Europa, it would need to dig several metres before it could hope to collect a sample that contained signs of life, if there was any.

This apprehension has relaxed with the findings of the Caltech and John Hopkins researchers. What they found was that Europa's own magnetic field shepherds the radiation, fortunately for life forms near the surface, and does not allow it to be equally strong at all latitudes. It is similar to the effect of the Earth's magnetic field that keeps it safe from the solar wind. The stream of charged particles striking the Earth gets deflected by the magnetic field and it forms a region called Van Allen's Belt around our planet. The paper in *Nature Astronomy* says that modelling the way the charged barrage would deflect in Europa's magnetic field shows that radiation would be strong near the equator and at the poles, but considerably weaker at high latitudes. Simultaneous laboratory trials with radiation and its effect on amino acids have indicated that in a selected latitude belt on Europa, amino acids would be able to survive at a depth of just a centimetre below the surface. At other places, this depth could go to tens of centimetres or more.

This is good news, as NASA is in the process of readying a craft to land on Europa. The launch is planned for 2024 and the landing for 2031. Including equipment to dig deep into the surface would almost certainly not be possible. But now it appears that samples where there are signs of life, if there is any, could be collected at shallow depths, which would be within the lander's capability.

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Ever expanding 'egg'

Here's a look at the cosmic mystery that remains at the heart of our universe after the Big Bang

ANDREW GRIFFIN

Google celebrated Georges Lemaître's 124th birthday with a special doodle last week. But even after all this time, his greatest discovery is an enthralling mystery.

Lemaître, a Catholic priest who died in 1966, is best known for first proposing the Big Bang theory of the universe, which explains how everything around us came to be. He knew it as the "cosmic egg" — its more famous name was actually coined to mock the idea, and has been criticised for giving a misleading idea of what happened.

But just as thrilling as the cosmic egg is what it suggested — that the universe has been expanding ever since. It is expected to keep expanding forever, to the point that it becomes so expanded its central processes break down.

The mechanisms behind this process remain mysterious, with cosmologists suggesting that it is being propelled by unknown dark energy. But there is a greater mystery at the heart of the idea, too.

Though scientists know an incredible amount about that expansion, and have studied in fascinating detail the rate at which it is happening, it is still not clear how quickly that expansion is happening. And that is not because we do not know enough — rather because the vast amount we do know does not seem to agree.

In fact, as scientists get more precise measurements of that rate, known as the Hubble constant, they become more confused. And recent ultra-precise measurements have suggested that some mysterious, new and undiscovered physics might be at work in the universe.

Repeated findings from measurements using technology such as the Hubble Space Telescope have found strange discrepancies in the speed of expansion. Repeated findings have discovered that the universe appears to be expanding faster now than it was just after the big bang.

The strange discrepancy looks like a mistake. But it becomes more clear as the results become more precise that it is in fact "not a bug but a feature of the universe", as Nobel Laureate Adam Riess has put it.

The discrepancy — which relies on work done by Lemaître decades ago — is something like measuring the height of a child when it is three years old, then meeting the same child again when it is older and finding that it is far more tall than you would ever expected it to be.

A whole host of explanations for this strange effect have been proposed. Almost all of them rely on the 95 per cent of the universe that remains dark and mysterious to us — the parts of the cosmos that we know through theory that are there, but which we have never directly seen.

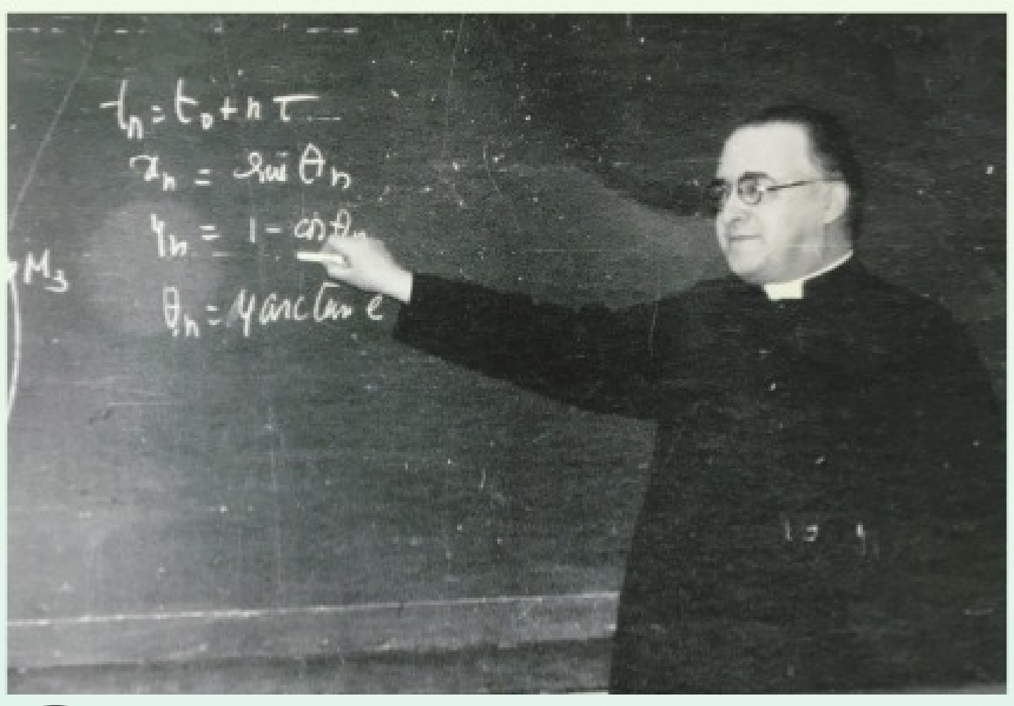
The strange effect could be the consequence of dark energy, which scientists already think is powering the expansion of the universe. It might be that dark energy is pushing galaxies apart with more strength, suggesting that the Hubble constant, so important to Lemaître's work, is not really a constant at all but changes through time.

Or it could be caused by a mysterious subatomic particle, travelling through the universe at the speed of light but which we have not yet seen. Yet another suggestion is that dark matter could interact with normal matter in ways we didn't understand before.

Scientists don't know which of these is the case — or if the explanation is something else entirely. But it does appear that there is something very strange and as yet undiscovered happening in the universe, acting as it expands.

Whatever it is will shed new light on the expansion of the universe — an already stunning discovery when it was first proposed by Lemaître, and one that becomes all the more awe-inspiring as we learn more about it.

Who was Georges Lemaître?



Georges Lemaître was an astronomer and professor of physics who is thought to be the first to have theorised that the universe is expanding. His theory was observationally confirmed soon afterwards by Edwin Hubble in what is now known as Hubble's Law.

Lemaître is also credited with proposing what has now become known as the Big Bang theory. The theory, which is now widely accepted, first appeared in 1931 in one of Lemaître's academic papers and was a significant break from the orthodoxy of the time.

Born on 17 July 1894 in Belgium, he initially began studying civil engineering. His academic pursuits were however put on hold while he served in the Belgian army for the duration of World War I. After the war, he studied physics and mathematics and was also ordained as a priest.

In 1923 he became a graduate student at the University of Cambridge before going on to study at Harvard and Massachusetts Institute of Technology. In 1925, he returned to Belgium, where he became a part-time lecturer at the Catholic University of Leuven. Two years later, he published his groundbreaking idea of an expanding universe.

His initial idea was not related specifically to the Big Bang, but his later research focused on the concept of the universe starting from a single atom. In 1933 at the California Institute of Technology, some of the greatest scientists of the time from around the world gathered to hear a series of lectures. After Lemaître delivered his lecture and theory, Albert Einstein stood up and said, "This is the most beautiful and satisfactory explanation of creation to which I ever listened."

He was elected a member of the Royal Academy of Sciences and Arts of Belgium and the Pontifical Academy of Sciences. In 1951, Pope Pius XII claimed that Lemaître's theory provided a scientific validation for Catholicism — a claim that Lemaître resented, as he stated his theory was neutral.

He died in 1966, shortly after he discovered the existence of cosmic microwave background radiation, which added weight to his theory on the birth of the universe.

PLUS POINTS

In a new chapter

The last 4,200 years have been officially classified as a new chapter in Earth's history — the Meghalayan Age.

Beginning with a global drought that had devastating consequences for ancient civilisations from Egypt to China, the new age is the most recent section of a longer period known as the Holocene Epoch, which reflects everything that has happened over the last 11,700 years. The Meghalayan is unique because it is the first interval in Earth's geological history that has coincided with a major cultural event, as agricultural societies struggled to recover from the shift in climate.

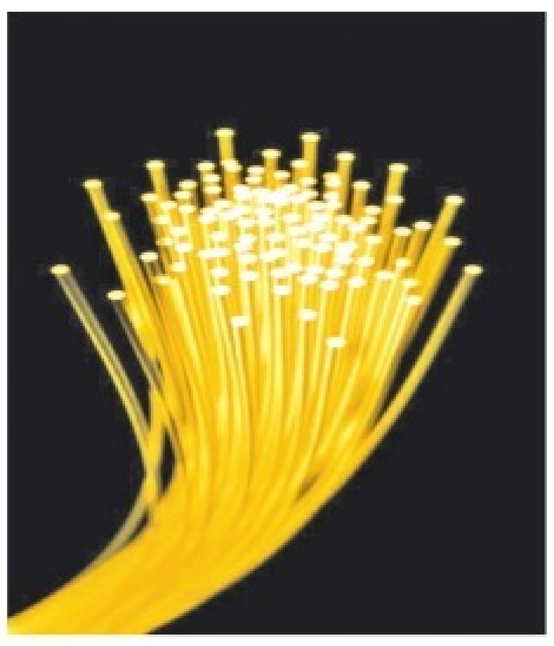
In a meeting held in June, the International Commission on Stratigraphy announced the new division in time, which will now appear on all official charts depicting Earth's geological past. Geologists use the International Chronostratigraphic Chart to show the divisions in the planet's 4.6 billion-year history, each of which is marked by major events like the break-up of continents or climate change. Every age is characterised by its global impact and a notable change in rocks and sediments.

The concept of the Meghalayan was first proposed seven years ago due to specific chemical signatures found in stalactites and stalagmites. A stalagmite found in the North-eastern Indian state of Meghalaya has provided the best evidence of this, so far and therefore gave its name to the new age.

However, some researchers have objected to the Meghalaya's creation, especially as there are ongoing discussions about the definition of a new geological period based on human activity — the "Anthropocene".

The independent

'Light' data transfer



Researchers at the University of Sheffield have solved a key puzzle in quantum physics that could help to make data transfer totally secure.

The team has developed a way of generating very rapid single-photon light pulses. Each photon, or particle of light, represents a bit of binary code -- the fundamental language of computing. These photons cannot be intercepted without disturbing them in a way that would alert the sender that something was amiss.

Transferring data using light passed along fibre optic cables has become increasingly common over the last decades but each pulse currently contains millions of photons. That means that, in principle, a portion of these could be intercepted without detection.

Secure data is already encrypted but if an "eavesdropper" was able to intercept the signals containing details of the code then — in theory — they could access and decode the rest of the message. Single photon pulses offer total security, because any eavesdropping is immediately detected, but scientists have struggled to produce them rapidly enough to carry data at sufficient speeds to transfer high volumes.

In a new study, published in *Nature Nanotechnology*, the Sheffield team has employed a phenomenon called the Purcell Effect to produce the photons very rapidly. A nanocrystal called a quantum dot is placed inside a cavity within a larger crystal — the semiconductor chip. The dot is then bombarded with light from a laser, which makes it absorb energy. This energy is then emitted in the form of a photon.

Placing the nanocrystal inside a very small cavity makes the laser light bounce around inside the walls. This speeds up the photon production by the Purcell Effect. One problem is that the photons carrying data information can easily become confused with the laser light. The Sheffield researchers have overcome this by funnelling the photons away from the cavity and inside the chip to separate the two different types of pulse.