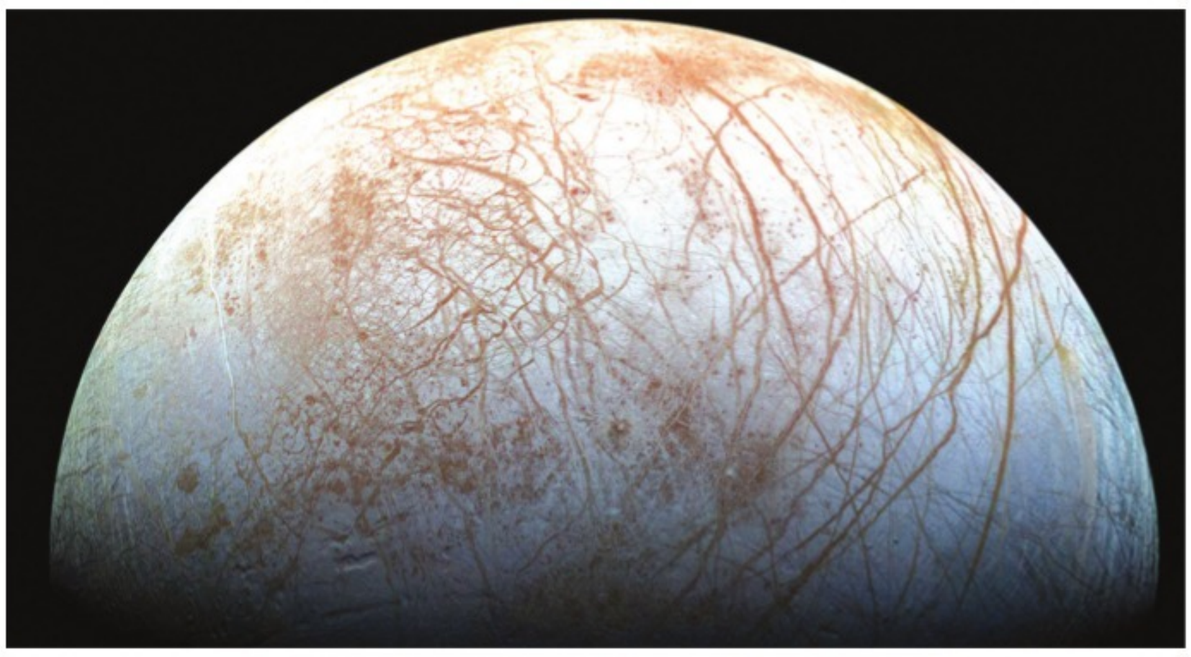
Rough landing

A prayer-field of ice may prevent a craft from alighting on Jupiter's moon, Europa



S ANANTHANARAYANAN

Jupiter's satellite, Europa, just a little smaller than our moon, is believed to be covered with water and a crust of ice. Its thin atmosphere is also rich in oxygen. Europa is hence a good candidate in the search for extraterrestrial life. There have been detailed observations from Earth and from spacecraft that have flown by. And it would make sense that a mission be launched to land a research module on the surface of the satellite.

Daniel EJ Hobley, Jeffrey M Moore, Alan D Howard and Orkan M Umurhan from Cardiff University, Nasa Ames Research Centre in California and the University of Virginia, however, write in the journal, *Nature Geoscience*, that there may be problems in getting a research station down to the surface of Europa. A theoretical study of the known conditions on Europa indicates that water on its surface would form an ice-field of spikes and blades, which would be hazardous for a landing craft to approach.

Europa is the smallest of the four satellites of Jupiter that Galileo discovered in 1610, and the sixth from the mother planet of the 79 moons finally discovered. Around 800 million km from the Sun, the average surface temperature is 171°C below freezing. With its low surface gravity, it has lost most of its atmosphere, but what remains is rich in oxygen. Sightings show Europa to be the smoothest object in the Solar System. This and studies of the amount of light that it reflects lead to the idea that there is an ocean of liquid water that lies below its surface of ice. And hence, the idea that it may harbour the components essential for life.

The current study, reported in *Nature Geoscience*, however, questions the impression that the surface of Europa is smooth. This impression had arisen because it was thought that the onslaught of charged particles that are known to strike Jupiter's moons, thanks to the gas giant's magnetic field, would have a diffusive effect, and wear down the surface of ice in a process known as impact gardening. In arid and low pressure conditions, as could be found on Europa, the diffusive effect of radiation, or sunlight, is not to melt low temperature ice to water, but to make the ice sublime, or pass directly to the vapour form. This effect, called ablation, is often observed in a snowfield after a cold spell and is one way that glacier ice gets eroded.

On Earth, however, the study says, there are conditions in which the process of sublimation dominates over the diffusive effect, leading to roughness, at the centimetre level or even the scale of metres. The same effect, the paper says, is expected at the equatorial belt on Europa, a conclusion that is in keeping with anomalies that have been observed in radar signals bounced of the equator region.

Roughness arising out of sublimation of ice is clearly seen in the formation of "penitents" or *nieves penitentes* (Spanish for "penitent snows") on the plains atop the Andes, at altitudes above 4,000 metres. The name has come from the resemblance of a field of penitentes to a crowd of kneeling monks doing penance.

The spikes of ice give the impression of the white, pointed hoods that the brothers of religious orders wear during Processions of Penance, in the Spanish Holy Week. These spikes, which can be from a few centimetres to five metres tall, were first described in scientific literature, by Charles Darwin, who saw them in 1835, in the course of his travels around the coast of South America.

The reason why *penitentes* arise is known as "differential ablation", or erosion in the troughs between the spikes but not of the spikes themselves. Once a hint of a spike and a trough forms, the spike presents a side, rather than a surface, to radiation from overhead and there is greater ablation at the trough. The glancing angle that the sides of the spike present then directs radiation into the trough, and this accelerates the process of spike formation. The Andes are high altitude, arid and at the equator. The conditions of low pressure, low vapour content of the air, low temperature and sunlight from directly above for much of the time are just what it takes for *penitentes* formation.

The authors of the *Nature Geoscience* paper note that the conditions of "bright, sustained sunlight, cold, dry, still air, and a melt-free environment" are there on the surface of the satellite, Europa. It is also "tidally locked" with its parent planet, Jupiter. This means that the tidal forces exerted by the planet have slowed down the rotation of the satellite so that one rotation takes the same time as one revolution around the mother planet. This is just like our own moon, which always shows the same face to the Earth as it goes around.

Further, Europa's orbit is also almost along Jupiter's equator, and Jupiter's own axis has a very slight tilt. The result is that Europa, at the equator, has the sun right overhead for most of the time. The team has worked out the effect of different conditions, like the temperature, radiation, movement of air and the geometry of the spikes that form, on the maximum height of *penitentes* that form. They work it out that given the age of the surface of Europa and the known conditions, sublimation to a depth of 15 m should have taken place. Assuming that the growth of *penitentes* is such they are half as far apart as they are tall, the *penitentes* should be 15 m tall and 7.5 m apart.

This has grave implications for plans of missions to Europa and landing a research station on the surface. "This should motivate further detailed quantitative analysis", the paper says. The European Space Agency's "Jupiter Icy Moons Explorer" set to launch in 2022 and Nasa's "Europa-Clipper" proposed between 2022 and 2025 are two such, which would take high resolution pictures of Europa's surface.

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Penitentes under the night sky of the Atacama Desert

Chemically richer

Nasa's Cassini spacecraft has revealed unknown details about Saturn's rings — and just how strange they are

ANDREW GRIFFIN

Nasa's Cassini spacecraft has revealed new details about Saturn — and found it much more strange than we'd ever expected. The famous rings that sweep around the planet are far more chemically rich than scientists had previously imagined. They discovered expected things, such as water, but also found organic material present in there too.

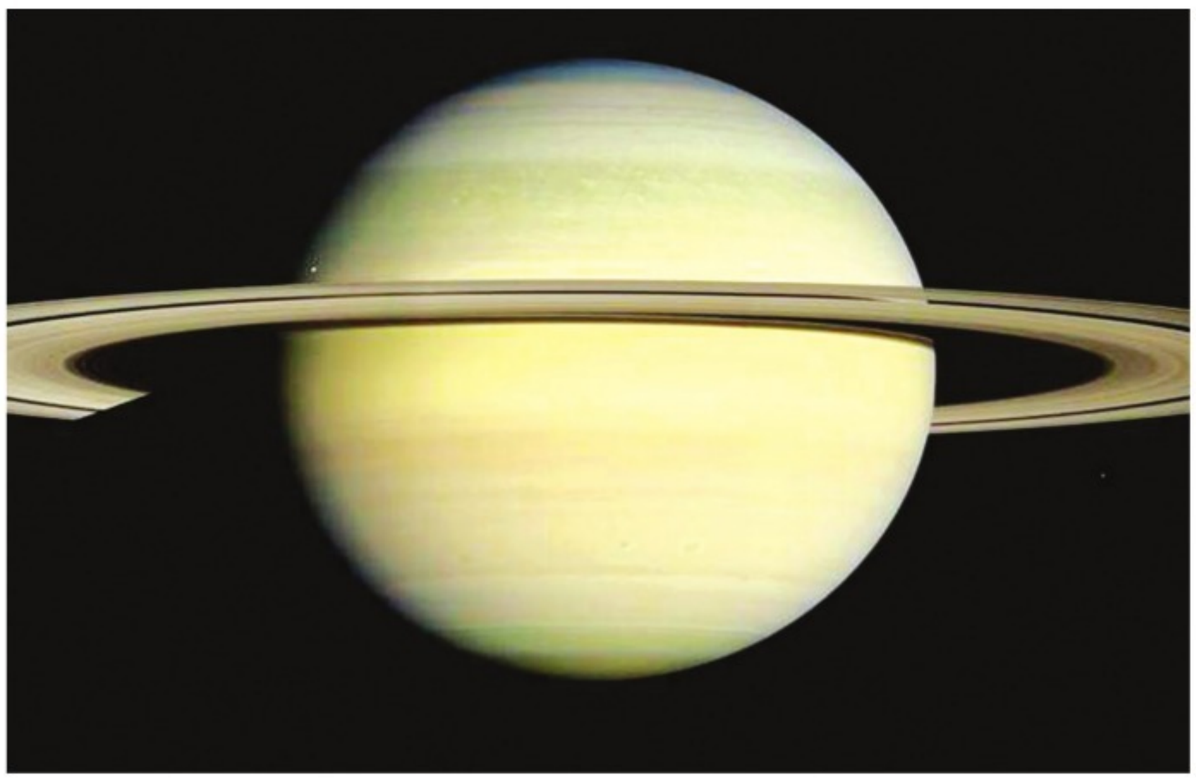
And new findings about the planet's magnetic field show that it is more structured than expected. But it gave no clues about how it was actually formed, continuing to puzzle scientists studying it.

The findings are the latest discovery from the last batch of data sent by Nasa's Cassini spacecraft. It smashed into Saturn and destroyed itself last year, but before it did so, it conducted a series of daring dives that allowed it to capture new details about the gas giant. The findings about the construction of the rings could change our understanding of how our own solar system works, according to researchers who worked on the new discoveries. "This is a new element of how our solar system works," said Thomas Cravens, professor of physics and astronomy at the University of Kansas and a co-author of the new paper.

"Two things surprised me. One is the chemical complexity of what was coming off the rings — we thought it would be almost entirely water based on what we saw in the past.

"The second thing is the sheer quantity of it — a lot more than we originally expected. The quality and quantity of the materials the rings are putting into the atmosphere surprised me."

In time, the findings could help us understand how the mysterious rings that surround Pluto and other planets might have formed. "This could help us understand, how does a planet get rings? Some do, some don't," said Cravens, "What's the lifetime of a ring? And what's replenishing the rings? Was there a time when Saturn didn't have rings? How did that composition get into there in the first place? Is it left over from the formation of our solar system? Does it date back to proto pre-solar nebula, the nebula that collapsed out of interstellar media that formed the sun and planets?"



And the structure of the magnetic field suggests we might have to alter our understanding of the way they can form. Previously, scientists thought that planets could only form a magnetic field if their magnetic and geographic poles were slightly tilted away from each other, like they are on Earth, but the new data shows that isn't the case on Pluto.

"It may still be that Saturn's turbulent atmosphere of thick gases is obscuring some of the magnetic data, but it looks increasingly likely we will have to rethink the ways different kinds of planets can form magnetic fields," said principal investigator for the magnetometer Michele Dougherty, from the Department of Physics at Imperial.

The independent

Sorting & leaving

Here's a look at the roles of the Endoplasmic reticulum and Golgi complex in protein trafficking

TAPAN KUMAR MAITRA

Membrane-bound and soluble proteins synthesised by ribosomes attached to the rough Endoplasmic reticulum must be directed to a variety of intracellular locations, including the ER itself, the Golgi complex, endosomes, and lysosomes.

Moreover, once a protein reaches an organelle where it is supposed to remain, there must be a mechanism for preventing it from leaving. Other groups of proteins synthesised in the rough ER are destined for incorporation into the plasma membrane or for release to the outside of the cell.

Each protein contains a specific "tag" that targets the protein for inclusion in transport vesicles that will convey material from one specific cellular location to another. Depending on the protein and its destination, the tag may be a specific amino acid sequence, an oligosaccharide side chain, a hydrophobic domain, or another structural feature.

Tags may also be involved in excluding material from certain vesicles.

It has recently been shown that membrane lipids can also be tagged to help vesicles reach their proper destinations.

This tag can be one or more phosphate groups attached to positions 3, 4, and/or 5 of a phosphatidyl-inositol molecule in the membrane. For example, it has been shown that a functional PI-3-kinase is required for proper sorting of vesicles to the vacuole in yeast.

Inhibition of inositol kinases in mammalian cells perturbs vesicle trafficking to the lysosome.

Aside from tags, the length and degree of saturation of certain membrane lipids have also been shown to be important in vesicle trafficking.

Sorting of proteins begins in the ER and early compartments of the Golgi stack, which contain mechanisms for retrieving or retaining compartment-specific proteins.

This is an important step in the sorting process, for it preserves the compartment-specific functions needed to maintain the integrity of glycosylation and processing pathways.

The final sorting of material that will leave the Golgi complex occurs in the Trans Golgi Network, where lipids and proteins are selectively packaged into distinct populations of transport vesicles, each destined for a different location in the cell.

In some cells, the Golgi complex is also involved in the processing of proteins that enter the cell by endocytosis.

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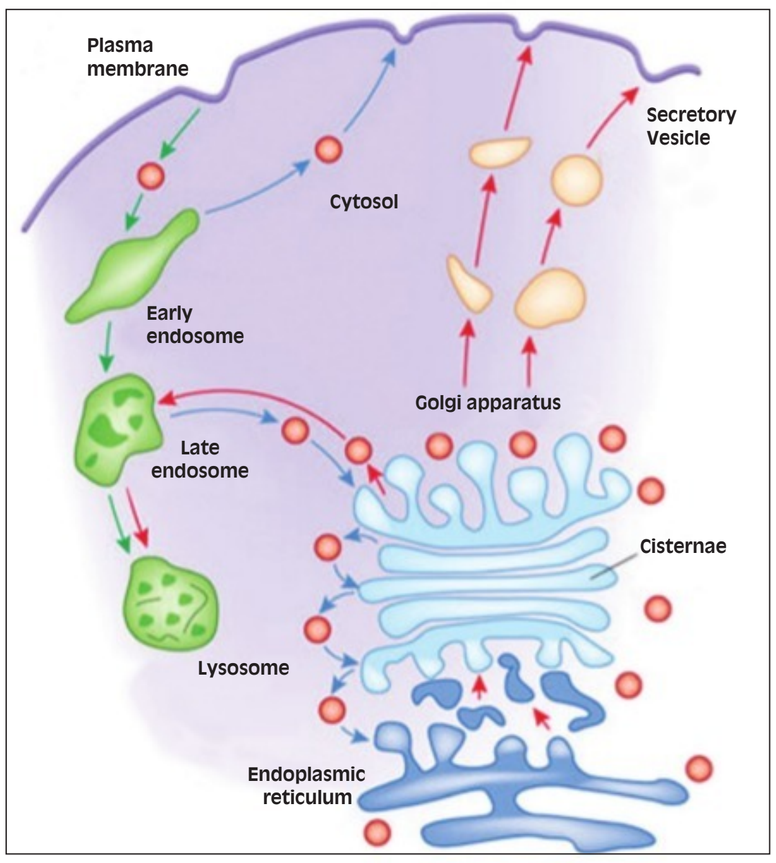

PLUS POINTS

Lederman no more

An experimental physicist who won a Nobel Prize for his groundbreaking work on subatomic particles has died aged 96.

Leon Lederman coined the phrase "God particle", a shorthand description of the then-theoretical Higgs boson, in the title of a 1993 book. His discoveries proved crucial in the identification of the subatomic particle that accounts for matter having mass in 2012.

In 1988 he was awarded the Nobel Prize in Physics for his part in the discovery of another sub-atomic particle, the muon neutrino. The American scientist later auctioned off his gold medal for $765,000 to help pay medical bills after being diagnosed with dementia. He died at a nursing home in the Idaho town of Rexburg last week said Ellen Carr Lederman, his wife of 37 years.

"What he really loved were people, trying to educate them and help them understand what they were doing in science," she said.

Dr Lederman was seen as a giant in his field who also had a passion for sharing science. "He made extraordinary contributions to our understanding of the basic forces and particles of nature," Michael Turner, a professor at the University of Chicago, said, "But he was also a leader far ahead of his time in science education, in serving as an ambassador for science around the world, and transferring benefits of basic research to the national good."

Lederman directed the university's Fermi National Accelerator Laboratory from 1978 to 1989. "Leon Lederman provided the scientific vision that allowed Fermilab to remain on the cutting edge of technology for more than 40 years," said Nigel Lockyer, the current director of the Fermi National Accelerator Laboratory.

Lederman was only the second living laureate to sell a Nobel Prize gold medal. Following the auction, in 2015, his wife said he had enjoyed the award but "but feels it is time for someone else who shares his love of science to treasure his medal".

The independent

Trees the answer

Look out of the window and you will probably see one of the most effective weapons in the fight against climate change — a tree.

Trees soak up large amounts of planet-warming carbon dioxide as they grow and produce oxygen in return. On a large scale, forests are huge carbon stores and help regulate the climate by capturing and releasing water for rivers and clouds. Forests also provide livelihoods for millions of people in local communities.

Scientists say that if we get the policies right, forests, along with grasslands, mangroves and wetlands — even carefully managed farmlands — can become powerful tools that can soak up more CO_2 and buy time in the quest to avoid dangerous climate change.

Big forest nations such as Indonesia, Brazil and the Democratic Republic of Congo could limit risks by being major players in using nature to fight climate change by soaking up excess CO_2. "The tropical forest countries should be the highest priority, not only because they hold so much carbon and take up so much carbon every year, but because tropical forests also act as a global air conditioner," said Deborah Lawrence, Professor of Environmental Sciences at the University of Virginia, US.

Plants and soil absorb about 20 per cent of mankind's greenhouse gas emissions, though this is offset by emissions from land use change, including land clearing and agricultural activities, according to a study published last year in the journal *Proceedings of the US National Academy of Sciences*.

But in their analysis, the authors estimated that stopping deforestation, restoring forests and improving forestry practices could cost-effectively remove seven billion tonnes of CO_2 annually, or as much as eliminating 1.5 billion cars.

The straits times/ann