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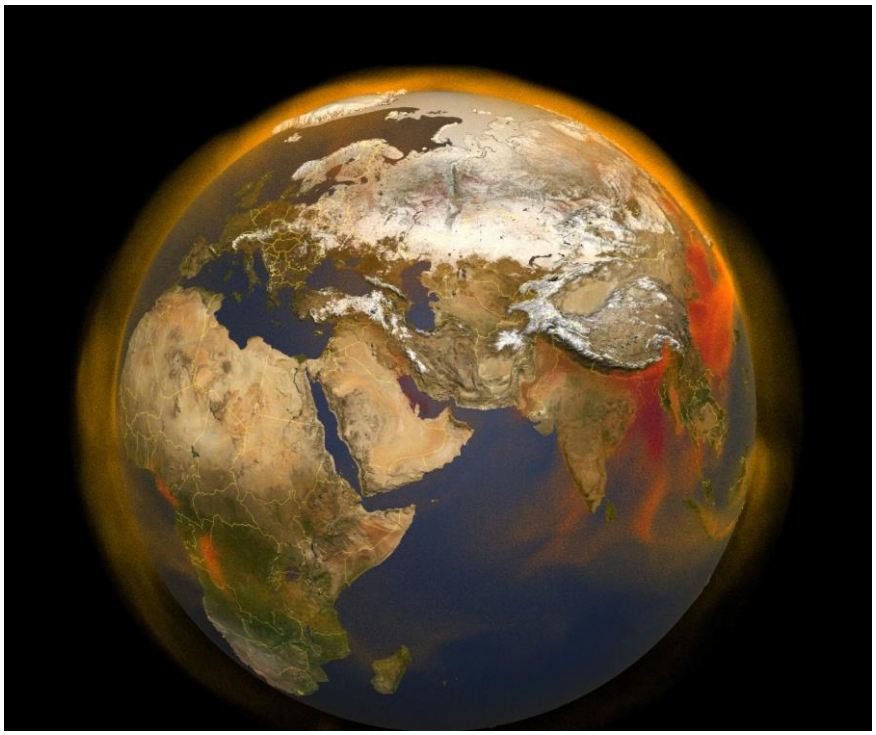
# INSIDE THIS ISSUE





*NASA/Scientifuc visualisation Studio: A 3D portrait of methane concentration showing the World's second largest contributor to greenhouse warming*

# CAFÉ SCIENTIFIQUE:

# THE NEWSLETTER

## EDITOR'S NOTE: P-ADIC NUMBERS

Different number systems are familiar to us: rationals, irrationals etc. But there's more to see here than meets the eye. If you zoom in on a sequence of rational numbers, you approach something, a number that itself cannot be rational. We usually solve this problem by arranging the rationals in a line and filling the gaps with irrationals.

But there are other ways of arranging the rationals. The p-adic numbers, to take an example. These are an infinite collection of alternative number systems, each associated with a unique prime number.

Based on modular arithmetic, the p-adic numbers have become an essential setting in which to investigate questions about rational numbers that go back millennia. Each p-adic number is defined by following an infinite path up a tower of classified modulo numbers. These numbers provide mathematicians with a wide range of settings in which to explore questions about the rationals.

One example of their use is in finding rational solutions to multi-variable poynomial equations. To find the p-adic solutions, we use the local-global principe that if a polynomial has a solution in the real numbers and in the p-adic numbers, then that polynomial also has a solution in the rational numbers- to prove the existence of solutions within the rational numbers, mathematicians look for solutions in infinitely many other number systems, such as the reals and the p-adics.

Shivanshi ☺

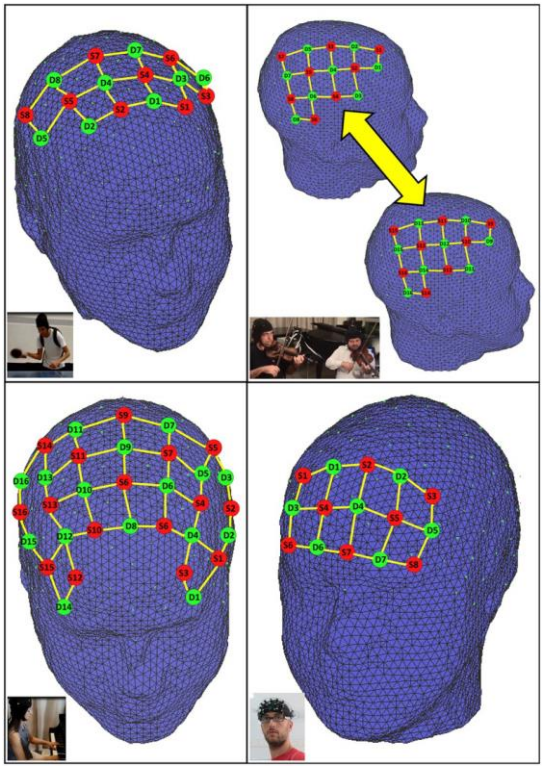
# STICKY ELECTRONS

Click here to read the full article

Similarly to the way that water molecules combine to form droplets, electrons can come together at certain points, as if they are partially sticking together. Now with the help of complex calculations on super computers, it has been possible for the first time to explain exactly what happens at the boundary between the repulsion of the elections, and the sudden counteractive attractive force that enables these counterintuitive effects.

Electrons are negatively charged and repel each other, and therefore electrons that move though the material are scattered by other electrons. However, this scattering is not always equally strong, and is possible that this repulsion is screened in the material. At the borderline where the unusual effects tend to appear, this scattering process becomes theoretically infinitely strong due to the lack of screening, known as divergence, which poses a great challenge for research. If you approach the mathematical limit, the repulsion becomes stronger and stronger, and at the limit the scattering becomes infinitely large; however if you cross this limit, the repulsion suddenly causes and additional attraction. This effective attraction forces the electrons together to gather at certain points in space, as if they were partially 'sticking' together.

This result is reminiscent of liquid water and water vapour- under certain conditions there is an attraction force between the molecules, which binds them together and creates a mixture of liquid droplets and gaseous steam.



example fNIRS probe setup

Livescience.com : An Artistic Impression of an atom

# LOVERS & COLLABORATION

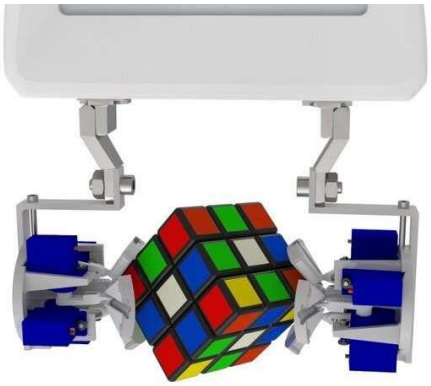
Over the past few decades, some psychology researchers have conducted studies aimed at understanding the effects that love can have one people's creativity. Inspired by previous works, a research group at Shaanxi Normal University in Xi'an, China recently carried out a study that explored the possibility that romantically involved couples may perform better on creative tasks than others.

After birth, human beings typically form social relationships of which romantic seem to be an essential part of most people's adult life, and so it is not surprising that many artists have been inspired by them; as the main form of adult attachment, the romantic relationship has always been a theme that many poets and writers have always been praised.

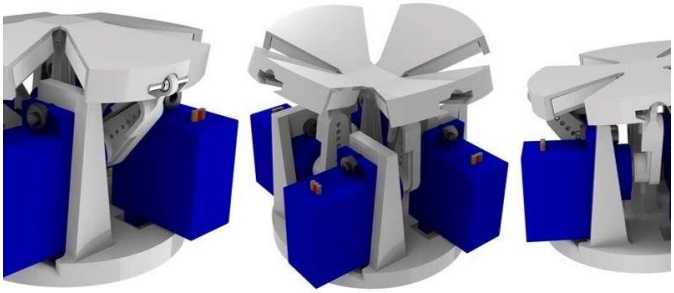
In a recent experiment, participants were recruited to perform a creative task, and had their brain activity recorded using a technique called functional near-infrared spectroscopy (fNIRS)-based hyper scanning, which is used to record cerebral cortical activity. The team used this method to assess the correlation between the brain signals of the pairs of participants by calculating their inter-brain synchronisation (IBS). In this context, IBS measurements represent the extent to which a person puts the same effort on completing a task as their partner . Past findings suggest than an enhanced IBS is reflected in an enhanced cooperation.

In addition to highlighting the possible benefits of romantic relationships, the study found no gender differences, showing that lovers perform similarly, regardless of their gender.

# ORIGAMI ROBOTIC HANDS



Techxplore.com : An example grasp using a pair of designed morphing fingertips



Techxplore.com : Contact primitives of the fingertip in 3 morphing modes

Researchers at Hing Kong University of Science and technology have recently developed a robotic fingertip that can change its shape and switch across 3 different configurations, which could allow it to grasp a broader variety of objects. This unique design is inspired by the renowned Japanese art of Origami.

Researchers have been trying to develop techniques to control the grasping poses of robotic grippers for several decades, however most existing approaches have significant limitations that prevent them from performing well across different objects.

The new origami-based shape morphing fingertip has two main components: a soft origami skeleton that acts as the fingertip's morphing surface, and motor driven four-bar linkages that serve as action and transmission mechanisms. The researchers evaluated the three morphing modes that the fingertip can achieve on movements that are essential for effective robotic grasping. The researchers tested the effectiveness of the convex mode for what is known as pivoting and pinch grasping, the concave mode for performing a power grasp and the tiled planar mode for pin-hand manipulation and reorientation.

Overall they found that the fingertip they developed has many advantageous characteristics, including the ability to shift quickly between different morphing primitives and grasping modes, as well as between stable and dexterous grasp modes based on the task at hand. The fingertip's configuration is effectively simulated and guided by the kinematic model they used.

# THE ESCAPE OF WATER FROM MARS

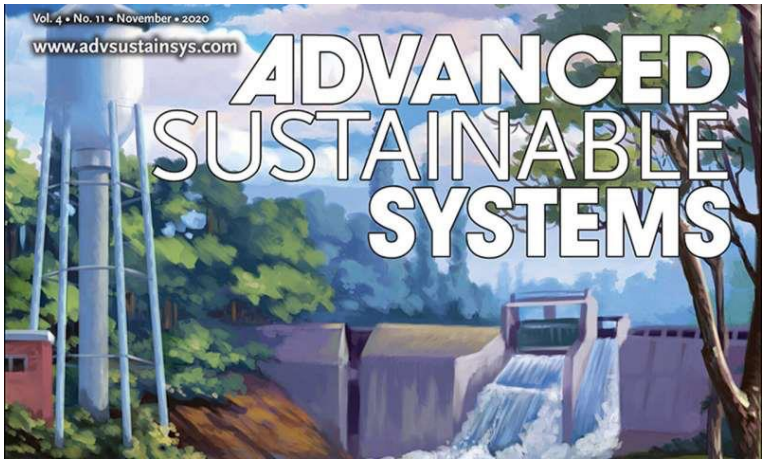
Mars once had oceans, but is now bone dry, leaving many to wonder how all the water was lost. We know that there must have been a thicker atmosphere, and that somehow, Mars lost the majority of its atmosphere to space. MAVEN (Mars Atmosphere and Volatile EvolutioN) is trying to characterise the processes responsible for this loss, and work out exactly how Mars lost all its water. Past observations show that the loss of water from the Martial upper atmosphere varies with the seasons; when Mars is nearest the sun, more ice from the surface moves to the upper atmosphere, where it is lost to space; this happens once every Martian year (2 earth years). The regional dust storms that occur on Mars also lead to a further heating of the atmosphere, and a surge in the upward movement of water. However the processes that make this cyclical movement possible contradict the classical picture of water escape from Mars. According to the classical process, water ice is converted to a gas and is destroyed by the Sun's rays in the lower atmosphere ; this process however would play out as a slow, steady trickle, unaffected by the seasons or dust storms, which doesn't mesh with current observations. This is important as we didn't expect to see any water in the upper atmosphere of Mars at all. If we compare Mars to Earth, the water on Earth is confined close to the surface because of hygropause, a layer in the atmosphere that's cold enough to condense and stop any water vapour from travelling upwards. In Mars, the water is moving past what should be Mars' hygropause, which is likely too warm to stop the water vapour. After extrapolating data back 1 billion years, a team found that this process can account for the loss of a global ocean about 17 inches deep, and while we can't extrapolate further back than that, we think that this process likely didn't work the same way before that, and that Mars might have had a stronger hygropause long ago..

# WASTE MILK & CO2 EMISSIONS

Click here to read the full article

An article from Clarkson University shows how surplus milk may be used to capture carbon dioxide from fossil-fuel based power plant emissions, and was featured on the font cover of the November issue of *Advanced Sustainable Systems.* Two major sources of greenhouse gases are carbon dioxide from fossil-fuel based power plants, and methane emissions from cattle. There is a strong scientific consensus that emissions like these are causing human-induced climate change. The article, 'CO2 Capture: Dry and Wet CO2 capture from Milk-Derived Microporous carbons with Tuned Hydrophobicity', explains that it is possible to greatly reduce power plant CO2 emissions by using surplus or waste milk from cows to create activated carbons, which will absorb or scrub the CO2 from the output. Powdered milk can be converted into advanced carbons with the right porosity and surface chemistry to absorb the CO2, allowing much better control than with the current materials used for this process, like coconut shells or coal.

Although Milk consumption has declined more than 30% since 1980, there has been a 13% increase in annual milk production per-dairy-cow, resulting in an oversupply in which farmers now dispose of more than 50 millions gallons of milk annually. The article says that cows on average release 150 to 260 pounds of methane per year, and that employing their milk to capture CO2 would also help offset this emission. Researchers also say that these milk derived carbon sorbents could also be used in other applications, such as indoor air purification and water treatment, and that commercialisation of the process may be in the future.




National geographic , Jorinde Van Ringen


A selection of microfibres found in snow samples from Mt. Everest Balcony. (8,440 m).

# MICROPLASTICS ON EVEREST

Researchers analysing snow and stream samples from the National Geographic and Rolex Perpetual Planet Everest Expedition have found evidence of mircoplastic pollution on Mount Everest. While the highest concentrations were found around base camp, the team also found them as high as 8,4400 meters above sea level, just below the summit. Mount Everest is now being described as 'the world's highest junkyard', says first author Imogen Napper, a scientist based in the University of Plymouth and has been described as a 'plastic detective'. The samples gathered showed significant quantities of polyester, acrylic, nylon and polypropylene fibres, which are materials increasingly being used to make the high-performance outdoor clothing that climbers use, along with tents and climbing ropes. While this study demonstrated the presence of these microplastics, the best way to clear them seems unknown. We now need to start focusing on deeper technological solutions that focus on microplastics, such as changing fabric design, and incorporating natural fibres instead of plastics when possible.

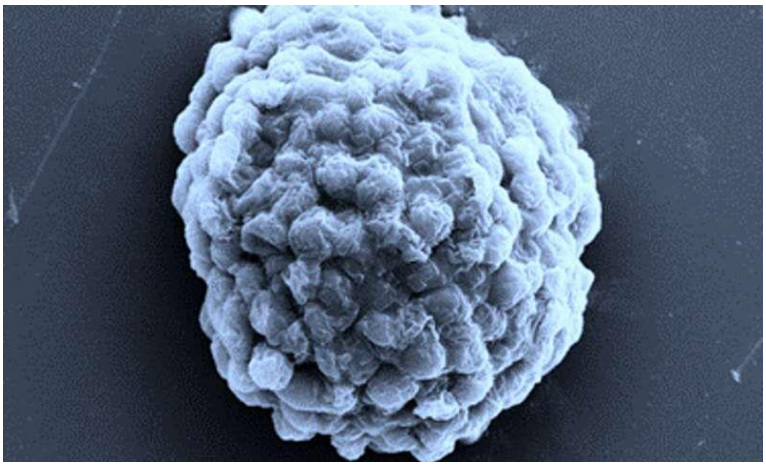
# CLIMATE CHANGE AND AUTUMN LEAVES

Click here to read the full article

Researchers at the Swiss Federal Institute of technology studied the degree to which the timings of colour changes in autumn tree leaves was determined by the growth of the plant in the preceding spring and summer. Previously, temperature and and day length were accepted as the main determinants of when leaves changed colour and fell, leading some scientists to believe that warming temperatures would delay this process until later in the season. However using data from the Pan European Phenology Project, observers found that for every 10% increase in photosynthetic actively, trees shed their leaves , on average, eight days earlier. The research shows that deciduous tress can only absorb a set amount of carbon each year and once that limit is reached, no more can be absorbed. At that point, leaves begin to change colour. This limit is set by the availability of nutrients, particularly Nitrogen, and the physical structure of the plant itself, especially the inner vessels which move water and dissolved nutrients around. Nitrogen is a key nutrient which the plant needs to grow, and it it often the amount of Nitrogen that limits total growth. Together, these constraints mean that the carbon intake during the growing season is a self-regulating system in trees and herbaceous plants.

In a world with more carbon in the atmosphere, these new findings imply that warmer weather and longer growing season will not allow temperate deciduous trees to take up more carbon dioxide. The study's predictive model suggests that by 2100, when tree growing seasons are expected to be between 22 and 34 days longer, leaves will fall from tress between 3 and 6 days earlier than they do now.

This has significant impacts on climate change modelling; if we accept the amount of carbon taken up by deciduous trees in temperature countries like the UK will remain the same each year, carbon dioxide levels will rise more quickly than was previously expected. The only way to change this will be to increase the capacity of trees to absorb carbon.



Electron microscopy image of a densely packed droplet of hydrogen producing algal cells

Shivanshi Bhatt: The Autumn leaves on October 17th 2020

# HYDROGEN PRODUCING DROPLETS

Click here to read the full article

Scientists have built tiny droplet-based microbial factories that produce hydrogen instead of oxygen when exposed to daylight in air. Normally, algal cells take in carbon dioxide and produce oxygen by photosynthesis, however this study used sugary droplets packed with living algal cells to generate hydrogen, rather than oxygen by photosynthesis. Hydrogen is potentially a climate neutral fuel, offering many possible uses as a future energy source. One major drawback is that making hydrogen involves using a lot of energy, so green alternatives are being sought after and this discovery could provide an important step forward. The team trapped ten thousand or so algal cells in each droplet, which were then crammed together but osmotic compression. Oxygen levels fell to a level which then switched on special enzymes called hydrogenases that hijacked the normal photosynthetic pathway to create hydrogen .

# COLOURFUL SUNSETS

Why do sunsets appear the colour they do? Why is the sky blue but the sunset red? This is due to a process called light scattering.

The interaction of sunlight with matter can result in one of three behaviours: absorption, transmission, and reflection. The atmosphere contains many different types of particles, the two most common being nitrogen and oxygen. These particles are most effective in scattering the high frequency and short wavelength portions of the visible light spectrum. The scattering of light occurs by the interaction of light with molecules and small particles in the atmosphere, sometimes called a Tyndall or Rayleigh scattering. The intensity of the scattering is inversely related to the wavelength of the light (i.e blue light is scattered more than red). Atmospheric nitrogen and oxygen scatter violet light most easily, followed by blue and green. To an observer standing on the earth with the sun in the sky, the sky appears blue , because of the scattering of the short wavelength light from the atmosphere. At sunset, the light from the sun just grazes the surface of the earth, passing through a long column of atmosphere. During its passage through the atmosphere, the blue components of the light are reduced in intensity, making the transmitted beam of sunlight appear more warm in colour.

The effect of a red sunset becomes more pronounced if the atmosphere contains more particles ; the presence of sulphur aerosols (emitted as an industrial pollutant and by volcanic activity) can cause some very serious environmental problems, however can lead to some magnificent sunsets!