So notoriously unpredictable

WITH COMET ISON SET TO GET CLOSEST TO THE SUN TODAY, **AMALENDU BANDYOPADHYAY** EXPLAINS WHAT IT ALL MEANS

A faint and distant comet was discovered by two amateur astronomers, Vitali Nevski and Artyom Novichonok, using the 16-inch reflector telescope of the International Scientific Optical Network at Kislovodsk Observatory, Russia, on 21 September 2012. It was named Comet Ison after the International Scientific Optical Network, which is involved with its discovery. It was soon obvious that this was a new comet on a parabolic orbit and was going to pass very close to the sun. On the basis of a few positional measurements of brightness, there was immediate speculation that this would be a spectacular object, a "great comet" perhaps, brighter than the moon and one that would graze the sun. It does get very near the sun at its closest point in its orbit. The closest point a comet gets near the sun is termed the perihelion and Comet Ison reaches perihelion on 28 November (today) when its distance from the sun will be 0.012 astronomical units (one astronomical unit is the average distance of the earth from the sun = 1.496×10^8 km).

The appearance of a great comet is one of the most striking celestial phenomena that can be seen by the naked eye. That the occurrence of comets is generally unpredictable and that they may suddenly appear as large and prominent objects only serves to make them more remarkable.

What is a comet? Comets are small bodies, anywhere from 100 metres to a few dozen kilometres across that originate from the outer Solar System. Many astronomers reason there is a huge "cloud" of them far beyond the orbit of Pluto, completely surrounding the sun. It is named the Oort Cloud after Dutch astronomer Jan Oort, who first wrote of the possibility of such a vast and distant reservoir of inactive, frozen comets. Despite their great distances and long periods, Oort Cloud comets are still gravitationally bound to the sun. Their orbits are governed by the same laws of motion that control the planets. Comets have been likened to dirty snowballs — a mush of dust and frozen gases, mostly water vapour but also carbon dioxide, carbon monoxide, methane, various alcohols, even deadly hydrogen cyanide.

On occasion, comets will be nudged from the Oort Cloud and head towards the sun. As one enters the Solar System, it begins to warm and the various gases begin to vaporise from their surfaces, creating a fuzzy head around the comet's nucleus, called a coma, and a long tail that streams away in the opposite direction to the sun, blown by the solar wind.

No comet has a permanent individuality to distinguish it from others. The only identification mark is the path it pursues around the sun. Comets fall into two groups, namely periodic comets and non-periodic comets.

Those with definite elliptical orbits are known as periodic comets. The ellipse is a closed curve and comets orbit around the sun, which remains at one focus. The time taken by a comet to make one complete orbit around the sun is known as its period. Comets whose periods are less than 200 years are termed as short-period comets and when the periods exceed 200 years, they are known as long-period comets. The period of Halley's Comet is 75-76 years, but of Kohoutek's Comet about 75,000 years. This period may extend up to many millions of years.

Faint comets are common, bright ones are very few and extremely bright ones a rarity. Generally, one associates comets with long graceful tails but not all have tails and those that have display these only when close to the sun. Far from the sun, a comet has no visible tail and when first sighted through a telescope it looks like a hazy dot with a bright head called the coma. Sometimes a coma contains a star-like point called a nucleus. as a comet nears the sun, solar energy warms its head and vaporises the gases frozen in solid crystals during the many years it was far from the sun. These gases stream out behind the comet's head. Excited to luminescence by the absorption of solar radiation, the stream forms a spectacular glowing tail that is visible to the naked eye as it nears the sun. The tail reaches its maximum length and brightness soon after the comet has passed its perihelion and gradually decreases as it recedes from the sun. A few comets may become so brilliant as to be visible even in day time. In all cases, a comet's tail points away from the sun.

The nucleus from which the coma and the tail are derived is extremely small, less than 16 km in diameter. At the time of maximum development, the tail length may extend up to 250 million km, which is the same as the farthest separation of Mars from the sun. Comets generally come in two types, distinguished mostly by the appearance and material composition of their tails. Type-I tails are approximately straight, often made of glowing, linear streamers containing ionised molecules. The Type-I tail is often called the ion or plasma tail and its colour is usually bluish. Type-II tails are usually broad, diffused and gently curved. They are rich in microscopic dust particles that reflect sunlight, making its colour yellowish.

Comet Ison is a long-period comet, possibly on its first ride into the inner Solar System from the distant Oort Cloud. It is big, too, around six kilometers across. This comet has remained at constant brightness since January 2013, rather than growing brighter as it gets closer. One possible reason is that Ison may be relatively short of water-ice that can sublimate to form a large bright tail and coma.

Vitali Nevski and Artyom Novichonok.

Nevertheless, it does sport a tail as seen in images from the Hubble Space Telescope. Several factors are needed to produce a great comet, one being that it should get close to the sun, the second that it should pass close to earth and the remaining important factor concerns the size and activity of its nucleus.

Ison fulfils the first factor, but with a closest approach of 0.43 astronomical units it does not get so close to earth, so this factor will only make it a nice comet, not a great one. The comet is also fairly average in terms of size and activity, so again not a great comet. However, comet activity can change at any time in response to the input of solar energy, causing "geological" changes in the nucleus and, in this case, the sun's gravity may cause physical change, too.

Comet Ison is to disappear into the morning twilight just a week shy of its 28 November perihelion. At that time, a short, not particularly bright tail should trail its intensifying coma. On perihelion day, its head may spike very briefly to around magnitude -6, brighter than Venus. As Ison re-imerges in the dawn sky a few days after perihelion, it will sport a brilliant, quickly straightening trail perhaps 10°-16° long. This impressive appendage will grow longer by the morning, while the comet's head becomes ever less distinct. The crescendo of the apparition will likely reach its peak between 10-14 December when the comet will be best seen just before dawn after the moon sets.

Comet Ison indeed carries considerable potential for becoming a spectacular object, but comets are notoriously unpredictable. Observers need only recall the dismal failure of Comet Elenin in 2011, which was also touted to become a grand spectacle. We will just have to wait to see.

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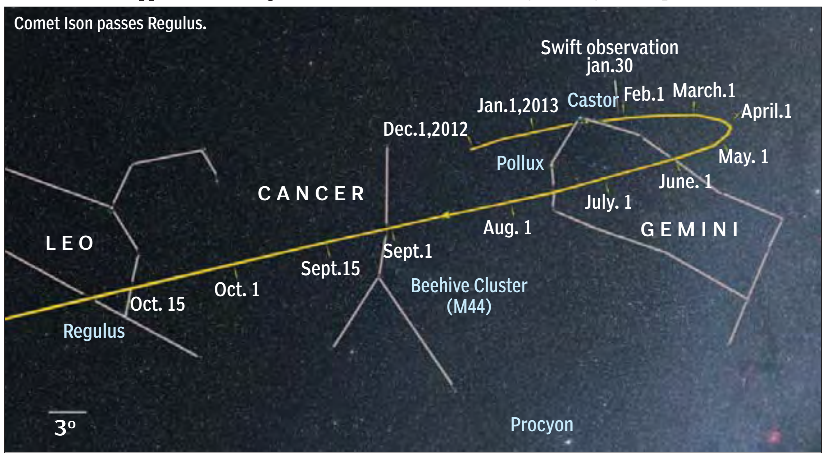


Comet Ison passes Regulus.

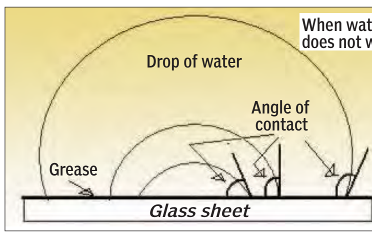
STAYING DRY

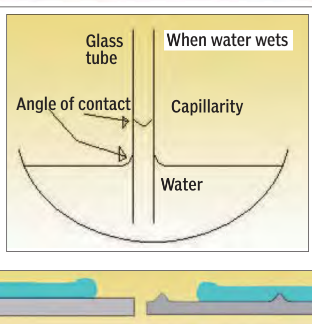
THE GEOMETRY OF A SURFACE IS FOUND TO MATTER AS MUCH AS THE MATERIAL WHEN IT COMES TO SHRUGGING WATER AWAY, SAYS **S ANANTHANARAYAN**

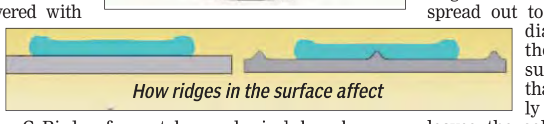
The material of a duck's feathers and the lotus petal are renowned for not getting wet. The *lotus effect*, as it is called, is the property of these surfaces to strongly repel water, so that water that falls on them simply runs off and does not stick, or wet the surface. The surface, thus, stays dry and firm, which is useful for a plant that grows in water and for the butterfly, which needs its wings to get about. But the water does wet any dirt particles on the surfaces, and takes them away, leaving the surface not only dry but clean.

The surface of the lotus petal and also of other plants like the nasturtium, the prickly pear and some grasses have been found to have structure at the very fine level and a coating of waxes. The lotus petal has tiny hair-like protuberances, just 10-20 microns in size, and these are covered with waxes that are hydrophobic, or water-repelling. The waxes have been considered to be the main agency that keeps these surfaces dry. But the work of James C Bird, Rajeev Dhiman, Hyuk-Min Kwon and Kripa K Varanasi at Boston University and the Massachusetts Institute of Technology, reported in the journal *Nature*, finds that veins and ridges, or a larger dimension structure of the surface, plays an important role.

The property of being water repelling has to do with the molecular structure of the material and with how it relates to the structure of water molecules. A drop of water, free of other forces, takes a spherical shape because this is the energy efficient form, as a sphere presents the least surface area for a given volume. But if the drop is placed on a sheet of glass, for instance, the molecules of water are strongly attracted to the glass surface and retaining the spherical shape, against both gravity as well as the attraction of the surface, takes energy. If the drop is more than very small in size, it would hence spread out to minimise energy, and the drop would be said to have *wet* the glass.







How ridges in the surface affect

This happens because the material of glass has affinity for water, or is *hydrophilic*. But if the material were a layer of oil or grease, for instance, the material has a closed molecular surface and is unable to blend with water molecules. The droplet of water is, hence, not drawn to spread out and is able to retain its spherical shape and shrink away from the surface even when it is a reasonably large drop. When the drop grows very large, of course, the tendency of the surface to minimise itself, which is called *surface tension*, cannot support the greater weight and the drop collapses. A material that behaves like this — examples being oils or a wax-covered surface – are called *hydrophobic*.

Creating surfaces like this, where drops of water do not adhere to them but bounce off, is of great interest. Surfaces like this stay dry, clean and, as they do not wet, also avoid getting covered with ice in cold weather.

Bouncing off

The authors of the paper in *Nature* note that the current understanding of what transpires when a drop of water strikes a surface suggests that it is important that the time of contact of water and the surface, till the drop bounces off, be kept as short as possible. "A drop striking a non-wetting surface of this type will spread out to a maximum diameter and then recoil to such an extent that it completely rebounds and leaves the solid material," they note in the paper.

When the drop strikes the surface, it is the motion energy of the drop that is able to spread it out over the surface, creating tension in the surface of the deformed drop. When the movement stops, the surface tension draws in the drop into a spherical shape again, and the reaction against the surface propels it back, to rebound.

Theoretical considerations would suggest that it is in symmetrical deformation, equally in all directions, that the energy of impact would get converted and reversed in the most efficient and, hence, fastest way. The least contact time between the water and the surface would help prevent the development of attractive forces, called "pinning forces", which promote wetting. Studies so far have focused on properties such as the angle of contact of the interface of a drop on a surface, to delve into ways to increase water repellence. The picture shows the shape of a drop of water on a surface that it does not readily wet, like a greasy (as opposed to a clean) sheet of glass. It can be seen that there is a large angle of contact in the case of the largest drop, where the surface tension has to support the largest weight of water.

The angle of contact also comes into play when attractive, wetting forces between glass and water support a column of water by capilarity when a narrow glass tube is dipped in water. But in respect of water bouncing off a surface, the Boston/ MIT group tested the assumption that uniform, "axisymmetrical" deformation of the drop promotes fastest recoil. The hydrophobic surface they used was a sheet of silicon coated with *flourosilane*, a known *super-hydorphobic* or strongly water-resistant material, like the lotus petal. The experiment was then to let fall a drop of water, 2.66 mm in diameter, from a height of just over a metre, on to the coated silicon surface. The spreading of the drop on the surface, and then the recoil and bounce back were recorded, from the side and from above, by high speed cameras.

The photographs show the progress, from 0 milliseconds, when the drop just strikes, to 2.7 milliseconds when it has spread to the maximum, at 4.7 milliseconds when it is drawing inwards, at 7.8 milliseconds when the drop is forming again and at 12.4 milliseconds when it starts bouncing off the surface. The upper pictures are the side view and the lower pictures are the top view. It can be seen that while the rim of the drop spreads out and recoils, the centre stays stationary.

The second step in the experiment was to introduce non-symmetric spre-ad, where the centre also moves. This was achieved by criss-crossing the silicon surface with a macrostructure of ridges. The principle was that if the drop is divided and the portion near the centre also gets into the act of promoting the recoil of smaller drops, then the time of contact may be reduced. The results of the second part of the trials are in the second picture, where we can see that the recoil is complete by 7.8 milliseconds, while it took 12.4 milliseconds in the first case – a saving of 37 per cent.

The effect of the ridge is to start the recoil in both directions along the ridge, for faster recovery and also resulting in smaller droplets, which would be less likely to wet the surface in subsequent contact, too.

The group tried out the effect of the ridge-like macrostructure on waterproofing other surfaces, like one of anodised aluminium and copper, coated with flourosilane, to obtain similar results. It was also seen that in nature, too, the wings of the butterfly and the leaves of the nasturtium contain a macrostructure of ridges, and these surfaces showed less water drop contact time than the legendary lotus leaf.

Creating materials that resist wetting would have industrial value. The property would prevent corrosion and save maintenance. The last property, of not icing in cold weather, would be useful in high altitude aircraft components, for instance.

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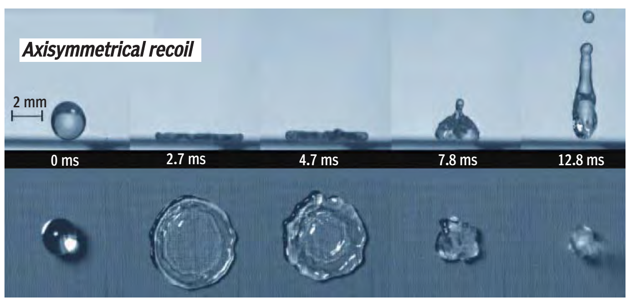
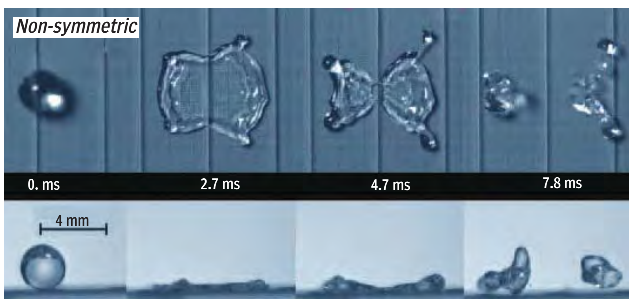
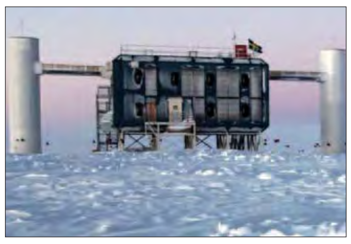


Axisymmetrical recoil



Non-symmetric

PLUS POINTS



The IceCube Laboratory at the Amundsen-Scott South Pole Station, Antarctica.

A new age of astronomy?

Scientists are predicting a new age of astronomy with the discovery of the first sub-atomic neutrino particles from deep space, which could provide fresh insights into cosmic events in distant regions of the Universe such as exploding stars and black holes. An international team of researchers has confirmed the first detection of high-energy neutrinos — sub-atomic particles from beyond the Solar System — by highly sensitive optical instruments buried a mile deep in the ice sheet of Antarctica.

Neutrinos from deep space normally pass straight through objects such as the earth without being detected but the IceCube laboratory in Antarctica has now confirmed the telltale flashes of light from 28 highly energetic neutrinos it has identified since it began operating in 2011, scientists said.

The breakthrough means that it is now possible to envisage a new class of telescopes based on neutrino detection. These could observe and measure cosmic phenomena that are difficult to detect with conventional telescopes, the researchers said. "The era of neutrino astronomy has begun. The sources of neutrinos, and the question of what could accelerate these particles, have been a mystery for more than 100 years," said Professor Gregory Sullivan of the University of Maryland. "Now we have an instrument that can detect astrophysical neutrinos. It's working beautifully, and we expect it to run for another 20 years." He is one of the 260 scientists from 11 countries who are participating in the IceCube project.

More than 5,000 highly sensitive light detectors are suspended from 86 steel cables embedded in a cubic kilometre of ice below the IceCube laboratory in order to pick up the brief flashes of blue light created as neutrinos very occasionally interact with the ice. Billions of high-energy neutrinos from deep space pass through our bodies unnoticed every second and several experiments around the world are designed to detect their telltale signals. But until now the only neutrinos that have been detected are low-energy particles from the sun or from a nearby supernova explosion observed by Japanese astronomers in 1987.

Now the search will start to concentrate on the possible sources of these neutrinos, which must come from some kind of cosmic particle accelerator such as an exploding supernova, when a giant star collapses in on itself, or an "accreting" black hole which radiates energy as it engulfs surrounding matter.

STEVE CONNOR/THE INDEPENDENT

Fire with fire

A data analysis has shown that the side effects of rosiglitazone, a drug to control blood glucose in patients with Type-2 diabetes, get subdued when the drug is administered in combination

with exanatide. One of the side effects of rosiglitazone is that it causes heart attack. The use of these two drugs in combination is found to have reduced the rate of heart attacks in rosiglitazone users.

Researchers from the Mount Sinai School of Medicine in New York used the US Food and Drug Administration's Adverse Event Reporting System to identify drugs that would mitigate the side effects of rosiglitazone for the study which was published online on 9 October in *Science Translational Medicine*.

Ravi Iyengar, director of the Systems Biology Center at the Icahn School of Medicine, Mount Sinai, said they now planned to work on other combinations. "We want to collaborate with physicians to develop rigorous clinical trials to see if the observations from Faers are truly valid. Since all of the Faers data are from humans, this type of analysis that identifies drug combinations that work in humans probably has a higher chance of predicting safer therapies," he said.