Comet slows down

In low mass objects, like comets, the forces of gravity are not strong and their structure is not firm

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The smallest celestial objects sometimes change their state of orbit or spin. The night sky has been long regarded as unchanging and even planets, the objects that move, are remarkably regular in their motion. We do know that the Earth has been gradually slowing in its rate of spin and gently closing in towards the Sun in its orbit. But the change is imperceptible and the cosmos has been a legendary ideal of constancy.

This is, however, more true of large objects, like planets and stars, than of smaller objects, like comets. Smaller objects are affected by the gravitational pull of larger objects that they pass, by impacts with dust or even of changes in their own structure. A major earthquake would not affect the movement of Earth but that is not true of an object only a few kilometres across. Dennis Bodewits, Tony L Farnham, Michael SP Kelley and Matthew M Knight from the department of astronomy, University of Maryland, report in the journal, *Nature*, the changes in the spin state of a Jupiter family comet, 41P/Tuttle-Giacobini-Kresá, known since 1858 and named after its three independent discoverers.

The spin of celestial objects arises from the way they were formed. Matter in the universe started from just gas, mainly hydrogen, and formed when the gas collapsed on itself due to gravity. Any motion within the gas or which was introduced during the collapse got magnified as dimensions reduced, and all the stars, galaxies or planets that we know of have a rate of spin. Even objects that broke away from other objects are ejected with spin. Objects that are in stable orbits also owe their stability to their spin, in the same way that a rifle bullet is imparted spin to keep it steady during its flight to the target.

Spinning objects, however, can change their rate of spin if they change the distribution of the spinning mass within themselves. We may be familiar with the ballerina, or the figure skater, who spin faster or slower by moving their arms towards or away from themselves. Movement of large masses in the crust of or within a planet can bring about a change in the rate of spin. The time it takes for such shifting of mass, however, is in centuries and we have not observed instances in recent history.

Things are different with small objects in space, like comets. In low mass objects, which are just kilometres in dimensions, the forces of gravity are not strong and the structure of the objects is not firm. A flow of material, erosion, et al, can hence bring about collapse or re-alignment of large parts of the object and this would affect its rate of spin.

Another effect with objects of long orbits is that they are sometimes close to a mother star and most of the time very far away. Material hence vaporises during the time the object is near the star but freezes when it is far away. We can imagine that this would cause flow of matter and changes in the shape of the object.

41P (green object in the centre) in the night sky

41P/Tuttle-Giacobini-Kresák goes around the sun once every four and a half years. It is only 1.4 km in diameter and can be seen only through a telescope. A particular feature of the comet is that it has been periodically flaring up. In 1973, the flare was dramatic and the comet became visible to the naked eye. The University of Maryland researchers report another feature in their paper, that the rotation of 41P has been slowing down, over measurements made just two months apart, and they suggest the processes in the comet that may be responsible.

The first measurement was in March 2017 using the 4.3 metre and 36 megapixel imager at the Lowell Observatory, Arizona. From 6 to 9 March, the time taken for a rotation was found to increase from 19.75 hours to 20.05 hours. The next measurement was in May 2017, using the ultra violet telescope aboard the robotic spacecraft, Swift, from some 7,000 km above the earth. The time of rotation in May was found to be between 46 and 60 hours. By and large, there seems to be a slowing down by about half an hour every day!

Measuring the period of rotation of a comet, when it is near the sun and covered with gas and vapour has its own challenge. There is no visible feature that can be seen to be going round, to help discover the time taken. In the measurements of March 2017, the feature used was plumes of cyanogen gas that the comet emits. When the comet rotates, the gas comes out in spirals. These can be detected, as cyanogen and the products of its exposure are fluorescent in sunlight. The measurements in May were of the light that came from a large area around the comet, with the rise and fall of the intensity indicating the speed of rotation.

This kind of indirect measurement is used even to assess the rotation of the gas giant planets, Jupiter and Saturn, where physical features cannot be seen. The case of Jupiter is simpler, as the magnetic axis of the planet is a pointer that rotates. In the case of Saturn, however, the magnetic axis is almost along the axis of rotation. It is with the help of faint radio emission of charged particles in the atmosphere, and the variation in the planet's gravitational field, that the speed of rotation could be worked out.

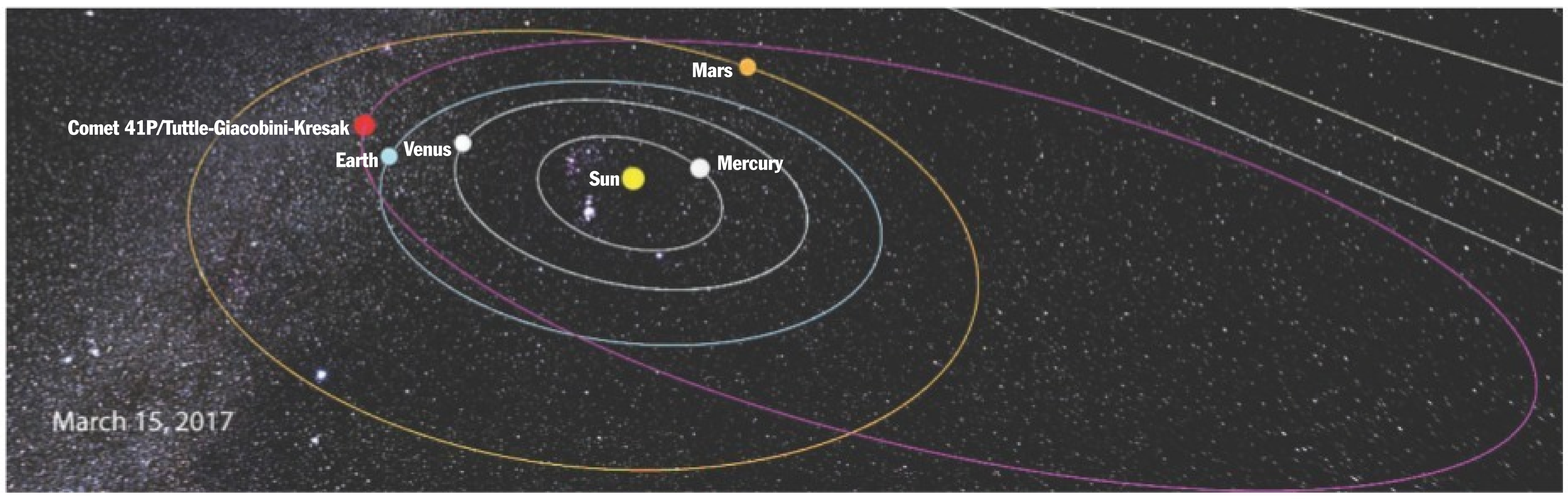
While the speed of rotation of many comets has been measured, it is in just a few cases that there has been a conclusive change, the paper says. The rapidity of slowing of 41P, however, outstrips the others by a wide margin. The paper notes the small size of 41P, and the indications that water production is active in about 50 per cent of its surface, in contrast with just three per cent in other comets, may be the reason. But then, there are similar instances that have not shown comparable slowing of rotation.

Further analysis shows the reason could be that the much of the gases emitted by the comet is in the direction opposed to the rotation. Emission of gases along the axis of rotation, or where the emission from different places cancel out, would not affect the speed of rotation."The active regions on the surface of comet 41P are probably oriented in such a way that its torques are highly optimised in comparison to many other comets," the paper says.

The team has extrapolated backwards the fall in the speed of rotation and the find that the speed must have been very high in the not so distant past. When an object rotates fast, its surface material experiences high centrifugal or "centre-fleeing" forces. It is like how we are thrown towards the far side of a car when it takes a sharp turn.

Now, in a small celestial object, the force of gravity is feeble and the material at the surface is not strongly bound. A fast rate of rotation would thus cause disturbances, fragmentation and landslides.

It could have been such events that led to the high luminosity seen in 1973 and again in 2001. It could even be that these events exposed new areas to emit gases and oppose spin, leading to slowing of rotation, the paper says.



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They have feelings too

Capuchin monkeys understand fairness; sheep recognise their friends and rats make sacrifices for buddies. Yes, animals are sentient. Here's the science

EMILY BIRCH

Years ago, we believed that we weren't animals and that animals were here solely for our use. Indeed, a cow was just a walking burger, steak of Sunday roast, keeping itself fresh and tasty, ready for when we were hungry.

Luckily, for their sake, things have progressed significantly from then and now we recognise that animals (including our "superior" human selves in that category) can experience emotions from more simple ones such as happiness and sadness to more complex ones such as empathy, jealousy and grief. Animal sentience is defined as the ability to feel, perceive and experience subjectively. In other words, it's about emotions and feelings and in some respects, having awareness that "you are you".

In fact, the scientific evidence for animals being sentient is vast — so clear that three scientists read 2,500 papers studying sentience in non-human animals and concluded confidently that sentience does indeed exist.

If you saw *Blue Planet II* recently, for example, you'll have seen the footage of a pilot whale carrying around her dead calf. For most humans, this clearly demonstrates a form of grieving, particularly given the behaviour changes in the wider family pod.

Studies have shown that sheep are able to recognise the faces of their sheep friends even after being separated for two years. Elephants form strong family groups with immense memories and they cry when they are hurt (both physically and emotionally). Capuchin monkeys know when they are receiving unequal pay (grapes versus cucumber) and macaques develop individual cultures, particularly when it comes to how one should wash a potato.

Capuchin monkeys know when they are receiving unequal pay

Chimpanzees like to keep the peace by redistributing bananas if someone complains that their share is unfair and even rats have been shown to demonstrate empathy by giving up their favourite snack to save a drowning friend. They also giggle when being tickled!

Fish use tools and octopuses weigh up whether the effort needed to gain a food reward is worth it depending on the type of food. There is also plenty of evidence on how animals have individual personalities

Elephants form deep family bonds that last a lifetime

and indeed how some are a "glass half full" type while others are more "glass half empty".

But it isn't just from watching their behaviour that we can say animals are sentient. When we examine the brains of species (and indeed individuals), we can draw parallels from what we know about human brains and start to make assumptions. Emotions mainly stem from a part of our brain called the "limbic system". Our limbic system is relatively large and indeed humans are a very emotive species. So when we come across a brain that has a smaller limbic system than ours, we assume it feels fewer emotions.

But, and here's the big but, when a limbic system is comparatively much bigger than ours, we don't assume it feels more emotions than us. Most likely because we cannot imagine something that we do not feel or even know about.

In some marine mammals, their limbic system is four times larger than ours. In addition to this, some marine mammals have spindle cells, which we originally thought were unique to humans, allowing us to make rapid decisions in complex social situations. Arguably, would these evolve if they weren't used for the same (or at least similar) purposes?

One potential reason why we don't like thinking too much about animal sentience is because we like to kill animals. Some to eat and some quite simply because we do not like them. Look at those poor spiders in autumn, coming in to find some shelter, only to meet their end being smacked by a slipper-wielding human. We also turn a blind eye to systematic cruelty on a mass scale to ensure we save some money on meat at the supermarket. It's far easier to pretend these animals don't have feelings or emotions so that we can enjoy a cheap dinner without the emotion of guilt creeping in.

So is animal sentience a big deal? Yes, it is. We need to ensure we include it everywhere to safeguard the welfare of all animals, not just our pets. We live in a world where a lady putting a cat in a bin causes immense public shaming, yet we'll pop down to the nearest fast food outlet and eat meat from an animal that has lived the most abhorrent life ever without thinking twice. It really is time that we spent more time thinking about the thinking beings around us.

The writer is a research fellow in human canine interactions at Nottingham Trent University, UK

the independent

Sheep are able to recognise the faces of their sheep friends even after being separated for two years

PLUS POINTS

'Rainbow' dinosaur

A duck-sized dinosaur found in China had a head and chest covered in shiny feathers similar to those seen on hummingbirds. The creature has been named *Caihong juji*, meaning "rainbow with the big crest" in Mandarin. When palaeontologists analysed a fossil of the dinosaur, first discovered by a farmer in north-eastern China, they found evidence of brightly-coloured plumage.

Iridescent feathers, which are found on some modern bird species, have a metallic sheen and change colour when viewed from different angles, giving them a "rainbow-like" appearance. "When you look at the fossil record, you normally only see hard parts like bone but every once in a while soft parts like feathers are preserved and you get a glimpse into the past," said Chad Eliason, a bird researcher at The Field Museum in Chicago and one of the authors of the paper describing the dinosaur.

Their findings were published in the journal *Nature Communications*. The discovery opens up questions about how iridescence first evolved. It could be that the *Caihong*'s "rainbow" feathers were used to attract mates, just like modern peacocks use their colourful tails.

The independent

Implanting a robot

Researchers at the University of Sheffield and Boston's Children Hospital, Harvard Medical School have created a robot that can be implanted into the body to aid the treatment of oesophageal atresia, a rare birth defect that affects a baby's oesophagus.

Dana Damian from the department of automatic control and systems engineering at the University of Sheffield and her team from Boston Children's Hospital have created the revolutionary prototype robotic implant, which encourages tissue growth in babies.

The robot is a small device, which is attached to the oesophagus by two rings. An incorporated motor then stimulates the cells by gently pulling the tissue. Using two types of sensors — one to measure the tension in the tissue and another to measure tissue displacement — the robot monitors and applies traction depending on the tissue properties.

The robot's function is inspired by the Foker technique of correcting the oesophageal atresia, which involves manually pulling the tissue slowly using sutures over a period of time. Damian said, "Doctors have been performing the Foker procedure as they realised that tissue lengthening can be achieved by pulling on the tissue. However, it is unknown how much force should be applied to produce tissue lengthening. Although the technique is one of the best standards, sometimes the sutures surgeons attach to the oesophagus can tear, which can result in repetitive surgeries or scar tissue can form that can cause problems for the patient in the future.

"The robot we developed addresses this issue because it measures the force being applied and can be adapted at anytime throughout the treatment. With it being implanted in the patient, it means they have — in effect — a doctor by their side all the time, monitoring them and changing their treatment when needed."

Oesophageal atresia is a rare genetic disease, which affects about one in 4,000 babies born in the US and Europe. It occurs when the upper and lower parts of the oesophagus don't connect, which means food can't reach the stomach. Some of these cases are characterised by a gap between three and 10 cm between the oesophageal stubs, called long gap oesophageal atresia. The treatment of these cases using Foker technique can start as early as three months old and can take months. Usually, the patient is sedated during the treatment to ensure the sutures in place do not tear.