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...ironment of space.) ...and piston are in ...t they drive in ...ity, eliminat... and also be... engine does ...ntinual explo... ...er, so it can use ...atly reduce wear. ...be powered by nothing ...sunshine concentrated by a concave mirror. That approach was being employed by Infinia, an American firm. ...a contract to ...g 429 of the ..., Infinia filed ...is may prove ...li-based pro... recently ac... ...en two centu... ...ilure, it does suggest that the curse of Robert Stirling has still not quite been lifted. ■

Comet ISON

The perils of sungrazing

The "comet of the century" may be a great spectacle, or a damp squib

AMATEUR stargazers have been hoping for a bright Christmas. If all goes well in the coming weeks then a comet called C/2012 S1—better known as ISON, after the Russia-based International Scientific Optical Network, which discovered it—could be lighting the night skies in one of the most spectacular displays seen for many a year.

Like all comets, ISON is a spacegoing snowball; a hunk of water ice, dust and pebbles. The path the comet is taking through the sky suggests that it has come all the way from the Oort Cloud, a hypothetical sphere of rocks, boulders and other detritus that extends up to a light-year from the sun and which marks the outermost edge of the solar system.

It is also what is known as a "sungrazer", which means that the comet will come very close to the sun. As *The Economist* went to press, ISON was making its closest approach and was predicted to pass around 1.1m km from the solar surface. As comets approach the sun, the rising temperature begins to boil them away, producing the spectacular dusty tails for which they are best known. ISON's should be visible to the naked eye from both hemispheres in December, as it heads back out of the solar system—assuming, that is, it survives its encounter with the sun.

Which it may not. The latest data suggest that ISON may have split apart under the stress of the sun's heat and gravity. If that is true (presently, no one is

Cracking up in the heat?

quite sure), then any December light show put on by its remnants will probably fall far short of the "comet of the century" that many had been predicting.

Even if it turns out to be an aesthetic damp squib, though, astronomers will still learn a lot. Comets like ISON are not very common. Besides the ground-based instruments being used to study it, a small fleet of space telescopes and robotic probes have also been pointed at it. As a NASA blog put it: "Remember: Comet ISON is a dynamically new sungrazing comet, fresh in from the Oort Cloud, and the last time we saw an object like this was never!"

Spring-cleaning outer space

Belt up!

Scouring electrons from near Earth could prolong satellites' lives

THE Van Allen belts, which were discovered in 1958 by some of the first artificial satellites, are a bane of those satellites' successors. The outer belt, which begins at an altitude of 13,000km above Earth's surface and goes up to 60,000km, is full of energetic electrons. The inner one, at 1,000-6,000km, is full of energetic protons. Both play havoc with satellites' electronics.

But what if you could sweep them away? This is the ambition of Reinhard Friedel, a physicist at Los Alamos National Laboratory, in New Mexico, and his colleagues. Dr Friedel reckons you could do the job with radio waves. In principle this should work because the gap between the inner and outer belts is maintained by natural radio waves from things like lightning.

Particles in the Van Allen belts are constantly on the move, following the lines of Earth's magnetic field towards the poles, gyrating as they travel. As they approach a pole, however, the laws of electrodynamics that govern the behaviour of gyrating particles force them to reverse their direction and head back towards the opposite pole. If a particle is moving towards a pole faster, it will come closer to Earth before bounding back and is more likely to hit an air molecule. If it does so it is, to use the jargon, "precipitated" into the atmosphere where it gives up its energy and never returns to space.

So the way to sweep the Van Allen belts clean of their troublesome electrons and protons is to bombard the particles with radio waves at a frequency that speeds them up as they head towards the poles. Protons are heavy and influencing them requires a lot of power. So sweeping the inner belt may be impractical. Electrons, however, are much lighter. That means a space-borne particle-sweeper for the outer Van Allen belt is a possibility, according to Dr Friedel. He reckons it would cost about $500m to launch and operate for 15 years. Not all satellites would benefit. But many, including all the geostationary communications satellites, have to contend with electrons in the outer belt. Sweeping could extend the life of all GPS satellites by two years, saving about $22m per satellite, or $660m in all.

The scheme is ambitious, but not foolhardy. Some talk of clearing larger chunks of space debris to stop them crashing into satellites. That would be hard. Sweeping away the cloud of electrons that surrounds Earth could be a better investment. ■