The Grand Finale of Cassini on Saturn by **Dr Greg Hunt** on 18th November 2016

Saturn orbits the Sun at ten times Earth's radius, taking 30 Earth years to do so. Its day length is about 10½ hours. Despite its appearance in photographs, the surface is not solid – Saturn is a gas giant with a radius R (to the where the pressure level is 1 bar) of 60,000 km.

The Cassini-Huygens mission was launched in 1997, and followed a path via Venus, Earth, Venus to gain gravitational boosts before heading to Jupiter in 1999 and reaching Saturn in 2004. The mission was to last until 2008, but was extended to 2010, and again to 2017 (it is now running low on thruster fuel). This means that Saturn will have been observed for half of one of its orbits.

The Cassini spacecraft is the size of two double decker busses. It weighs 2 tons, and at launch carried 4 tons of fuel, and a nuclear reactor to generate the 700W needed by the electrical equipment. Dr Hunt commented that it has a 1Mpixel camera, and 0.5 GB data storage [but, with large semiconductor feature sizes, more able to withstand cosmic rays than modern equipment - *ed*].

Dr Hunt's work is to use its Magnetometer and interpret the results as it passes by Saturn and its environs. Two magnetometers were mounted on an 11m beam to minimise the magnetic effects of the electronics in the main body of the spacecraft: one at the end of the beam, no longer operational; and that designed at Imperial College half way along the beam. Magnetometer calibration is done by rotating the spacecraft so that its magnetic effects alternately add and subtract from measurements. (Dr Hunt said rotation was desirable for his work, but not for the photography being done by others!)

Cassini has now done 248 orbits of Saturn, on a tour out into the Solar Wind beyond its magnetosphere, looking at the rings, and around the moons on its equatorial plane, and through the Cassini Gap between the Rings and the Planet. The tour was designed to orbit the larger moons to gain energy for orbital adjustments and minimise the use of thruster fuel. Two moons have well repaid their visits: Titan, which the Huygens module was built to photograph; and Enceladus.
- Titan is Saturn's largest moon, slightly larger than Mercury and furthest out orbiting at 20R. It has organic material on its surface, including methane lakes.
- Enceladus is a tenth the size of Titan, about 500 km in diameter, orbiting at 2R in Saturn's E-ring. It is an icy moon – covered in water ice, giving it a high albedo. It is active: during an early flyby a magnetic field deflection was seen; there are cracks at its north pole, but it is smooth further south. The cracks are hotter than the surroundings and emit Plumes of water – there seems to be a liquid ocean under the surface. Enceladus is in a locked orbit with Dione, another moon, giving rise to tidal heating. It exhibits *cryo-vulcanism*, covering the southern surface with new material.

Saturn has a magnetic field giving it a magnetosphere which reaches out to Enceladus so that it too has a magnetic sheath. The lines of force of both planet and moon are in alignment.

Saturn day length is indeterminate. The 10½ hour figure was found by the Voyager spacecraft; since then the Ulysses probe measured 10.7 hours, and Cassini has measured 10.6 hours in the northern hemisphere and 10.8 in the south – radio and magnetic measurements agree. As a gas giant different wind speeds are possible. It has a Great White Spot at the North Pole – with a hexagonal outline and a vortex at its centre. It was first seen in 1989; it waxes and wanes, and this is its fifth appearance since then. Its colour can change from blue to yellow due to chemical reactions – the yellow being due to ammonia. The upper atmosphere is heated, and has frequent storms – which grow until they encircle the planet at which point they collapse. Saturn is mostly made up of hydrogen and helium – hydrogen at the core being gravitationally compressed to its metallic state, in which currents can flow and generate a magnetic field. Saturn too has auroras, and a plasma tail away from the Sun. Saturn's core will be at a high temperature, and even its surface is about 400^{O}K – hotter than if it were only heated by the Sun.

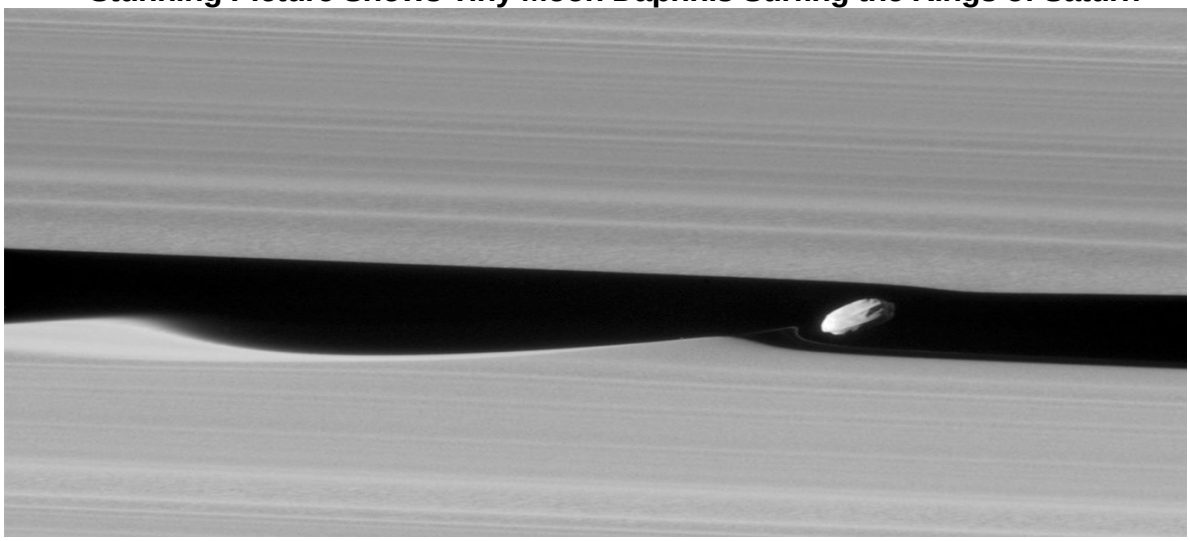
Much is still to be found out about Saturn: its day length(s); the periodicity of its weather; the close alignment of its dipole and spin axes; its internal structure, etc. In its last few months Cassini's orbital period will be speeded up, using a flyby round Titan, from 8 days to 6½ days and it will orbit 22 times at 30km/sec through the Cassini Gap to get even more information about the Saturn. Its final orbit is to end on 15th September 2017 at 12pm (GMT) when it will plunge beneath Saturn's surface.

If it was left to its own devices Cassini would not escape from Saturn's system of moons and rings – it could fly into and contaminate Titan or Enceladus where there is the possibility of life.

JUICE – JUpiter ICy moon Explorer is a mission already being planned to look particularly at Callisto, Europa, and Ganymede; though Jupiter has magnetic quirks to be investigated, and its structure and formation are to be studied. Ganymede has its own magnetic field, and could have an ocean.

The spacecraft will have a set of improved instruments - Imperial College are working on its fluxgate magnetometer. Launch is planned for 2022 followed by a 7½ year journey, then an operational life from 2029 to 2033. Seventeen countries were involved in the Cassini mission, and no doubt will be for JUICE.

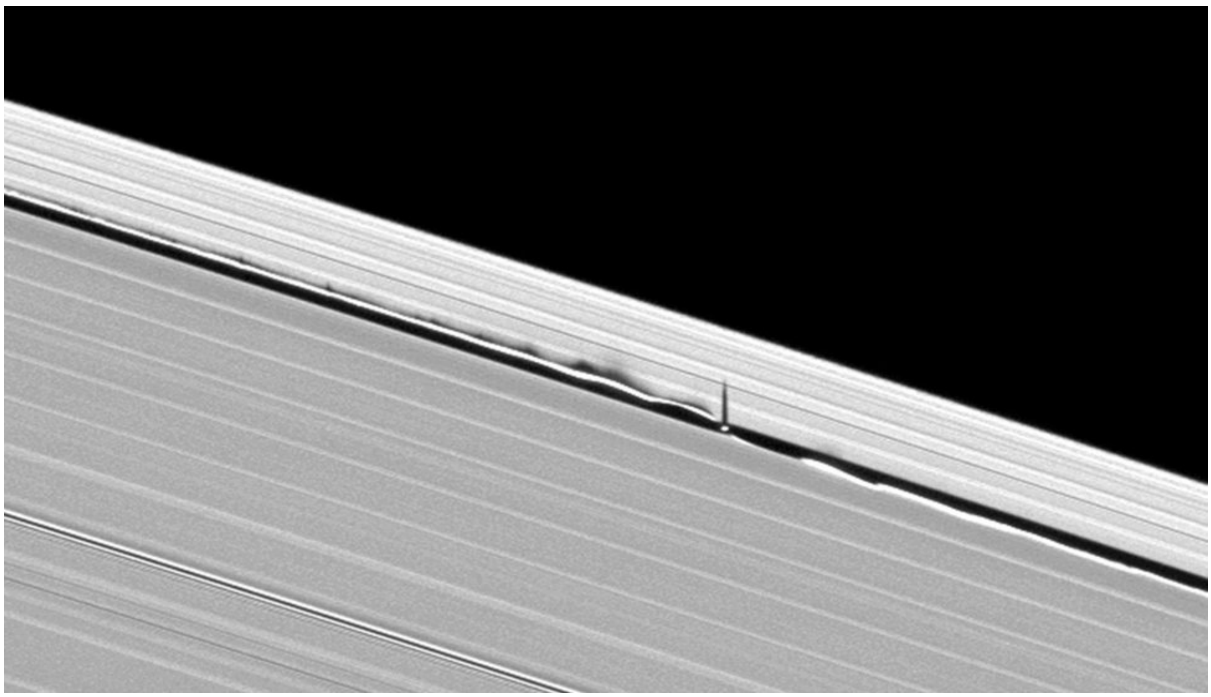
Stunning Picture Shows Tiny Moon Daphnis Surfing the Rings of Saturn



Of the 62 confirmed moons that orbit Saturn, none has more pluck than Daphnis.

A tiny dot compared to the gargantuan size of Saturn, Daphnis' orbit means that despite its small size it makes a big impact on what's around it. You see Daphnis 'surfs' on Saturn's rings, carving through the outer layers while leaving a fantastically beautiful wake behind it. Like a rock skimming over water you can actually see the ripples that Daphni's tiny gravitation pull has on the gas giant. At just 5 miles across Daphnis is well and truly minuscule when compared to Saturn's staggering size.

Captured by NASA's Cassini spacecraft, the 'wavemaker' was first spotted in 2009 as it sped through the 26-mile wide Keeler Gap found in Saturn's outer rings.



Saturn’s rings alone are astonishing. Stretching as far as the moon is from Earth, and yet in some places less than a kilometre thick Saturn’s rings contain dust, ice and large rocks.
Saturn itself is also a collection of impressive numbers. It is around nine times larger than Earth and is around 900 million miles from the Sun.