The Cassini Legacy and "JUICE" by Dr Greg Hunt on 16th February 2018

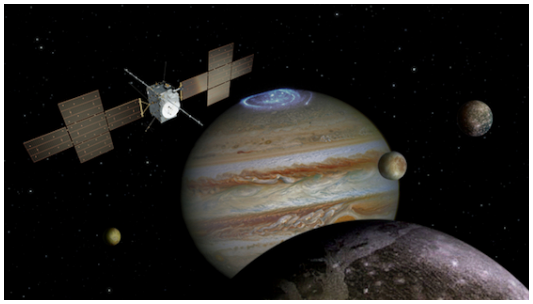
Dr Greg Hunt began from the point he had reached in his previous talk by announcing the success of the last 22 orbits that **Cassini** made in the gap between the inner edge of the rings and the surface of Saturn, despite worries of collisions with stray lumps of rock. Cassini still had sufficient thrust to make a perfect plunge into Saturn, sending back data all the while – the signal faded as the spacecraft entered Saturn's atmosphere, returned briefly then vanished. The upper atmosphere of Saturn is very interesting and over the last year 45 orbits (including the final 22) had been close enough to gather useful data.

The Cassini spacecraft was 6.8m tall & 4m diameter and weighed almost 6 tons. It had three nuclear (plutonium) reactors generating heat which was thermoelectrically converted to give 700W electrical power, sufficient to power the onboard equipment and keep it at room temperature. After the launch on 15 Oct 1997 the spacecraft took 7 years to reach Saturn. It made its death plunge into Saturn on 15 Sept 2017.

The Cassini-Huygens mission was to study Saturn and its moons – primarily its largest moon, Titan, for which the Huygens probe was designed. But then Enceladus became a focus of interest – with cracks (tiger stripes) at its south pole emitting a hundred fountains - caused by tidal forces between Enceladus and two other moons. The emissions are of water and higher organics (which, being unexpected, Cassini had not been equipped to be able to analyse). Most of the emitted material falls back to the surface, but some goes into one of Saturn's rings. On the moon's surface the water goes to ice, but beneath the surface there is sufficient warmth to make it liquid.

Is there life there, or on Titan? The Americans are already planning another mission to Titan.

Not to scale!



JUICE. Jupiter has been studied for centuries, and in 20C by several spacecraft – including Cassini; the Hubble telescope has photographed an aurora on Ganymede. Much is already known and JUICE is set to add detail. Jupiter is famous for its icy moons, Ganymede, Calisto and Europa, which are all to be visited. The programme is for the spacecraft to be launched by an Ariane 5 rocket in mid-2022 and arrive in 2029. Jupiter is close enough to the Sun to get power from a $97m^2$ solar array and deliver 850W.

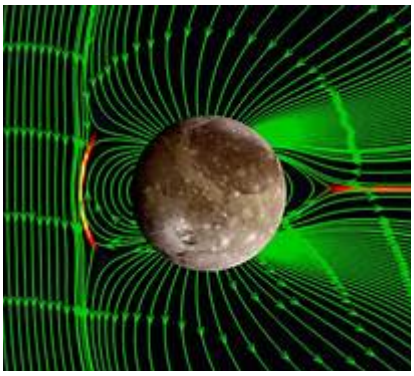
Imperial College are again responsible for the fluxgate magnetometer, J MAG (in which a measured current is generated to balance out the signal). It is an upgraded design from the one used on Cassini as it will have to measure similar low level signals around the moons in the presence the much higher magnetic field of Jupiter. The magnetometer is mounted at the end of a boom to minimise the effect of on board magnetic fields. It will need frequent calibration – done with the aid of one of the other instruments (on Cassini, said other instrument failed so calibration was done, more slowly, by deliberate tweaks to the spacecraft's orbit).

RIME is a new, Italian, instrument for JUICE - it is a Radar for Icy Moon Exploration to investigate the subsurface structure, and how liquid water is formed. On Europa, the instrument also will search for thin areas of ice and locations with the most geological activity, such as plumes.

The plan is for a fly-by of **Europa** in 2030, with the likelihood of seeing plumes of water and finding evidence of a sub-surface ocean. Then, until md-2031 the upper latitudes of Jupiter will be studied. Jupiter, like Saturn, is believed to have an electrically conducting metallic hydrogen core with vortices; its magnetosphere is the largest of any planet, and rotates fast, at once in ten hours. Its strength at the altitude JUICE will encounter it is about 1 gauss, some orders of magnitude greater than the moons' effects on it that are to be measured.

Io, Europa & Ganymede (outermost of the three) orbit Jupiter in resonance: Europa having twice the period of Io and Ganymede four times. Io is the much more volcanically active than Earth, giving it a mainly SO_2 atmosphere; tidal forces cause it to eject a ton of material per second from a

what is probably a magma ocean beneath a 30-50 km silicate crust, this disturbing Jupiter's magnetic field to give a measurable radio wave.



Jupiter is to the left

Then until 2032 the spacecraft will orbit **Ganymede** - the first time any spacecraft has done so. Ganymede has (uniquely for a moon in the solar system) a magnetic field, and its interaction with that of Jupiter is to be studied, Dr Hunt being particularly involved. Orbits will be at varying altitudes: 5000 km radius, elliptical, and at 500 km radius.

The crust is to be studied to see, inter alia, if Ganymede has a liquid water ocean under its surface.

The JUICE mission is planned to end in 2033, with the spacecraft plunged into Jupiter - so as not to contaminate a possibly life bearing moon.