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The Maxwell Apex Multiscale Mission

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Recent missions in near Earth space have involved the investigation of the global interaction of the magnetosphere with the solar wind (ISTP - Polar, Wind, IMAGE, Geotail), or the meso-scale physical processes which control its boundaries (Cluster). We propose a mission to investigate the processes which accelerate particles. The natural laboratory for investigating particle acceleration in space is the aurora. This area has yet to be addressed using modern multipoint and remote sensing techniques. Auroral processes studied at Earth will also be widely applicable at other planets, for example Mercury and Jupiter, and to a wide range of astrophysical situations.

Maxwell Apex is a mission consisting of multiple small satellites intended to investigate near Earth space. It addresses a wide range of science objectives in a novel, imaginative and highly cost-effective way.

- It will study the physics of the auroral oval and the cusp in three dimensions and on a range of temporal and spatial scales.

- It will make three-dimensional measurements of auroral structures for the first time, discriminating between the many theories of auroral acceleration and making clear the mechanisms which energise and eject ionospheric plasma into the magnetosphere.

- It will remotely sense magnetic reconnection in the magnetopause current layer using a unique combination of multi-point sampling and remote sensing in the interior cusp.

- Application of the same techniques on the nightside to remotely sense reconnection in the cross-tail current layer gives us the opportunity to finally resolve the outstanding controversies over the substorm onset mechanism.

- The combination of multipoint measurements, remote sensing and conjunction for long periods with ground based facilities will enable us to unambiguously determine the mapping of magnetospheric signatures along open or closed field lines to their ionospheric footprints.

- The high resolution particle time series and wave measurements resulting from our long residence times in various magnetospheric regions will be of great importance in the investigation of turbulence and non-linear effects in space plasmas.

The mission relies on the remarkable properties of the Molniya orbit to ensure that the spacecraft remain quasi-geostationary over the major European concentration of ground based equipment at Svalbard, and within the cusp and auroral regions, for many hours at a time. It is completely stable over the two year mission lifetime. The constellation does not require active maintenance. Moreover, spacecraft in higher orbit (lower altitude) Molniya Orbits will also line up. For example a spacecraft with half the altitude will be on approximately the same field line for around 30 minutes.

The mission is thus a natural consequence to E-prime, and will greatly enhance our understanding of the vertical transport of energy and mater into the upper atmosphere.

A fundamental factor of the proposal is the use of very low cost, flight-proven spacecraft technology, which has recently become available. Although only four spacecraft are needed for the mission, it is our intention to fly five, with one redundant, since this is cost neutral, adds capabilities and provides a 93% probability of four spacecraft surviving two years.

A second innovation is the concept of a distributed payload. All satellites carry a core payload comprising a low energy ion spectrometer, an electron spectrometer and a magnetometer, so as to perform the first multi-point measurements on the near-Earth plasma to resolve time and space in three dimensions.

In addition, each spacecraft carries a different remote sensing payload to relate these in-situ measurements to the overall cusp and auroral oval morphology. The instruments flown on only one spacecraft comprise an energetic particle detectors, neutral atom monitors, wave instruments and UV and X-ray imagers. The payload budget of the individual Maxwell Apex spacecraft varies between 20 and 27 kg. The overall mass for the five Maxwell Apex spacecraft is of order 600 kg, well within the capabilities of a Soyuz or Molniya launcher. The overall cost is around 95 Meuro. We also propose a low cost alternative.

The spacecraft and instruments rely on proven technologies, and do not require great technical innovation or risk. However, the deployment of a constellation of small satellites in this orbit is highly innovative, and will represent a major technical advance in European capabilities. They form a logical next step in research into Earth's space environment.