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On the need for multi-point, multi-scale and multi-region measurements for investigations of fundamental plasma processes in the Earth's magnetosphere.

C.J. Owen

UCL/Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, United Kingdom (cjo@mssl.ucl.ac.uk / Phone: +44-1483-204281)

Over the last few decades, the field of space plasma physics, and related disciplines, have evolved from a 'discovery mode', which defined the basic phenomenology occurring in and around the terrestrial magnetosphere, into one in which we are starting to understand the underlying physics of the fundamental processes which control the behaviour of the global system. In this respect, modern day studies are more akin to their laboratory counterparts than those of previous decades. For example, over the last few years ESA's Cluster mission has demonstrated that multi-point measurements are crucial to promote our understanding of plasma processes such as magnetic reconnection, shocks and turbulence, which are inherently 3D in nature. In particular, a number of interpretations which are derived from single spacecraft measurements are challenged when the datasets from other, even relatively closely separated spacecraft are considered. Moreover, the Cluster results demonstrate that many of these processes are also multi-scale – that is to say the observations made can be quite different, depending on the scale-size of the tetrahedron being used. This is of course not surprising since each particle species in the plasma imposes a characteristic time and spatial scale on the system, while a given 4-spacecraft separation scale can sample at most only one of these scales in 3D at any one time. However, in order to fully understand meso-scale phenomena, such as flux transfer events, or bursty bulk flows, which are observed by Cluster to have spatial and temporal scales of $\sim$ 1 R_E and a few 10's seconds, we also need to probe at least the underlying microphysical processes occurring on both electron ($\sim$10 km and 0.1s) and ion (100-1000km and 1-5s)

scales. Moreover, the importance of measurements on the global scale, such as those that can be inferred from auroral imaging and the ground-based magnetometer and radar networks, should also be recognised as crucial for a complete interpretation of such phenomena. In this presentation, we discuss the general need for such multi-scale and multi-region measurements by providing examples of where and how such measurements might improve our knowledge.