Cross-Scale: a multi-spacecraft mission to study cross-scale coupling in space plasmas

M. Fujimoto(1), S. Shwartz(2), T. Horbury(2), P. Louarn(3), W. Baujohann(4)

(1) Tokyo Institute of Technology, (2)Imperial College London, (3)CESR, (4)OEAW

Collisionless astrophysical plasmas exhibit complexity on many scales: if we are to understand their properties and effects, we must measure this complexity. We can identify a small number of processes and phenomena, one of which is dominant in almost every space plasma region of interest: shocks, reconnection, turbulence and boundaries.

These processes act to transfer energy between locations, scales and modes. However, this transfer is characterised by variability and 3D structures on at least three scales: electron kinetic, ion kinetic and fluid. It is the interaction between physical processes at these scales that is the key to understanding these phenomena and predicting their effects. However, current and planned multi-spacecraft missions such as Cluster and MMS only study variations on one scale in 3D at any given time. We must measure the three scales simultaneously completely to understand the energy transfer processes.

ESAĄfs Cosmic Vision 2015-2025 exercise revealed a broad consensus for a mission to study these issues, commonly known as M3. In parallel, Japanese scientists have been studying a similar mission concept, SCOPE. We have taken ideas from both of these mission proposals and produced a concept called Cross-Scale.

Cross-Scale would comprise three nested groups, each consisting of four spacecraft with similar instrumentation. Each group would have a different spacecraft separation, at approximately the electron and ion gyroradii, and a larger MHD scale. We would therefore be able to measure variations on all three important physical scales, simultaneously, for the first time. The twelve spacecraft would fly in formation through key regions of near-Earth space: the solar wind, bowshock, magnetosheath, magnetopause and magnetotail.

In preparation for an Announcement of Opportunity from ESA in 2006 for Cosmic Vision missions, we have been preparing a detailed science definition document for the Cross-Scale mission. Here, we present our progress to date, discussing the science objectives, practical constraints and open issues. We welcome all comments and discussion, and aim to propose a mission which reflects the scientific priorities of the space plasma physics community.