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Preface

This special issue includes a large fraction of the papers that were presented at the STAMMS (Spatio-Temporal Analysis and Multipoint Measurements in Space) meeting held in Orléans (France, 12–16 May 2003). The Cluster mission, with its four identical spacecraft, has so far been one of the most successful missions of the European Space Agency, delivering data with unprecedented resolution and providing a wealth of novel information about the Earth's environment. Three years after its launch, it seemed appropriate to evaluate the contribution of Cluster to some of the key problems in magnetospheric and solar-terrestrial science.

The Cluster mission is unique in that its four-point measurements allow us, for the first time, to distinguish spatial and temporal variations in an unambiguous way. Multipoint measurements have long been recognized as being crucial for understanding nonstationary, multiscale phenomena at the boundaries of the magnetosphere and in regions such as the cusp and the magnetotail. These measurements now provide new opportunities for studying the spatiotemporal structure of (i) the wave turbulence in the upstream regions of the solar wind/magnetospheric bow shock, (ii) large amplitude waves in the magnetosheath region, (iii) Flux Transfer Events and other energy transfer mechanisms at magnetopause boundaries, etc. Likewise, first results suggest that pertinent information can also be obtained on the sites of wave-particle interactions, as well as on the possible trigger sites of magnetospheric substorms.

The primary objective of the STAMMS conference was to point out what new inputs Cluster had provided to our understanding of physical processes in critical regions of the magnetosphere and its boundaries. It should be stressed, however, that Cluster has not only contributed to magnetospheric and solar-terrestrial science, but has also made a breakthrough in some topics that are of major interest to a much wider community, namely, astrophysics and laboratory plasmas. The list of key issues on which Cluster is going to deliver answers is long and at present far from being terminated.

Results from collisionless shocks, for example, provide unambiguous evidence for the presence of small-scale structures of the electromagnetic fields inside the shock front. This result, together with the observed shock front variability, will force us to revise the role of different acceleration mechanisms that are at play in shocks. In the same way, the analysis of particle distributions in the vicinity of the shock fronts has clarified the picture of the formation of the different ion populations; the importance of this result for plasma astrophysics is undisputable.

The direct measurement of fields and particle distributions close to the reconnection sites provides new clues for answering the long-standing question of the characteristics of the reconnection process. This result is of key importance for fundamental studies, as well as for astrophysical applications.

New results concerning the relative role of electron sound waves as compared to Langmuir waves (associated with beam-plasma interactions) is likely to change our picture of the generation of electromagnetic emissions in the vicinity of astrophysical objects. Cluster measurements can give us here new insight in the understanding of laser-plasma interactions where similar physical processes occur.

Multipoint measurements also allow one to reconstruct the characteristics of the spectra of wave turbulence in magnetized plasmas. We are now close to the point where these results can finally be tested against theoretical predictions and thereby help sort out concurrent models for turbulence.

Cluster also represents a turning point in the analysis of space plasma data. In spite of the efforts that were spent in preparing adequate analysis tools, it is and will remain a challenge to properly exploit this unique 3-D vision capability of Cluster. The return on this investment, however, will be profitable to future multipoint missions in geospace, such as Themis and MMS, but also to solar missions such as Stereo.

The session summaries of the conference are available on the website http://web.cnrs-orleans.fr/~weblpce/stamms.

So, we are happy to present to you this special issue which is dedicated to the results of the outstanding project called Cluster.

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Guest Editors