Institute for Space Weather Sciences Colloquium

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Mesoscale Processes in the Magnetosphere: The Elusive Mode of Plasma Transport and Energization and the Measurements Needed to Bring it to Light

Plasmas throughout the solar system, from the fast rotating magnetospheres of Jupiter and Saturn, to the supra-arcade downflows in eruptive solar flares in the solar corona, are heated through the interplay of multi-scale processes. At Earth, after decades of studying geomagnetic storms, we still do not understand their evolution to the level of predictability, because we still do not understand the bridge between the local and global geospace, that is, the mesoscale processes (1-3 earth radii in the magnetotail) and their global implications. In near-Earth space, in-situ observations have revealed ubiquitous fast, earthward-moving, mesoscale plasma and magnetic flux transport in the plasma sheet, associated with hot plasma injections, during geomagnetic storms, which are well within geosynchronous orbit. However, it has been extremely challenging observationally to assess the impact of these mesoscale structures on the overall energy flow that results in the buildup of the ring current. That is because of the spatially confined nature of the in-situ observations, which lack global context. On the other hand, Energetic Neutral Atom (ENA) imaging is the only technique capable of imaging the ion population in space plasmas at a global scale. Nonetheless, the limited temporal and spatial resolution of the so-far-flown ENA instrumentation prohibited the global observation of the temporal and spatial evolution -in size, frequency or intensity- of these mesoscale structures, as they move from the outer to the inner magnetosphere. Recent developments in ENA instrumentation allow for the imaging of the Earth magnetosphere with unprecedented temporal and spatial resolution, while still maintaining global coverage. These provide the essential measurements required to conclusively answer the question: do mesoscale structures constitute a fundamental mode of plasma transport and energization, with major impacts on the global development of the geomagnetic storm, or are they merely ripples on top of the global plasma convection flow?

Dr. Matina Gkioulidou is a space physicist at the Johns Hopkins Applied Physics Laboratory, with expertise that spans different regions in space as well space plasma regimes, from plasma acceleration processes in the Earth's magnetosphere during geomagnetic storms, to our heliosphere's interactions with the interstellar medium. Her research focuses on experimental space physics, including data analysis from space missions and energetic particle instrumentation. As Co-I of the RBSPICE instrument on the Van Allen Probes mission, she investigated physical processes that lead to the development of geomagnetic storm-time ring current, as well as ionospheric outflow. She is currently the Project Scientist of NASA's Interstellar Mapping and Acceleration Probe (IMAP) mission and the Lead of the IMAP-Ultra Energetic Neutral Atom (ENA) camera, which will measure ENAs coming all the way from our heliospheric boundary, revealing how that boundary is shaped by interactions with the interstellar medium. She is also the Deputy Instrument Scientist for the JENI instrument on ESA's JUpiter ICy moons Explorer (JUICE) mission, which will provide ENA images of Jupiter's magnetosphere for the very first time. Dr. Gkioulidou has been a member of NASA's Living With a Star Program Analysis Group, NSF's Geospace Environment Modeling Science Steering Committee, and NASA's Heliophysics Advisory Committee.