RECENT ADVANCES IN MAGNETOSPHERIC PHYSICS

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Plasma phenomena in the near-Earth space originate from the Sun, which emits a variable stream of charged particles carrying the solar electromagnetic field to the interplanetary space. The subsequent physical and environmental conditions form a rich plasma laboratory with spatial and temporal scales from milliseconds to decades and centimetres to billions of kilometres, which cannot be attained in terrestrial laboratories. Hence, many fundamental plasma physics discoveries originate in space physics.

As the solar wind plasma streams away from the Sun, it encounters our magnetised planet forming an obstacle to the flow, and a shock forms to encompass the domain controlled by the Earth's intrinsic magnetic field called the magnetosphere. Some particles reflect at the shock and propagate back upstream forming a foreshock. Most of the particles proceed to the magnetosheath, which is the shocked and highly turbulent plasma surrounding the magnetopause, the outer boundary of the magnetosphere. Part of the plasma penetrates the magnetosphere, where most of it ends up in the plasma sheet, which is a hot and dense region in the magnetospheric tail in the nightside. Sometimes the magnetospheric tail explosively disrupts in a substorm process, where reconnection accelerates particles towards the inner magnetosphere. The latter part of the solar particles' journey to the Earth's vicinity constitutes space weather, where high-energy particles cause radiation effects at telecommunication and weather satellite orbits, while the ionospheric precipitation causes ionisation leading to spacecraft, radar and radio signal degradation. The most energetic particles penetrate the atmosphere, where they take part in ozone loss. Forecasting space weather is highly challenging both because global modelling tools are not adequate to describe the system accurately, and because there are not enough global observations.

This presentation addresses highlights the recent advances in magnetospheric plasma physics. I first look at the state of the art ten years ago, emphasising the goals and challenges prominent at that time. I then describe the international framework and especially the Finnish role in advancing this incredibly rich and challenging field of physics. In particular, I present the newest world-wide breakthrough, world's only global hybrid-Vlasov simulation Vlasiator, developed at the Finnish Meteorological Institute. Vlasiator represents a grand leap forward in magnetospheric physics, promising answers to long-lasting questions in detailed physics as well as the physical scenarios behind e.g., the disruptive auroral displays.