Structure formation at shock waves and its space weather impacts

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The solar wind – supersonic plasma flowing out from the Sun – carries the Sun's magnetic field and connects to all the planets, comets, and other Solar System objects. Solar wind interaction with the region dominated by the Earth's magnetic field - magnetosphere – leads to, e.g., beautiful auroras. On the other hand, changes in Earth's space environment can be harmful to humans in space and our technological infrastructure. Such changes are collectively described by the term ***space weather***. As our society and way of life becomes increasingly dependent on sensitive technological systems such as satellite navigation, the processes in near-Earth space that can hamper their operation have increasing socio-economical relevance. Measurements from scientific spacecraft provide an opportunity to study space plasma processes in great detail.

When the supersonic solar wind meets with the Earth's magnetic field, a shock wave is formed in front of the Earth's magnetosphere (Figure). In addition to this large-scale structure, non-linear plasma processes lead to emergence of various smaller scale structures upstream and downstream of the shock. The most common downstream transient structure are called high-speed ***jets.*** Jets bigger than the size of our planet impact the outer boundary of the Earth's magnetosphere many times per hour. These impacts may change magnetospheric dynamics, launch waves making the magnetosphere boom like a drum, and affect the radiation environment of numerous satellites. Yet the precise nature of the risk they pose is still very poorly understood. The goal of the project is to understand and quantify this risk for the first time, and translate this knowledge to applications.

You will analyse data from various spacecraft and novel 3D simulations, as well as use statistical modelling, to investigate and ultimately forecast the jets' space weather effects.

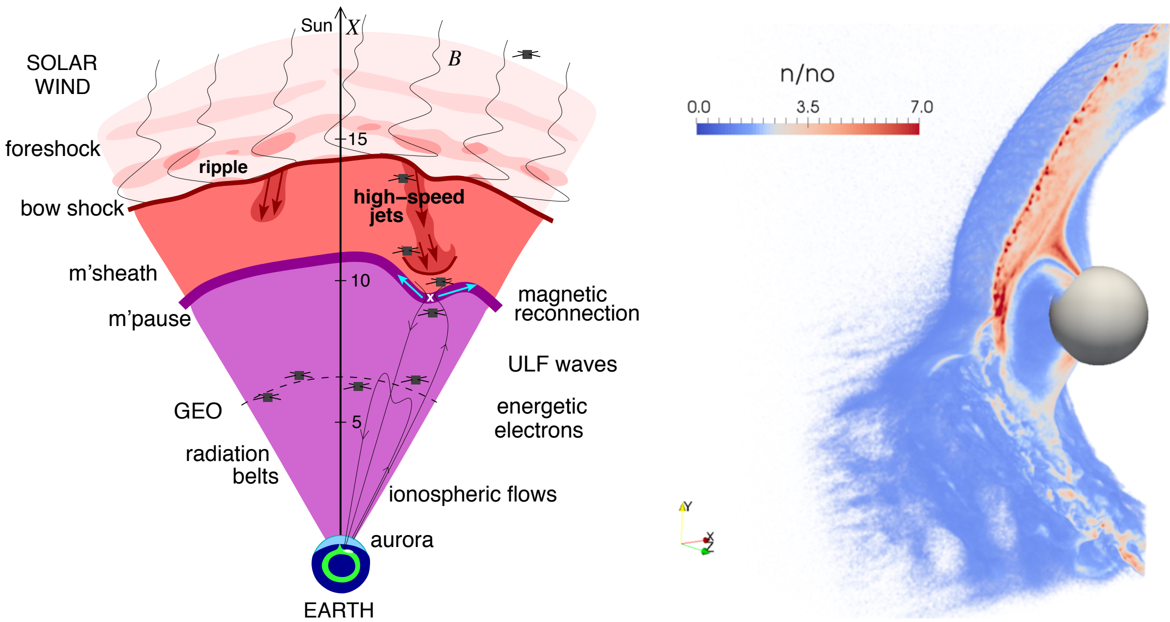

Figure: Left: The supersonic solar wind (flowing down from the top of the figure) forms a bow shock upon interaction with the Earth's magnetosphere. Typically, the solar wind is slowed down at the shock and flows around the magnetosphere in a layer called the magnetosheath. At times, however, the incoming plasma is not slowed down in localized regions, forming transient high-speed jets. Upon impact with the magnetopause, the jets can have various effects on the system, listed on the right of the sketch. Right: Density rendering of a 3D hybrid simulation. Solar wind flows in along the X-axis. The red layer is the magnetosheath. The grey sphere indicates the inner boundary of the simulation region.