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The Alfvén Mission for the ESA M5 Call

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The Alfvén mission will explore particle acceleration processes and their consequences for electromagnetic radiation and energy transport in strongly magnetised plasmas. In particular it will address the following three key questions.

Alfvén will discover where and how particle acceleration occurs in strongly magnetized plasmas. Charged particle acceleration in strongly magnetized plasmas requires the conversion of electromagnetic energy into magnetic-field-aligned particle kinetic energy. Several pathways of energy conversion have been proposed; to understand which are important, Alfvén will measure for the first time in a strongly magnetized plasma the occurrence and distribution of small scale parallel electric fields in space and time. In order to determine the relative efficiency of the different conversion mechanisms, Alfvén will also measure the corresponding particle energy fluxes locally and into the aurora. Alfvén discoveries will inform efforts to understand similar processes in other strongly magnetized plasmas, such as recent work to resolve paradoxes in models of solar flares.

Alfvén will discover how electromagnetic radiation is generated in the acceleration region and how it escapes. One of the most important consequences of particle acceleration in strong magnetic fields is the generation of non-thermal electromagnetic radiation. Some of the brightest astrophysical radio signals are from coherent generation in plasmas, which also occurs on every magnetized planet. Alfvén will make key measurements of Earth's powerful Auroral Kilometric Radiation (AKR) needed to test competing models of wave generation, mode conversion and escape from their source region. These will reveal the mode conversion processes and which information is ultimately carried by the polarization of radio waves reaching free space. The resulting discoveries will make a strong contribution to a better understanding of astrophysical radio sources.

Alfvén will discover the global impact of particle acceleration on the dynamic coupling between a magnetized object and its plasma environment. Energy can be transported over vast distances in several forms regulated by the magnetic field, including Poynting flux of plasma waves, accelerated particle fluxes, and bulk plasma flows. A key to understanding the coupling between a magnetized object and the surrounding plasma is how the energy converts from one type to another. Dual spacecraft measurements offer the unique opportunity to unambiguously determine which part of the energy flowing into the ionosphere is eventually dissipated in this collisional plasma and which part is transmitted to outflowing ions of ionospheric origin. Alfvén will discover what combination of plasma and magnetic conditions controls the conversion of Poynting flux into particle energy at Earth. These conditions will be compared to those at the outer planets, illuminating the theoretical descriptions of energy deposition in these remote environments.

The Alfvén mission design involves use of two simple identical spacecraft, a comprehensive suite of inter-calibrated particles and fields instruments, cutting edge auroral imaging, easily accessible orbits that frequently visit the region of scientific interest and straightforward operations. This has not previously been possible, but is now compelling and timely. It is a low risk mission that is compatible with the M5 cost cap.