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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.

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, and also the corresponding particle energy fluxes locally and into the aurora. Alfvén discoveries will inform efforts to understand paradoxes in models of solar flares and particle acceleration at other strongly magnetized solar system planets.

Alfvén will discover how electromagnetic radiation is generated in the acceleration region and how it escapes. 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 contribute to a better understanding of solar system and 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. Alfvén dual spacecraft measurements offer the unique opportunity to unambiguously determine 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, advanced auroral imaging, easily accessible orbits that frequently visit the region of scientific interest and straightforward operations. We emphasise that together with excellent two-point in situ plasma measurements, Alfvén uses cutting edge imaging to provide spatial and temporal context of the plasma processes, through imaging the energetic particle outputs on the auroral atmosphere. Implementing a mission of this design has not previously been possible, but it is now compelling and timely. Alfvén is a low risk mission that is compatible with the M5 cost cap.

The Alfvén mission proposal has successfully passed the ESA M5 technical and programmatic review, and we are awaiting the outcome of the scientific assessment process.