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Energy and Momentum Transfer in Magnetized Space Plasmas: The Legacy of Hannes Alfvén

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Fifty years of space explorations, discoveries and a wealth of data have improved our understanding of space in general and solar-terrestrial physics in particular. A revealing phenomenon related with energy and momentum transfer in magnetized plasmas is the polar aurora, light emissions connected with the acceleration and precipitation of energetic charged particles into the Earth's upper atmosphere. Discrete and extended aurora curtains, frequently with intrinsic fine structure, exemplify how the Earth's strong magnetic field confines space plasma into cellular structures with sharp boundaries. Polar aurora is a mirror image, an atmospheric "TV-screen", for subvisual plasma energy and momentum transfer in the Earth's neighbourhood. Only when the magnetized plasma is sufficiently dense and hot, can entire magnetized plasma entities become "visible". Close-up views of the Sun and the solar corona from the SOHO spacecraft exemplify such entities. Solar imagery enables us to resolve the complex topology of magnetized plasma domains of a star in surprisingly fine details. Achievements from half a century of space plasma missions, and new knowledge acquired from the Sun and solar corona represents fundamentals in contemporary space science, with impact on Geophysics and Astrophysics.

Hannes Alfvén argued that solar-terrestrial plasma physics sets the standard for physics of the "Plasma Universe". Most plasma phenomena occurring in the Earth's neighbourhood are expected to have their analogues in Universe. The omnipresent energy and momentum transfer processes (e.g. plasma acceleration and deceleration) is a key to many of these analogues. This makes it important for the space plasma physics community to further achievements and knowledge unambiguously to other science disciplines. Example of an issue that remains ambiguous is the applicability of "ideal

MHD". Hannes Alfvén founded the concept over forty years ago, but kept warning against its use during the rest of his career.

Space plasma physics is today anyway mature. Its importance for understanding “spaceship Earth” rises, and it is indispensable for understanding distant objects in the “Plasma Universe”, objects unattainable by in-situ measurements. A brief exposé of achievements made in the physics of magnetized space plasmas is given in this talk. Some interesting analogues in astrophysics with clear evidences of plasma energy and momentum transfer will also be presented.