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Electromotive force in space plasmas

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Electromotive force is a class of electric field that arises out of turbulent fluctuations in plasmas and electrically conducting fluids. Even though the electromotive force plays a central role in the turbulent dynamo mechanism (see an article by Yokoi [1] and references therein), this quantity has largely been overlooked in the wave and turbulence studies of space plasmas.

Recent studies using the HELIOS spacecraft data in the solar wind shed light on the electromotive force [2-4], reviving the motivation for the pioneering works by Marsch and Tu [5,6]. The concept of electromotive force can be implemented into a data analysis tool for spacecraft data for various purposes, e.g., evaluation of magnetic field amplification through the helical flow motion (alpha term), evaluation of turbulent diffusion coefficient (beta term), cross helicity effect (gamma term), guessing the flow pattern, and identifying the shock crossings. Spacecraft data analysis in view of the electromotive force opens the door in the research area of space plasma observations, and fills the gap between the dynamo theories and the physics of space plasmas. It is pointed out that the lowest-order picture of turbulent fields with energy and helicity densities can be completed by determining the electromotive force.

One of the applications of the electromotive force is diagnosis of plasma and magnetic field dynamics across transient events in the solar wind (e.g., magnetic clouds, coronal mass ejections, co-rotating interaction regions). Both magnetic field amplification (through the alpha term) and turbulent diffusion (the beta term) are locally enhanced during the transient events, suggesting that the solar wind serves as a natural laboratory for testing for the dynamo theory.

References

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