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Electromotive force measurements in the context of magnetic reconnection

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Magnetic reconnection is a fundamental process in astro- and geophyiscal plasmas, as well as for the confinement of fusion plasmas. We know that electrons are strongly driven into a non-thermal velocity distribution while undergoing an acceleration within a reconnection current sheet or by experiencing reconnection electric fields. Such processes have been observed in the past years by NASA's MMS mission, for example. Related simulation works try to explain observations of such non-thermal electron velocity distributions [1].

For solar physics, the heating processes in the corona are a common riddle since decades. Eventually, the ultimate plasma process to convert magnetic energy into heat is probably through magnetic reconnection and subsequent thermalization of non-thermal electrons. This process can be studied in fundamental kinetic simulations, while studying ensembles of electrons and determining their chaotic behavior with the Lyapunov indices [2].

From a comprehensive study of measurements in the solar wind obtained by the Helios-1 and -2 missions, we found that – unlike previous common knowledge – there are indeed strong peaks in the electromotive force whenever a magnetic transient event or a possible coronal mass ejection passed over the spacecraft during its inter-planetary cruise phase between 0.28 and 1 au. We also see how the amplitude of such peaks in the electromotive force seems to decay with growing heliocentric distance [3].

We would expect that and fast magnetic reconfiguration, be it inter-planetary shocks, as well as dipolarization fronts in the Earth's magnetosphere, would cause a strongly enhances electromotive force peak, as compared to the regular conditions with a less fluctuating field closer to a time-averaged background configuration. Indeed, we found such peaks also in Cluster mission data while crossing the magnetotail of the Earth, as well as in high-precision and high-cadence SolarOrbiter observations of an inter-planetary coronal mass ejection [4].

The electromotive force may play a role in confirming predictions of the magnetic helicity in the solar corona. This helicity should remain unchanged while it is ejected into inter-planetary space by solar outbreaks and coronal mass ejections and while it propagates beyond Earth orbit. Models have proven that magnetic helicity in the solar corona can be predicted, now it is an important task to verify such predictions on real observed events.

This talk will discuss the importance of magnetic reconnection, the generation of helicity in the solar corona, as well as its propagation in the solar wind. Finally, we will discuss how the electromotive force can be used to improve our understanding on turbulent dynamo processes in space plasmas, as well as how we can improve observational capabilities of certain space missions without human interaction.

References

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