PAP301 Seminar in Particle Physics and Astrophysical Sciences
Abstract (2.4.2024)
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ICME-driven Sheath Regions

Interplanetary coronal mass ejections (ICMEs) are enormous plasma clouds that erupt from the Sun into the interplanetary space, releasing massive amounts of plasma and magnetic field. A shock wave often forms ahead of an ICME, compressing the plasma and magnetic field between the shock and the ICME. This complex intermediary region is referred to as a sheath region. Sheath regions flow through the interplanetary space, potentially encountering the Earth. Despite being relatively unknown, sheaths are recognized as the key drivers of space weather disturbances on Earth. Due to their properties, sheath regions can cause extreme geomagnetic disturbances in the Earth's magnetosphere. A comprehensive understanding of sheaths and their geomagnetic consequences can lead to important outcomes, including enhanced predictions of space weather.

The aim of this work is to investigate how sheath regions propagate and evolve as they approach the Earth and whether the fluctuations of the sheath regions can be transmitted to the Earth's magnetosphere. This work focuses on the sheath region of the ICME on 15 August 2015. It is thoroughly studied using observations of the space environment obtained from spacecraft magnetometers and particle instruments, as well as observations of the Earth's magnetic field obtained from ground-based magnetometers. Multi-spacecraft timing analysis is used to obtain information about the structure of the sheath in space by constructing the normal directions and the speeds of its various discontinuities. Wavelet analysis is used to study the fluctuations within the sheath region and their possible transmission into the Earth's magnetosphere. It decomposes one-dimensional time series into two-dimensional time-frequency space, revealing the dominant fluctuations and enabling a comprehensive comparison of two time series.

Our analysis reveals the complexity of the sheath regions, emphasizing their high variability. They can undergo considerable changes as they propagate within short intervals, which presents challenges for our study. It is crucial to determine how the sheath propagates to effectively compare data obtained from different sources. Especially when comparing spacecraft and ground-based measurements, we may encounter challenges due to their differences in measurement environments. Since the analysis of the ground-based measurements is still ongoing, we are unable to share our final results; however, we can offer some of our insights on the matter. Ground-based measurements reveal some response to the sheath region observed in space, but the observed response is not as significant as initially expected, despite sheaths' known ability to drive intense geomagnetic disturbances. Numerous factors can significantly impact both the sheath itself and the fluctuations it generates in the Earth's magnetosphere, which can explain the complexity of our results.