8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Direct observation of magnetic reconnection resulting from interaction between magnetic flux rope and magnetic hole in the Earth's magnetosheath

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Magnetic flux rope (MFR) is a kind of helical magnetic field structure that is frequently observed in the Earth's magnetosphere. At the dayside magnetopause, MFRs are generally generated by the reconnection of the Earth's intrinsic magnetic field and the interplanetary magnetic field, especially when the interplanetary magnetic field points southward. These MFRs have diameters ranging from the microscale (ion or electron inertial length) to the macroscale (tens of Earth radii), corresponding to different generation mechanisms or temporal evolution [1]. Of particular interest is their ultimate fate, as it affects flux and energy transfer in the magnetosphere.

It is generally believed that MFRs can be formed in a current sheet by multiple X-line reconnection. Recent observations have revealed the occurrences of ion-scale or electron-scale MFRs, which are interpreted as a result of secondary reconnection. These secondary MFRs tend to grow larger in size after they are expelled from the reconnection X-line and then travel along the magnetopause, and ultimately disintegrate into the cusp [2].

In this study [3], we provide another potential fate of these magnetopause MFRs. They can interact with the magnetosheath magnetic holes and dissipate through reconnection with multiple magnetic holes. Based on the Magnetospheric Multiscale observations, we provide direct evidence of reconnection between the MFR and the magnetic hole, which has a pivotal role in this scenario. The observation provides a mechanism for the dissipation of MFRs and thus opens a new perspective on the evolution of MFRs at the magnetopause. Our work also reveals one potential fate of the magnetic holes in the magnetosheath which could reconnect with the MFRs and further merge into the magnetopause. Such a process may not be rare since MFRs and magnetic holes are both common structures in the magnetosheath. Future studies, especially numerical simulations, are needed to reveal their roles in the coupling between the solar wind and the magnetosphere.

References

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