6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Magnetic reconnection in the magnetospheres of the Earth and centrifugally dominated giant planets

Ruilong Guo[1], Zhonghua Yao[2]
[1] Laboratory of Optical Astronomy and Solar-Terrestrial Environment, Institute of Space Sciences, School of Space Science and Physics, Shandong University, Weihai, China
[2] Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
e-mail (speaker): grl@sdu.edu.cn

Magnetic reconnection is crucial in understanding magnetospheric dynamics and aurorae processes at planets. In planetary magnetospheres, magnetic reconnection has often been identified on the dayside magnetopause and in the nightside magnetodisk, where thin-current-sheet conditions are conducive to reconnection. At the Earth, the magnetopause and magnetotail current sheets are primarily controlled by the upstream solar wind. At giant planets Jupiter and Saturn, their fast rotation and internal mass sources lead to an additional current sheet that encircles the planet, forming a magnetodisk inside the magnetosphere. The reconnection processes in the magnetodisk current sheet are associated with centrifugal force-driven dynamics. Here we discuss the fast rotation-driven magnetic reconnection and make a comparison between the reconnection-related processes on Earth and giant planets.

The mass and energy circulations at the magnetopause and nightside magnetodisk associated with the solar wind are called the ‘Dungey cycle’. Moreover, the rapid rotation of Jupiter and Saturn can transport plasmas, initially generated by the volcanic activities of their moons, radially outward and form magnetodisk. The rotationally driven mass circulation is known as the ‘Vasyliunas cycle’. It is generally accepted that the magnetodisk reconnection site starts in the pre-evening sector and ends in the dawn sector before encountering magnetopause. Here we demonstrate that the magnetodisk reconnection is not limited at nightside but discretely distributed at all local times inside the magnetosphere[1,2]. The reconnection sites also rotate with the magnetosphere (left plot in Figure 1). These widely distributed small-scale reconnection sites can result in the global release of energy and mass from the magnetosphere.

The reconnection-related aurorae were found on both the Earth and giant planets but showed differences in the global picture. The heavy ions (sulfur/oxygen) released from the moons of giant planets play a critical role in the evolution of the reconnection process. The giant magnetospheres allow particles to gain very high energy to simulate more intense aurorae in the ionosphere. Besides, the aurorae on Earth are not rotating. We here proposed that rotating multiple reconnection sites at the giant planets form multiple filed-aligned currents and simulate rotating aurorae (right plot in Figure 1)[3,4].

References
[1] Guo, R.-L., Yao, Z.-H. et al., Nat. Astron., 2, 640 (2018)
[2] Guo, R.-L., Yao, Z.-H. et al., ApJL, 884, L14 (2019)
[3] Guo, R.-L., Yao, Z.-H. et al., ApJL, 919, L25 (2021)
[4] Guo, R.-L., Yao, Z.-H. et al., Geophys. Res. Lett., 48, e2021GL093964 (2021)

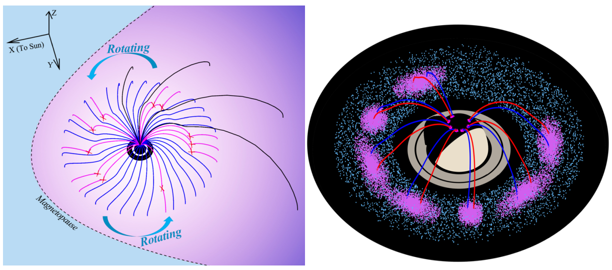

Figure 1. (Left) Illustration of the rotating multiple small-scale reconnection regions as presented by the cross signs ‘×’. (Right) Sketch of the rotating multiple FAC system (blue and red curves) with the patchy magnetospheric active regions (magenta areas in the equatorial plane) and patchy aurorae (magenta spots in the north polar region).