Solar Wind Charge Exchange Soft X-Ray Emissions in the Magnetosphere during an Interplanetary Coronal Mass Ejection Compared to Its Driven Sheath

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The solar wind – magnetosphere – ionosphere is a system that constitutes the near-Earth space environment, and the interaction in this system is an essential topic for the study of space weather. In situ satellites provide detailed observations of the system in localized regions, nevertheless, there are still key problems that prevent us from a complete understanding of the overall interactions on system level. Soft X-ray emissions from solar wind charge exchange (SWCX) are applied in a recently developed approach to study the magnetosphere using panoramic soft X-ray imaging. In this context, Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) is jointly proposed and supported by the European Space Agency (ESA) and Chinese Academy of Sciences (CAS), which is due for launch around 2025. One of the important research topics for the pre-study of SMILE before launch is to better understand the SWCX process from the magnetosheath.

This study represents the first attempt to distinguish magnetospheric SWCX emissions observed by XMM-Newton during the impact of an interplanetary coronal mass ejection (ICME) and its driven sheath on Earth. It is shown that SWCX emissions peaked during the ICME, although the solar wind flux decreased to a much lower level. A comparison of spectral results with ion data probed by ACE revealed that high ionization states in the ICME effectively enhanced line emission intensity for heavy ions. Thus, despite a low proton flux, elevated high-valence ion abundance in the ICME favors magnetospheric soft X-ray observations. Furthermore, the fitted X-ray flux of ion line emissions was consistent with elemental abundance ratios determined in situ by ACE. This confirms the viability of spectral diagnosis of SWCX emissions as a new method for remotely analyzing high state ion distributions in solar wind.

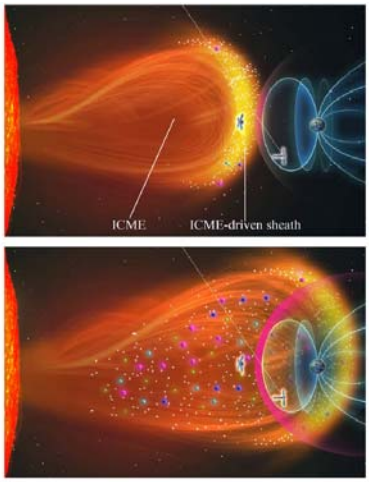

Figure 1 Schematic plot of X-ray emission from the Earth's magnetosheath after the impact of ICME (adopted from Zhang et al., [2022])

Reference

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