Dynamics of the outer radiation belt during CIR passage

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Dynamics of the inner magnetosphere is largely controlled by the large-scale solar wind structure such as corotating interaction regions (CIRs) and coronal mass ejections (CMEs) as shown by Miyoshi and Kataoka [2005]. Toward comprehensive understanding the variation of outer radiation belt, it is therefore necessary to reduce the structure dependence for finding the actual solar wind parameter dependence. It has been known that the outer belt flux enhancement is well correlated with the high-speed solar wind, while several studies have suggested that the southward interplanetary magnetic field (IMF) may be another important parameter for the flux enhancement. Here we reveal the actual parameter dependence of the flux enhancement, for the first time, based on the superposed epoch analysis of the radiation belt response to the CIR followed by the high-speed stream with fluctuating IMF.

A total of about 200 CIR events are identified using the OMNI-2 data for 10 year interval from 1995 to 2004, and the response of the radiation belt is examined using the data from GOES and NOAA satellites. We classify the CIR events into two groups: (A) IMF sector after the SI crossing is toward (away) in fall (spring), and (B) vice versa. Due to the Russell-McPherron effect, Group A (B) has significant negative (positive) offset on GSM Bz after the SI passage. Comparing Groups A and B, by superposing about the stream interface, pure Bz dependence can be obtained because all the other solar wind parameters change in the same manner according to the stream interface properties, i.e., speed and temperature increase with density drop.

As a result, the greatest flux enhancement after the CIR passage is found in Group A, while an obvious enhancement is not seen in Group B, suggesting that fluctuating IMF with southward Bz offset is a necessary condition for strong flux enhancement. It is also found that, in Group A, there is a positive correlation between the strength of the flux enhancement and the solar wind speed, suggesting that the high-speed solar wind is not a sufficient condition but just a necessary condition for strong flux enhancement. Further we show that the strong flux enhancement in Group A tends to be associated with weak geomagnetic storms with minimum Dst ˜-50 nT in average, indicating that the driving mechanisms of radiation belt are different from ring current enhancements.

Reference: Miyoshi, Y. and R. Kataoka, Ring current ions and radiation belt electrons during geomagnetic storms driven by coronal mass ejections and corotating interaction regions, Geophys. Res. Lett., 2005.