Comparison between flux rope axis orientations at 1AU and near the Sun using the cylindrical and the toroidal interplanetary flux rope model

*Nobuhiko Nishimura[1], Munetoshi Tokumaru[1], Katsuhide Marubashi[2]

1. Institute for Space Earth Environmental Research, 2. National Institute of Information and Communications Technology

Coronal mass ejections (CMEs) are observed by coronagraph as large bright structure moving from the Sun to interplanetary space. CMEs detected in interplanetary space are called interplanetary CMEs (ICMEs). In situ observations of ICMEs show a smooth rotation of magnetic field direction. This unusual magnetic field variation is interpreted as the bundle of helical field lines around the central axis which passes the observer, called the interplanetary flux ropes (IFRs). The axis orientation of IFR is one of the controlling factors of the geo-effectiveness of ICMEs and important for understanding the physical process of its propagation. Some studies suggest that the axis of IFRs rotates during its propagation in interplanetary space (Yurchyshyn, 2008; Isavnin et al., 2012). However, Marubashi et al. (2015) show that the axis orientation changes only slightly during its propagation from the Sun to 1AU. These different conclusions may result from different assumptions used in their studies. The former does not consider the possibility of the encounter with the flank of IFR in which its axis curves, whereas the latter takes account of the curvature using toroidal flux rope model fitting to IFR observations. This toroidal model can reproduce observation of IFR and the derived axis direction often substantially differs from that of the self-similarly expanding cylindrical flux rope model of Marubashi and Lepping (2007) in which the curvature of the axis is not considered. The toroidal model fitting has been recently developed and little utilized for the analysis of IFR yet. Thus we use both the cylindrical and the toroidal model in order to investigate the evolution of IFR axis orientation in more detail. In this presentation, we report IFR axis orientations determined from in situ measurements at 1AU and comparison between IFR axis orientation at 1AU and near Sun region. We analyze 16 ICME events listed in both the LINKCAT (https://www.helcats-fp7.eu/catalogues/wp4_cat.html) and the KINCAT (https://www.helcats-fp7.eu/catalogues/wp3_kincat.html) during 2008 and 2012. The axis orientations are determined from in situ observations by Wind, STEREO-A or STEREO-B using two kinds of IFR model: the cylindrical model and the toroidal model (Marubashi and Lepping, 2007). 12 out of 16 IFR events are fitted well using the cylindrical or the toroidal model, and multiple solutions are generally obtained especially for the toroidal case. The axis orientations of IFRs determined here are compared with those of flux ropes inside corresponding CMEs listed in the KINCAT. If we select the solution which has the minimum deviation from the observation, axis orientations of IFRs are different from those near the Sun by more than 30 degrees for nine events. This result suggests that most of the events rotate during its propagation. If we choose the solution which has the minimum difference from the axis direction near the Sun, axis orientations are different between IFRs and CMEs by more than 30 degrees for three events. Therefore these three events indicate the rotation of IFR even if we choose any solution.

Keywords: interplanetary flux rope, coronal mass ejection, interplanetary space, space weather

