37th COSPAR Scientific Assembly 2008

Space Plasmas in the Solar System, including Planetary Magnetospheres (D)
New Views of the Sun-Earth Connection, Multi-spacecraft Imaging and In Situ Observations / Joint with E32 (D22)

FITTING A TORUS-TYPE FLUX ROPE MODEL TO THE MULTI-SPACECRAFT OBSERVATION OF THE MAGNETIC CLOUD ON APRIL 16-18, 1999

Dr. Tomoko Nakagawa, nakagawa@tohtech.ac.jp
Tohoku Institute of Technology, Sendai, Japan
Ayako Matsuoka, matsuoka@stp.isas.jaxa.jp
JAXA, Sagamihara, Japan

A torus-type flux rope model applied to an interplanetary magnetic cloud was tested by the magnetic field observations by ACE spacecraft on April 16-17, 1999, and by NOZOMI spacecraft on April 17-18, 1999, which was 0.2 AU downstream of ACE within 3 degrees of heliocentric longitude. At the passage of the magnetic cloud, the Bz component was positive at NOZOMI while negative at ACE. On the basis of a single observation by ACE, the magnetic cloud was once fitted to a torus-shaped flux rope model through which the spacecraft passed at the southern tip (Ishibashi and Marubashi, 2004), however, the model did not reproduce the NOZOMI observation. Therefore, an attempt was made to fit a torus-shaped flux rope to the simultaneous observations by NOZOMI and ACE. An analytical solution of force-free magnetic fields inside a troid with an arbitrary aspect ratio (Romashets and Vandas, 2003) was employed as a model flux rope. The parameters to fit are the large radius R_0, the small radius r_0, the attitude of the troid (the direction of the symmetric axis of the troid), the 'impact parameter', which is the minimum distance between the center of the cross section of the torus and ACE, and the position of the closest approach (the toroidal angle measured from the top of the torus). They were determined so that the sum of the square of the difference between the model field and the hourly averages of the observed field normalized by the magnitude would be minimized. The start time of the observation (within 1 hour) was also adjusted so that it would minimize the difference. The direction of the troidal field is determined so that it reproduces the radial component of the magnetic field observed in the magnetic cloud. The chirality was chosen so that it reproduces the observations. Self expansion of the flux rope is assumed in proportion to the heliocentric distance of the center of the torus. The bulk velocity of the plasma of each part of the torus was also calculated in accordance with the self expansion, and then compared with the observation of the solar wind speed. The result shows that the ACE and NOZOMI spacecraft passed through the northern part of a torus-shaped flux rope with the large radius of 0.16 AU and the small radius of 0.09 AU. The direction of the symmetric axis of the torus was $(\phi, \theta) = (\ 54°, \text{-}11°)$. NOZOMI traversed outer part of the torus than ACE did, resulting in large differences in Bz and By components measured by the two spacecraft. The chirality was positive, that is, the helicity was left-handed, suggesting that the solar origin of the magnetic cloud was a filament on the northern hemisphere. Assuming that the solar origin was the

filament disappearance observed on April 13, 1999, at N16 E00 as suggested by Ishibashi and Marubashi (2004), we can say that the filament traveled in interplanetary space across the ecliptic plane toward the heliospheric current sheet which was on the southern hemisphere at the longitude.