表面ピッチ角の扱いが異なるトーラス型フラックスロープモデルフィッテングの比較

西村 信彦 [1]; 丸橋 克英 [2]; 徳丸 宗利 [3]
[1] 名大・宇地研; [2] 情報通信研究機構; [3] 名大 ISEE

Comparison of toroidal flux rope model fitting with different boundary pitch angle treatments

Nobuhiko Nishimura[1]; Katsuhide Marubashi[2]; Munetoshi Tokumaru[3]
[1] ISEE, Nagoya Univ.; [2] NICT; [3] ISEE, Nagoya Univ.

Interplanetary flux rope (IFR) is a characteristic magnetic field structure expelled from the Sun. The magnetic field structure of IFR consists of helical field lines whose pitch angles change with the distance from the axis. Correct estimation of axis direction and magnetic flux of IFR is important for understanding the formation of IFR at the Sun and the rotation of axis direction during propagation. These properties of IFR have been estimated by model fitting methods. Constant-alpha force-free toroidal model is used by Marubashi et al. (2007) to consider curvature effect which arises when spacecraft passes through IFR flank. In this model fitting, pitch angle of magnetic field at IFR surface is fixed to 90 degree (hereinafter we call conventional method). However, Nishimura et al. (2019) found that approximately 30% of IFR events have pitch angle significantly different from 90 degree using the cylindrical model fitting in which pitch angle is a free parameter (hereinafter we call generalized method). Nishimura et al. (2019) also found that estimated axis direction and magnetic flux of IFR were different between the conventional and generalized methods for the cylindrical model fitting. In this presentation, we introduce the generalized method for the toroidal model fitting. We show the difference between the results of the conventional and generalized methods, and the statistical distribution of pitch angle obtained from the generalized method for the toroidal model fitting. The toroidal model is fitted to in situ observations of magnetic obstacles (MOs) by Wind, STEREO-A or STEREO-B between 1995 and 2016 using the conventional and generalized methods. We compare the results of the conventional method and those of the generalized method. The difference of the results between the conventional and generalized methods is found to be small for poloidal magnetic flux (flux perpendicular to IFR axis), direction normal to torus plane, and tilt angle of axis direction at IFR apex. However, for toroidal magnetic flux (flux parallel to IFR axis) large difference (larger than the factor of $10^{0.25}$) is shown for approximately 35% of the events. This result shows that it is better to use the generalized method than the conventional method for the estimation of toroidal magnetic flux. The statistical distribution of pitch angle, which was estimated using the generalized method, shows a spread of 30 degree centered at 90 degree and that 65% of events are between 60 degree and 120 degree. This distribution is similar to that obtained from the cylindrical model fitting, in which the generalized method was used, by Nishimura et al. 2019. These results suggest that pitch angle at the surface of IFR is constant from the apex to the flank of IFR and for most of the events magnetic field direction at the surface of IFR is perpendicular to IFR axis.