

Orientations of flux ropes in ICMEs and magnetic field structures of their solar source regions

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Do all CMEs that reach 1 AU have flux ropes? Focused on this question a series of the Coordinated Data Analysis Workshop were held in 2010 and 2011 (CDAW 2010, 2011). An additional problem is to find out some possible differences in the properties of solar source events between ICMEs with and without flux ropes if there ever exist both types of ICMEs. For this purpose the CDAW organizers prepared the list of 54 ICMEs attached with the most probable solar source events for them and provided to the workshop participants (CDAW List). The pre-selected ICMEs consist of 23 magnetic clouds (MC) and 31 non-cloud ejecta (EJ).

In this study we first attempted to identify the flux rope structure in each of the 54 ICMEs by the model fitting method. Two flux rope models, cylinder and torus models, were applied in the model fitting. As a result, it was found that magnetic field variations in some part of ICMEs can be well reproduced by a flux rope model in 51 cases out of 54. Then, using the ICME flux rope orientation at 1 AU obtained from the fitting, we estimated the orientation that each flux rope should have had at the time of eruption in the coronal region from. It should be noted here that the model fitting generally provides two or more possible orientations for a single ICME depending on the model, cylinder or torus. Correspondingly two or more possible estimates are obtained for the orientation of a flux rope at the time of CME eruption. Comparing with the magnetic fields in the source region, we could find out at least one estimated flux rope orientation that is close to the orientation of the neutral line in the source region.

Summarizing the above analysis results, we conclude:

- (1) All CMEs that reach 1 AU (ICMEs) have flux ropes.
- (2) The orientation of flux ropes ejected by CMEs is preserved during propagation to 1 AU and observed as the ICME flux ropes.

Keywords: solar wind, coronal mass ejection, flux rope, cylinder model, torus model, magnetic neutral line