New findings of magnetic clouds 0btained from a torus model

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The geometry of magnetic clouds is considered to be a loop-shaped structure with the structure of magnetic flux rope, extending from the Sun with both legs rooted on the Sun deformed to match the Parker spiral when viewed globally. While many of the foregoing studies of MC's geometry were made by comparing the observed magnetic field variations with those calculated with cylindrical flux rope models, this technique is applicable only to those cases where the spacecraft traverses the region around the apex of the loop. When the spacecraft traverses the region near the leg of the loop, curvature effects must be taken into consideration to explain the observed field variations. The curvature effects can be taken into account by using a torus-shaped flux rope model. This is an attempt to find out as many magnetic cloud events as possible that can be taken as the MC crossed near the loop leg. In this study, we focus upon the magnetic cloud events with long durations, considering that the durations tend to be longer when traversed near the leg than when traversed near the apex.

We identified 17 magnetic clouds with durations equal to or longer than 30 hours through surveying the solar wind data from WIND and ACE observations covering 10 years from 1995 through 2004. Then, we performed the model fitting analyses for these MC events with both cylinder and torus models, when possible. Comparing the fitting results with the cylinder and torus models, we can classify the 17 cases into the following 4 categories.

Category A (5 cases with field rotations exceeding 180 degrees): The cylinder-fit is insufficient. Only the torus model can well explain the observations.

Category B (6 cases for which both models give similar orientations): The torus model improves the fitting results.

Category C (5 cases for which the cylinder and torus models give different orientation): It is hard to say which model better explains the observation though the torus model gives a better fit in general.

Category D (1 case for which no curvature effect is seen): It may well be concluded that the spacecraft traversed the apex of loop cloud in this case.

New findings obtained from this study of the magnetic cloud geometry using the torus model are summarized as follows.

(1) The probability is high that the long-duration magnetic clouds correspond to those cases where the spacecraft traversed the legs of the loop-shaped magnetic cloud (Category A & B, a part of Category C). This geometry must be taken into account when studying the relation between the stand-off distance of ICME-driven shocks and the ICME sizes.

(2) For some magnetic clouds, different orientations can be obtained by using the different models: the cylinder model and the torus model. This result gives caution needed when comparing the magnetic cloud orientation with the parent coronal field structure.

(3) The estimated sizes (radii) of magnetic cloud are generally smaller when the torus model is used than those estimated by the cylinder model. This result strongly affects those studies to estimate magnetic flux and magnetic chirality quantities carried from the corona by ICMEs.