From SOHO to STEREO: Understanding Propagation of Coronal Mass Ejections

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Direct comparison between coronal mass ejections (CMEs) from near the Sun and their solar wind counterparts became possible roughly a decade after the discovery of CMEs (Lindsay et al. 1999). This comparison revealed that fast CMEs decelerate and slow CMEs accelerate due to the interaction with the solar wind. Gopalswamy et al. (2000) quantified this interaction as an interplanetary acceleration which is useful in predicting the arrival time and speed of CMEs at 1 AU. The interplanetary acceleration is essentially due to the aerodynamic drag between the CME and the solar wind because the propelling force and the solar gravity are effective only near the Sun. Combined remote-sensing and in situ observations from SOHO and Wind/ACE have helped us estimate the influence of the solar wind on the propagation of CMEs. However, these measurements have severe limitations because the remote-sensed and in-situ observations correspond to different portions of the CME. Furthermore, the true speeds of Earth-directed CMEs cannot be measured accurately from a spacecraft located along the Sun-Earth line. There have been attempts to model the CME as a cone and get the space speed of the CME, which did improve the travel time predictions. Instruments on board the Solar Terrestrial Relations Observatory (STEREO) mission were able to provide observations of Earth-arriving CMEs without projection effects, while the same CMEs were observed at Sun-Earth L1 by Wind and ACE spacecraft. The quadrature between STEREO and L1 spacecraft presented an ideal situation to study the interplanetary evolution of CMEs and test earlier model results. The quadrature observations did improve the CME travel time predictions, but additional factors such as the unusually slow solar wind, CME cannibalism, and coronal-hole deflection need to be considered to reconcile the difference between observed and predicted travel times. This point is illustrated using the 2011 February 15 CME.

References

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Lindsay, G. et al., Relationships between coronal mass ejection speeds from coronagraph images and interplanetary characteristics of associated interplanetary coronal mass ejections, J. Geophys. Res., 104, 12515, 1999