Monitoring Coronal Mass Ejections Using Images from SOHO

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Abstract

Coronal Mass Ejections (CME's) have received a great deal of attention lately due to enhancements in observational techniques and their potential impact on space and ground-based systems. The Large-Angle and Spectrometric Coronagraph (LASCO) on-board the Solar and Heliospheric Observatory (SOHO) has been recording white light images of the Sun's corona for about a decade. Using LASCO images, we examined the acceleration and configuration of three CME's that occurred on October 23, 2004, August 29, 2005 and February 17, 2006. In order to track the CME's, we created a MATLAB program that allowed the user to obtain the coordinates of specific CME features and follow them as the CME traveled through space. We find that the CME's experience significant acceleration out to 12 to 20 Solar Radii where they achieve a maximum speed of approximately 600 km/s. Our data shows that CME's retain their shape as they travel outward suggesting a magnetic field is responsible for their overall structure.

Solar and Heliospheric Observatory

- SOHO was launched in December of 1995 and is a joint project of the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA).
- Located in the Lagrange point L1, SOHO is constantly situated between the sun and the earth and is outside the moon's orbit which allows the satellite to maintain constant visual contact with the sun.
- On board SOHO is the Large-angle and Spectrometric Coronagraph (LASCO), which monitors the white light coronal intensity by using an occulting disk to block out direct light from the sun's photosphere and allow the corona to be viewed.
- During this study, LASCO C2 and C3 images were used. C2 images have a narrow field of view but high resolution, whereas the C3 images have a wider field of view but lower resolution.
- Together C2 and C3 images may be used to track CME's for longer periods of time.

Data Analysis

These plots show the distance the CME's traveled with respect to time along with fits to a third order polynomial. The slope of the line at any instant represents the velocity of the CME. The curvature of the plot illustrates the acceleration of the CME at any instant. Upward curvature indicates that the CME's speed is increasing, downward curvature indicates a decreasing speed. In cases 1 and 2 the maximum speed are 450 km/s and 600 km/s respectively. As can be seen in case 3 the curvature is downward (decelerating), this indicates that the CME had stopped accelerating before we were able to start monitoring it with the C2 coronagraph. Interestingly the maximum speed of the case 3 CME was only 115 km/s.

The images above show a CME from February 17, 2006, traveling first with the C2 image (at top) which has a small field of view, then through the C1 image which has a greater field of view but lacks detail.

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CME's generally take the shape of a loop which expands as they travel outward. This plot of case 1 shows the diameter of the loop with respect to the distance traveled. As can be seen, the graph is linear which implies that the shape is uniform. The graphs for cases 2 and 3 are remarkably similar.

Summary

Observations of CME's from previous studies (e.g., Sheeley et al., 1999) have revealed two general categories of CME: accelerating and constant velocity. Case 1 and Case 2 show a relatively steady acceleration reaching speeds of 470 and 600 km/s consistent with the accelerating CME type. This constant velocity CME may experience an impulsive acceleration below the altitude of the C2 field of view (e.g., Gopalswamy and Thompson, 2000) and generally reach higher velocities (~1000 km/s). The acceleration profile of Case 3 is consistent with the constant velocity type, though the velocity is slower (~120 km/s).