Monitoring Coronal Mass Ejections Using Images from SOHO

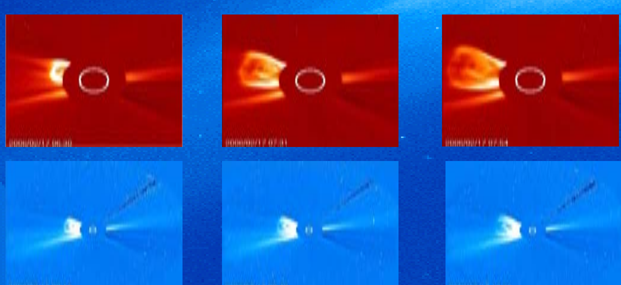
Thomas Kelly and Hugh Gallagher Jr.
Department of Physics and Astronomy, SUNY College at Oneonta, Oneonta ,NY.

Abstract

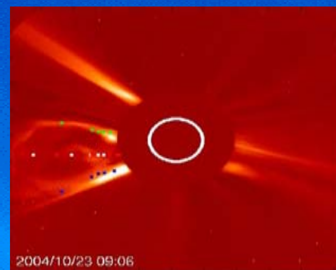
Coronal Mass Ejections (CME's) have received a great deal of attention Lately due to enhancements in observational techniques and their potential impact of CME's on space and ground based systems. The Large-Angle and Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO) 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 23, 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.

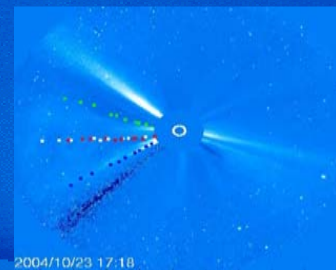
Solar and Heliospheric Observatory

- 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, where as the C3 images have a wider field of view but less resolution.
- Together C2 and C3 images may be used to track CME's for longer periods of time.



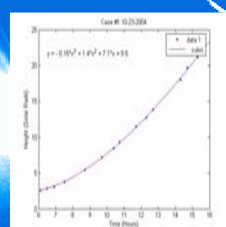
The images above show a CME from February 17, 2006,traveling, first with the C2 imager (at top) which has a small field of view, then through the C3 imager which has a greater field of view but lacks detail.

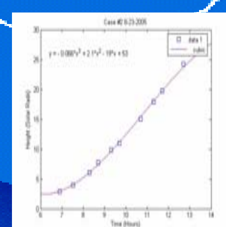


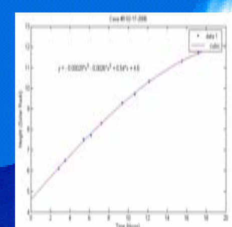


Measurements

- We carefully selected for analysis CME's that maintained their loop structure and were located on the solar limb. Certain types of CME's were not analyzed because of the difficulty in tracking specific features. These include halo, faint loop and loops that were not well defined.
- All measurements were taken from sequences of images gathered by the Solar and Heliospheric Observatory (SOHO).
- A Mat lab program was written to extract the location of salient CME features (distance from sun and diameter of loop) from individual images and record the location of the features as a function of time.
- The data was used to plot graphs of position versus time, from which the velocity and acceleration can be determined, and position versus diameter, which reflects the shape of the CME's.





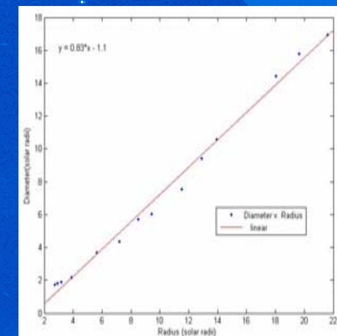


Data Analysis

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 stop 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.

Acknowledgement

- "The SOHO/LASCO data used here are produced by a consortium of the Naval Research Laboratory (USA), Max-Planck-Institut fuer Aeronomie (Germany)), Laboratoire d'Astronomie (France), and the University of Birmingham (UK). SOHO is a project of international cooperation between ESA and NASA."
- P. French For guidance with video analysis
- D. Moseman for assistance in printing this poster



The Shape

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 CMEs 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. The constant velocity CMEs 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).

The CMEs, which were chosen in part for the stability of the loop like structure retain their proportion through out the acceleration to a remarkable degree suggesting the importance of a magnetic acceleration mechanism.

Coronal heating, wave dissipation, magnetic buoyancy and magnetic reconnection are potential acceleration mechanisms. Future work: we will compare our observations to height-time profiles expected for the above acceleration mechanisms.

Sheeley, N. R. Jr., J. H. Walters, Y., -M. Wang and R. A. Howard, Continuous tracking of coronal outflows: Two kinds of coronal mass ejections, J. Geophys. Res., 104, 24739-24767, 1999.

Gopalswamy, N. and B. J. Thompson, The early life of a CME, J. of Atmospheric and Solar-Terrestrial Physics, 62, 1457-1469