The Relationship Between Flare-associated Coronal Dimmings & CMEs As Observed by SDO, SOHO, and STEREO

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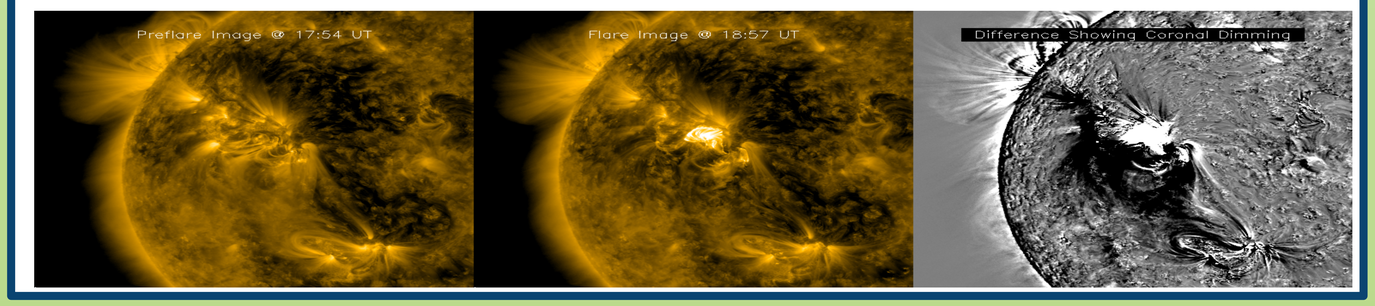
Motivation:

The project goal this summer was to study the parameters of flares that exhibit coronal dimming and coronal mass ejections to better understand the relationship between coronal dimming and CME properties.



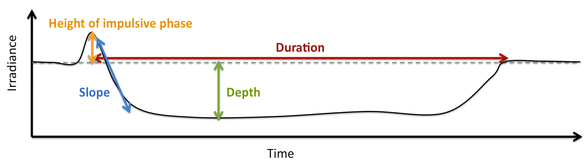
Process:

I wrote an IDL program that analyzed 55 flares that have coronal dimming mainly looking at three specific Iron light curves using SDO-EVE data. The three Iron lines I used are Fe IX (17.1 nm, 0.65 MK), Fe XII (19.5 nm, 1.35 MK), and Fe XIV (21.1 nm, 1.86 MK). In my analysis, I found that Fe IX was the best light curve to use and that Fe XIV was the worst. My program matches the times and locations of the flares with the CMEs as observed by SOHO and STEREO. Of the 55 flares, 34 had CMEs, and 10 had full CME catalog entries. Then, I ran correlations between the flare parameters and the CME parameters to see which had the strongest relationships.

Flares:

When given a flare id, it extracts the EVE data for Fe IX, Fe XII, Fe XIV, and plots the three light curves. The flare parameters are then calculated.

- ✧ Duration is calculated by the defined start time of the flare by GOES x-ray and the end of the flare is manually selected.
- ✧ Depth is calculated using the pre-flare irradiance as a baseline and finds the minimum within the flare duration.
- ✧ Height is calculated by using the pre-flare irradiance as a baseline and finds the maximum prior to the GOES x-ray peak.
- ✧ Slope is calculated by applying a linear fit to the data from the GOES x-ray peak to one-half of the dimming depth.

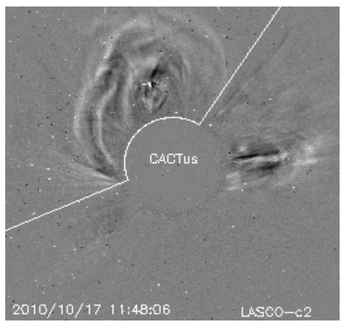


CMEs:

The code finds CME matches based on location and time of the flare. The program takes the flare location and determines the expected CME location for SOHO and STEREO. Using the CME catalogs, it finds a CME within 45° of the expected location and has a CME start time within 3 hours of the flare start time. LASCO is used for limb events and STEREO A and B are used for center flares.

CME Parameters:

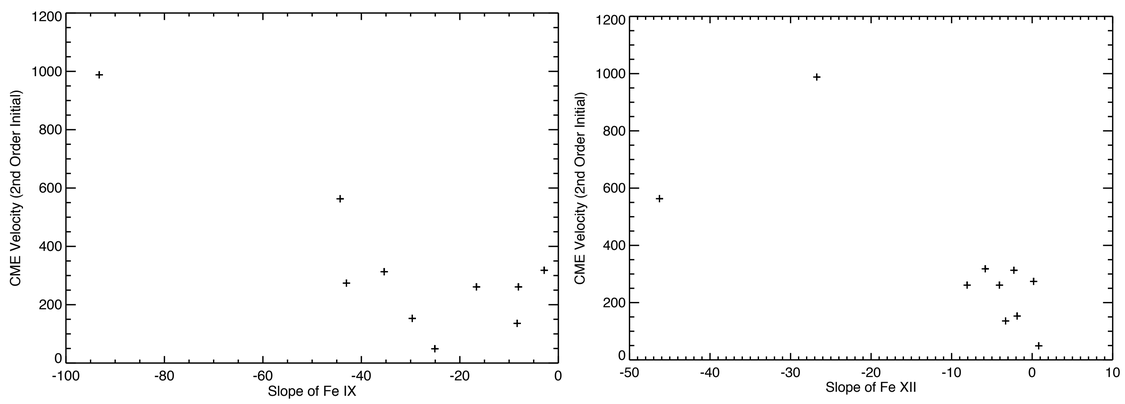
- ✧ Angular Width
- ✧ Velocity
- ✧ Mass



Correlations and Results:

Correlations were ran between the parameters of Fe IX, Fe XII, and the CME parameters. The correlations that were discovered are justified because the slope of the dimming is related to the initial velocity of the CME. This relationship is present because the steeper the dimming slope means the dimming is occurring faster and that the material of the CME is expected to be moving faster. The depth of the dimming is expected to be related to CME mass, but this analysis is not complete. CME mass and velocity are correlated, so the result that the depth is correlated with velocity is reasonable.

	Angular Width	Average Velocity	2nd O Initial	2nd O Final	2nd O 20R
Height Fe IX	-0.07	-0.27	-0.23	-0.21	-0.29
Depth Fe IX	0.4	0.19	0.4	0.59	0.08
Slope Fe IX	-0.02	-0.15	-0.82	-0.56	-0.57
Duration Fe IX	0.11	0.44	0.54	0.48	0
Height Fe XII	0.04	-0.27	-0.43	-0.47	0
Depth Fe XII	0.35	-0.08	0.01	0.44	-0.3
Slope Fe XII	-0.21	-0.17	-0.73	-0.71	-0.44
Duration Fe XII	0.19	-0.04	0.19	0.48	-0.36



The best found correlations are with CME second order initial velocity. The highest correlations were between Fe IX slope and Fe XII slope with CME second order velocity.

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