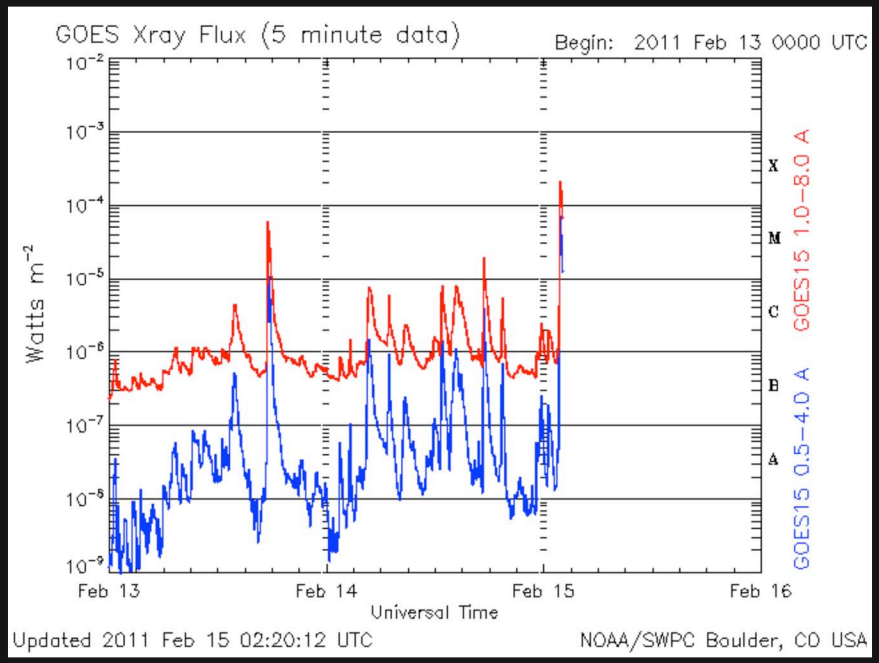
Classification of flares based on X-ray emission flux



Peak value of X-ray flux (1 – 8 Å, W/m^2)

A	10^{-8} – 10^{-7}
B	10^{-7} – 10^{-6}
C	10^{-6} – 10^{-5}
M	10^{-5} – 10^{-4}
X	> 10^{-4}

Ejection of solar magnetic fields into the interplanetary space

Statistical properties of CMEs

- Occurrence rate: **1 (solar minimum) ~ 3 (maximum) /day**
- Average speed: **450 km/s**

  slow CME... high latitude, gradually accelerated

  fast CME... active region, ballistically accelerated

- Total mass loss: **10^13 – 16 g /event** ⟷ solar-wind mass loss rate: 10^12 g/s

- Kinetic (mechanical) energy: **10^27 – 32 erg /event** ⟷ $L_{\odot} \sim 4 \times 10^{33}$ erg/s

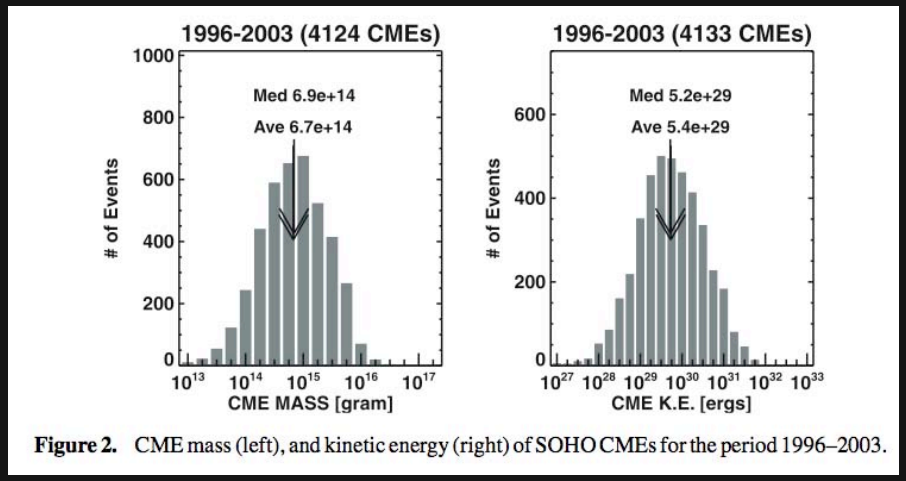


Figure 2. CME mass (left), and kinetic energy (right) of SOHO CMEs for the period 1996–2003.

Gopalswamy (2006)

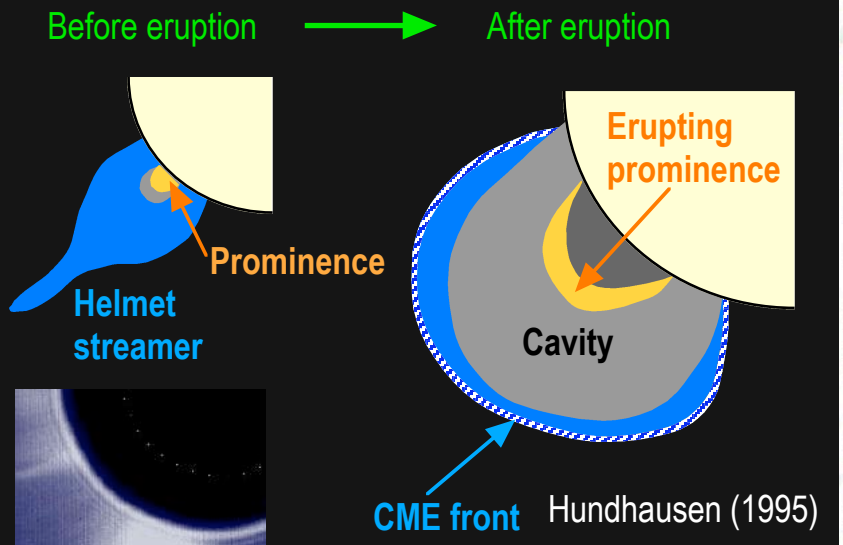
Table 1: Some Average Characteristics of Coronal Mass Ejections

	Skylab (1973-74)	Solwind (1979-80 & 1984-85)	SMM (1980, 1984-89)
Angular Size	42°	43°	47°
Speed	470 km sec^{-1}	460 km sec^{-1}	350 km sec^{-1}
Mass	—	4.0×10^{15} gm	3.3×10^{15} gm
Kinetic Energy	—	3.4×10^{30} ergs	6.7×10^{30} ergs
Potential Energy	—	—	7.1×10^{30} ergs
Mechanical Energy	—	—	1.38×10^{31} ergs

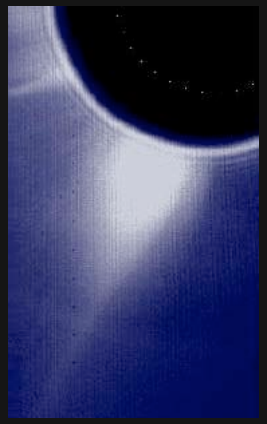
Hundhausen (2000)

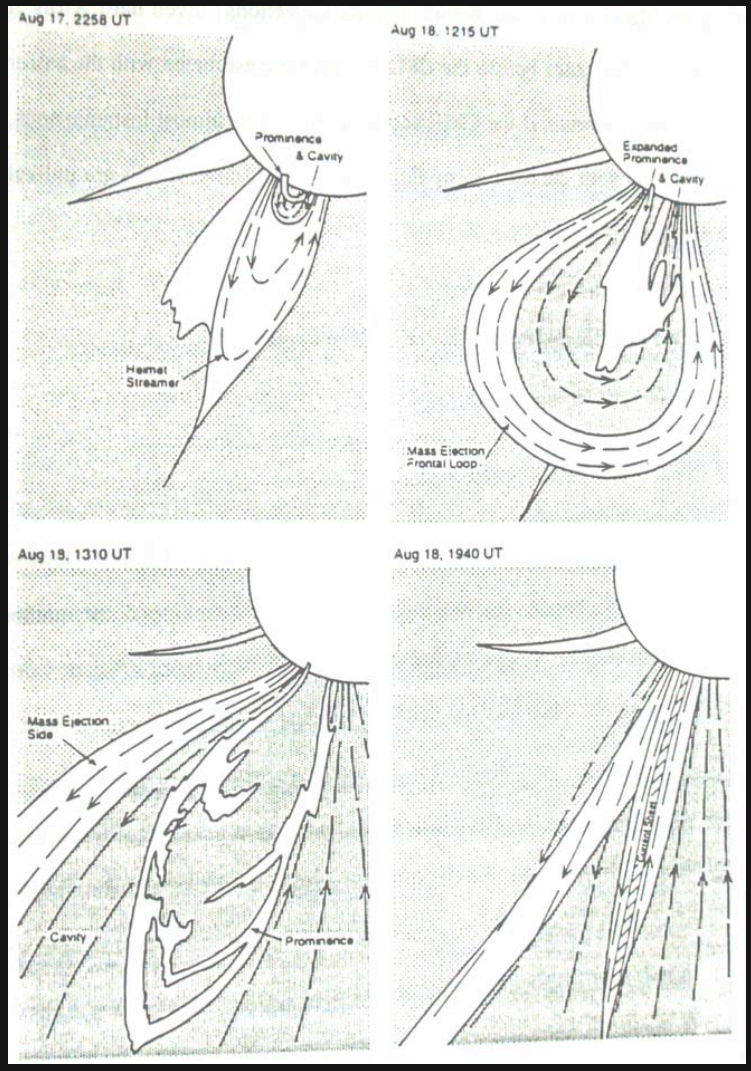
Structure of a CME

Three-part (magnetic) structure



Hundhausen (1995)





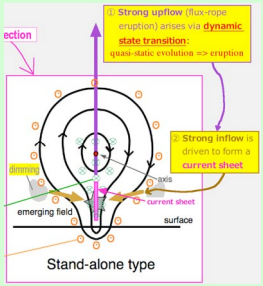
Choe (1995)

Accompanying phenomena of a CME

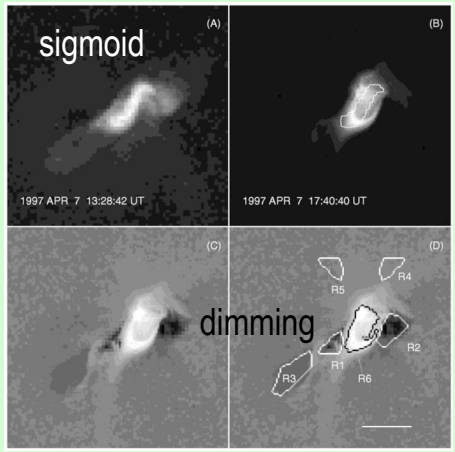
Sigmoid, Dimming

Sterling & Hudson (1997)

Canfield et al. (1999)

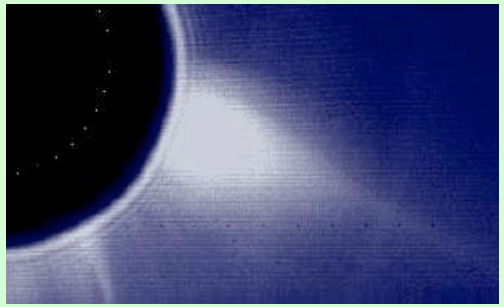


Yohkoh

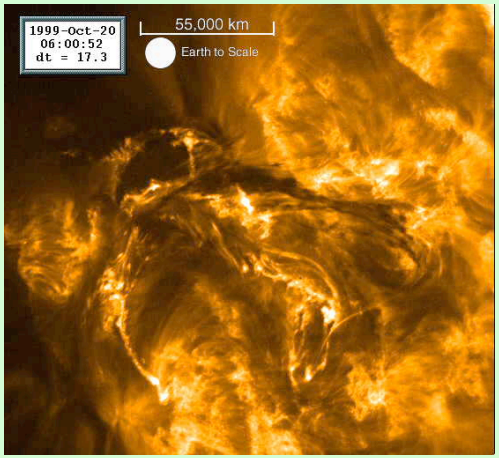


Helmet streamer

SMM

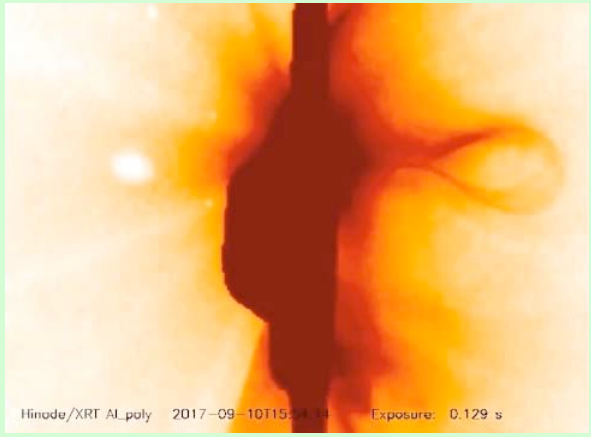


Prominence/filament eruption



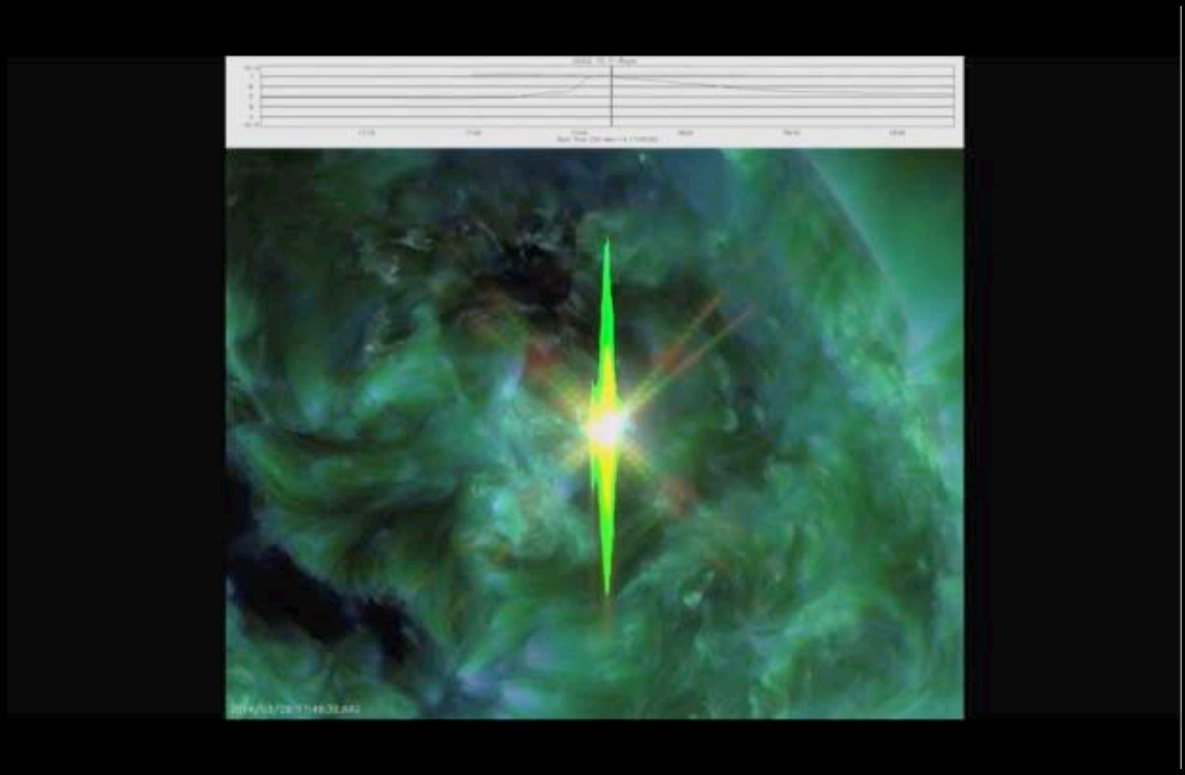
TRACE

Flare



Hinode

An X-class flare accompanying a CME (29 March, 2014)



Sigmoid appeared just before the onset of the flare.

SOHO, SDO