Distribution and configuration of overlying/underlying loops

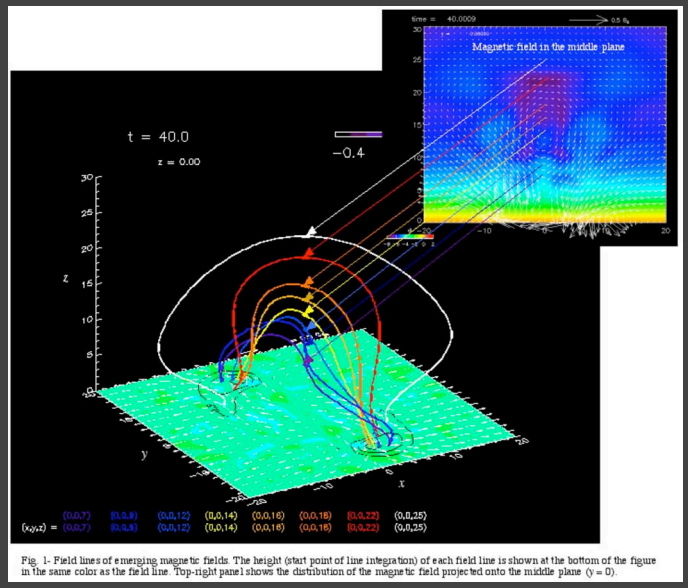


Fig. 1- Field lines of emerging magnetic fields. The height (start point of line integration) of each field line is shown at the bottom of the figure in the same color as the field line. Top-right panel shows the distribution of the magnetic field projected onto the middle plane (y = 0).

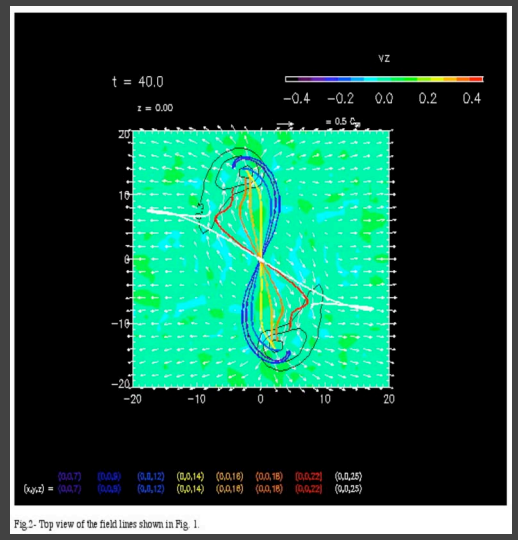
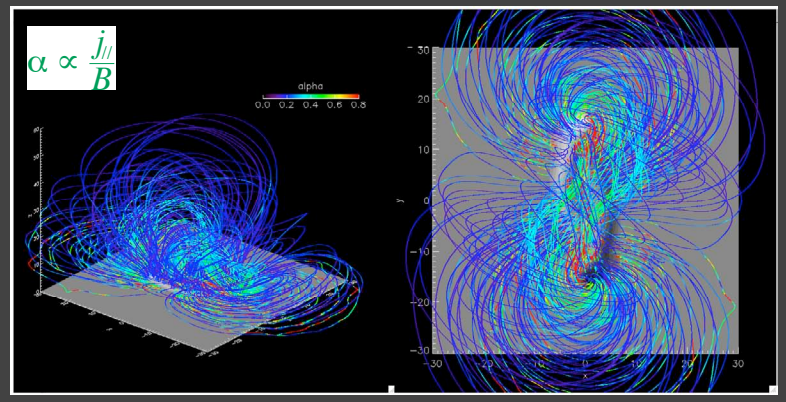
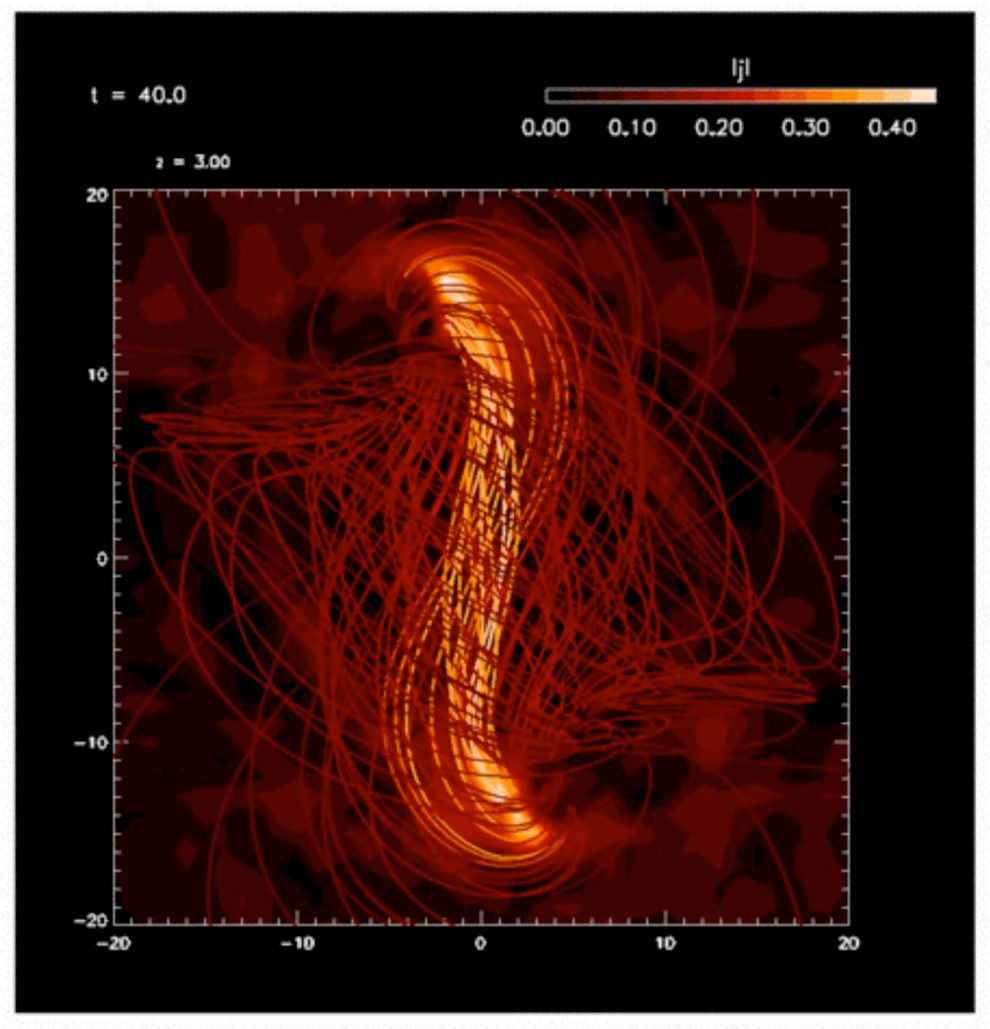


Fig.2- Top view of the field lines shown in Fig. 1.

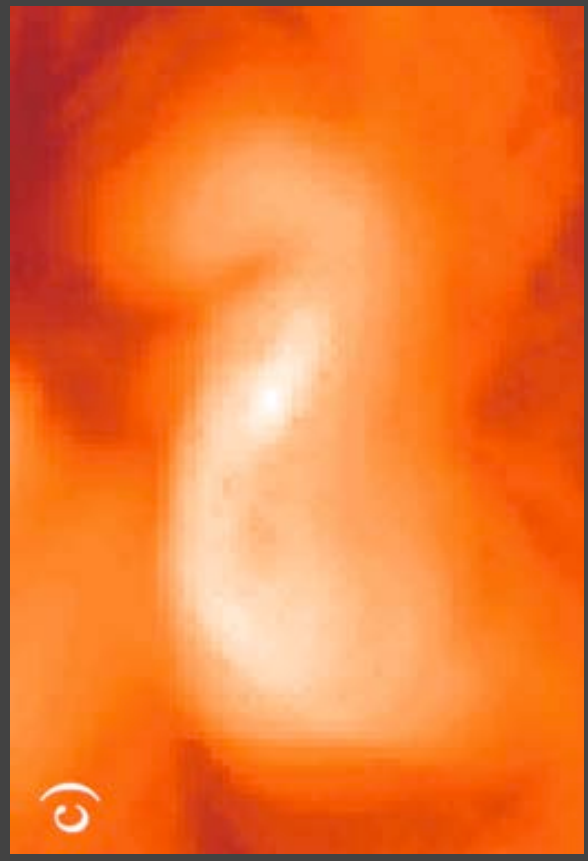


Distribution of α (=>FAC) along overlying/underlying loops

Lee and Magara (2014)



Inverse S-shaped sigmoid produced by an emerging flux tube of left-handed twist (MHD simulation**)**
(field-line color is adjusted based on the value of | j | measured at one footpoint of each loop)

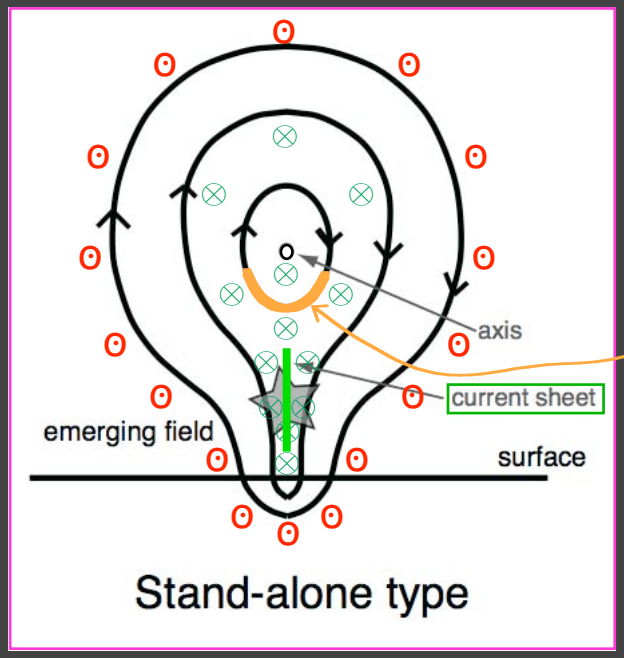


Inverse S-shaped sigmoid observed in soft X-ray
(Yohkoh)

Appearance of a sigmoid (precursor of a flare)

=> suggests emergence of the underlying loop (and axis)

2D (cross sectional) illustration



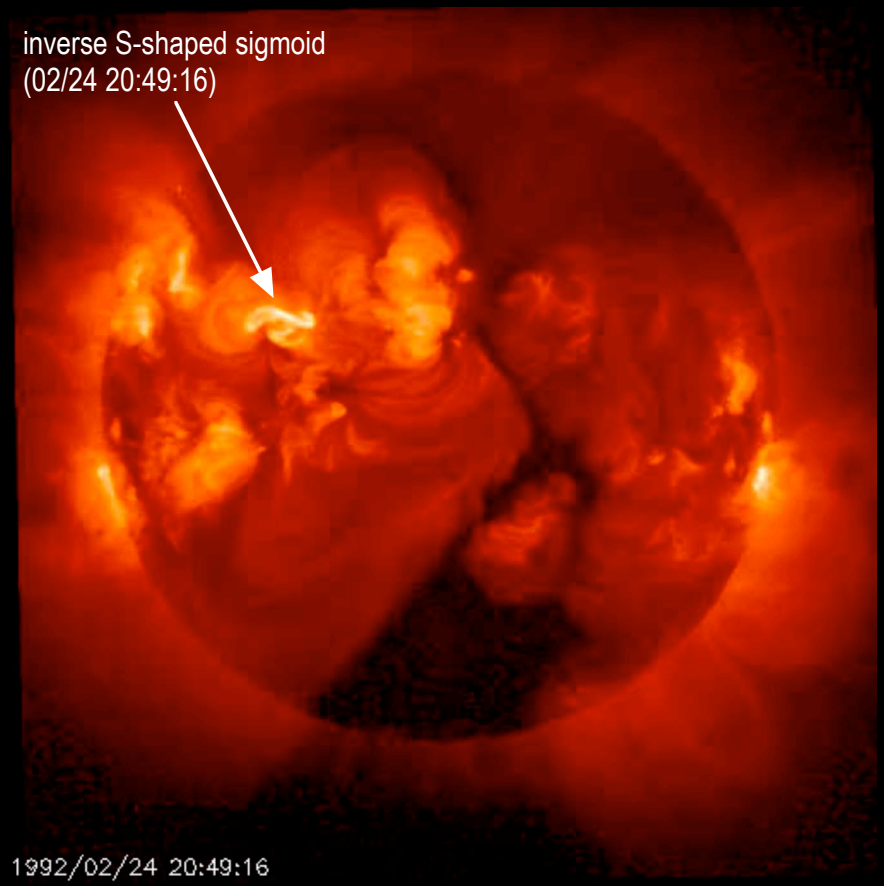
=> suggests formation of a current sheet below the axis

=> onset of a flare

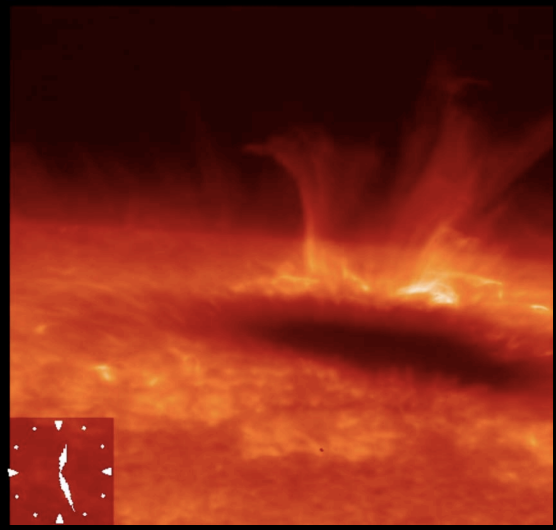
Solar flare

Solar corona is full of dynamic events (explosion & eruption)

... a different world from the solar surface (photosphere) observed in visible light



The Sun in soft X-ray (Yohkoh)
(Corona)



Sunspot in Ca II H (Hinode)
(Chromosphere)

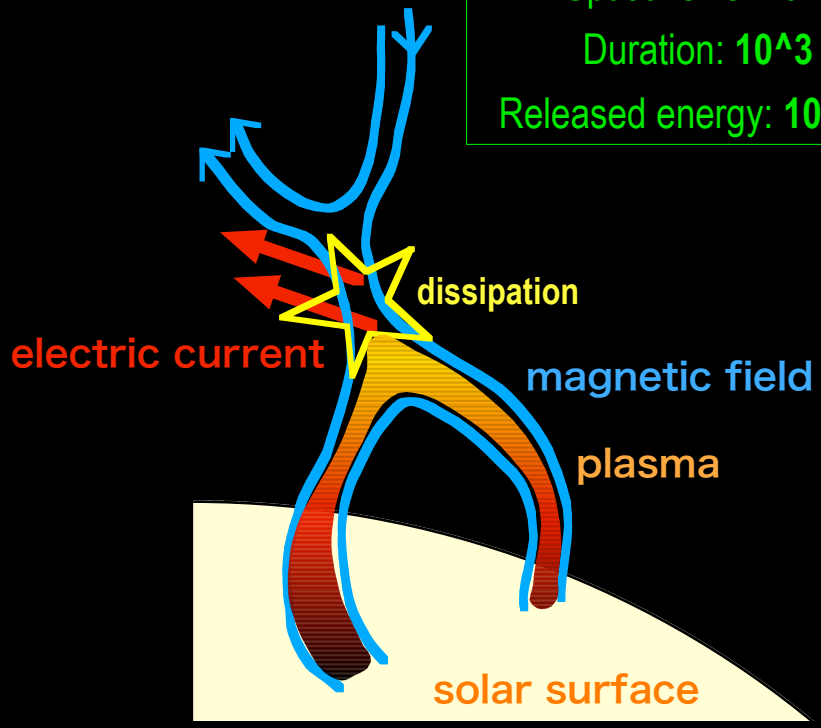
What is a solar flare?

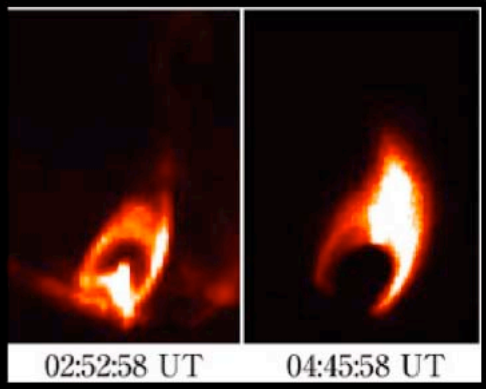
Coronal explosive phenomenon with **rapid release of free magnetic energy (dissipation of electric current)**

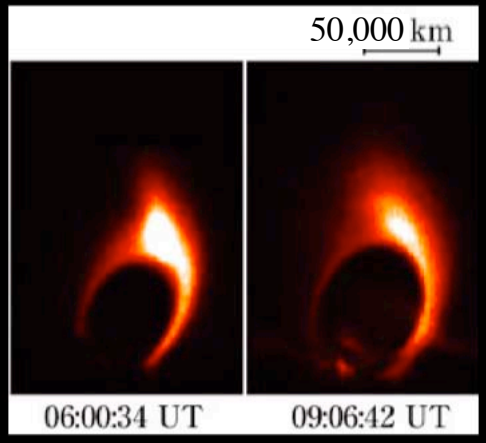
Spatial size: **10^4 – 10^5 km**

Duration: **10^3 – 10^4 sec**

Released energy: **10^28 – 10^32 erg**





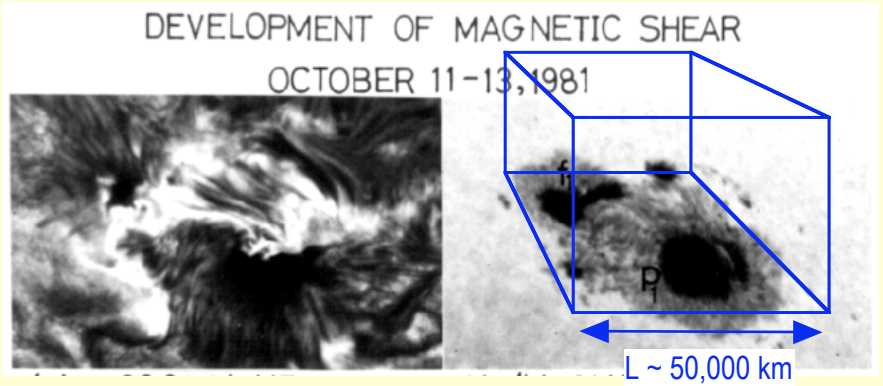


Estimate energy budget of a flare...

Magnetic energy stored in a typical active region:

Size: L ~ 50,000 km

Average magnetic field strength: B ~ 500 G



Kurokawa (1989)

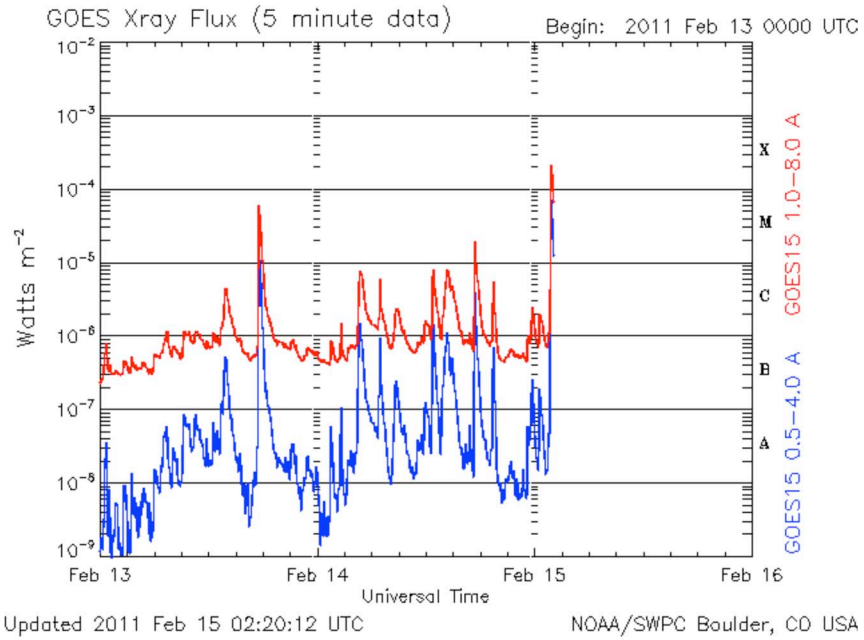
Total magnetic energy stored in active region is estimated as

$$\left(5\times10^{9}\ cm\right)^{3}\times\frac{\left(500\ G\right)^{2}}{8\pi}\sim10^{33}\ erg$$

CGS unit

Released energy of a flare: **10^28 – 10^32 erg**

Classification of flares based on X-ray emissions



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

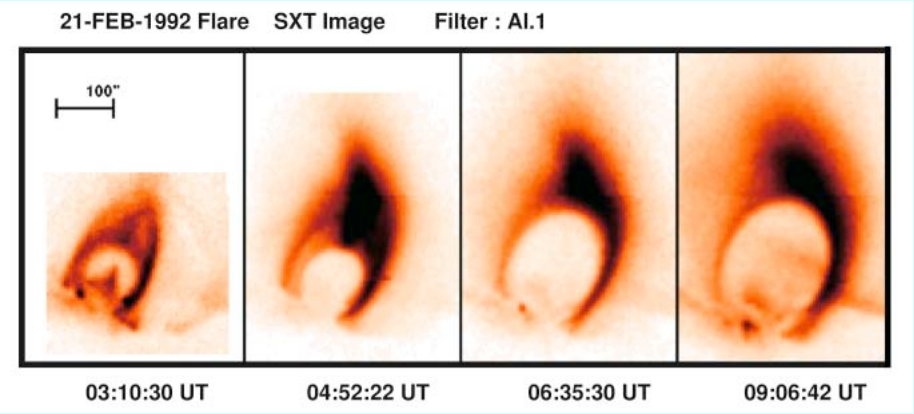
A	10^{-8} - 10^{-7}
B	10^{-7} - 10^{-6}
C	10^{-6} - 10^{-5}
M	10^{-5} - 10^{-4}
X	> 10^{-4}

Observational features of flares

Structural features
Statistical features

Structural features

Long durational event flares (LDE flares)

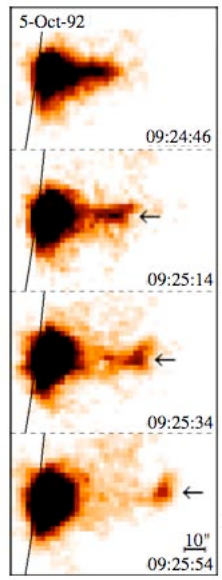


Tsuneta et al. (1992)

- Long time scale (several hours)
- Relatively large spatial size (≥ 100,000 km)
- Cusp-shaped structure

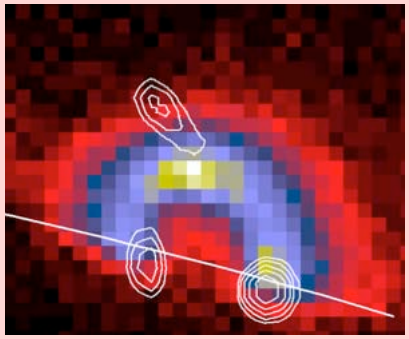
Common feature:

Plasmoid ejection (v ≥ 100 km/s)



Shibata (1998)

Impulsive flares (compact flares)



Masuda et al. (1994)

- Short time scale (less than an hour)
- Relatively small spatial size (≤ 100,000 km)
- No cusp-shaped structure