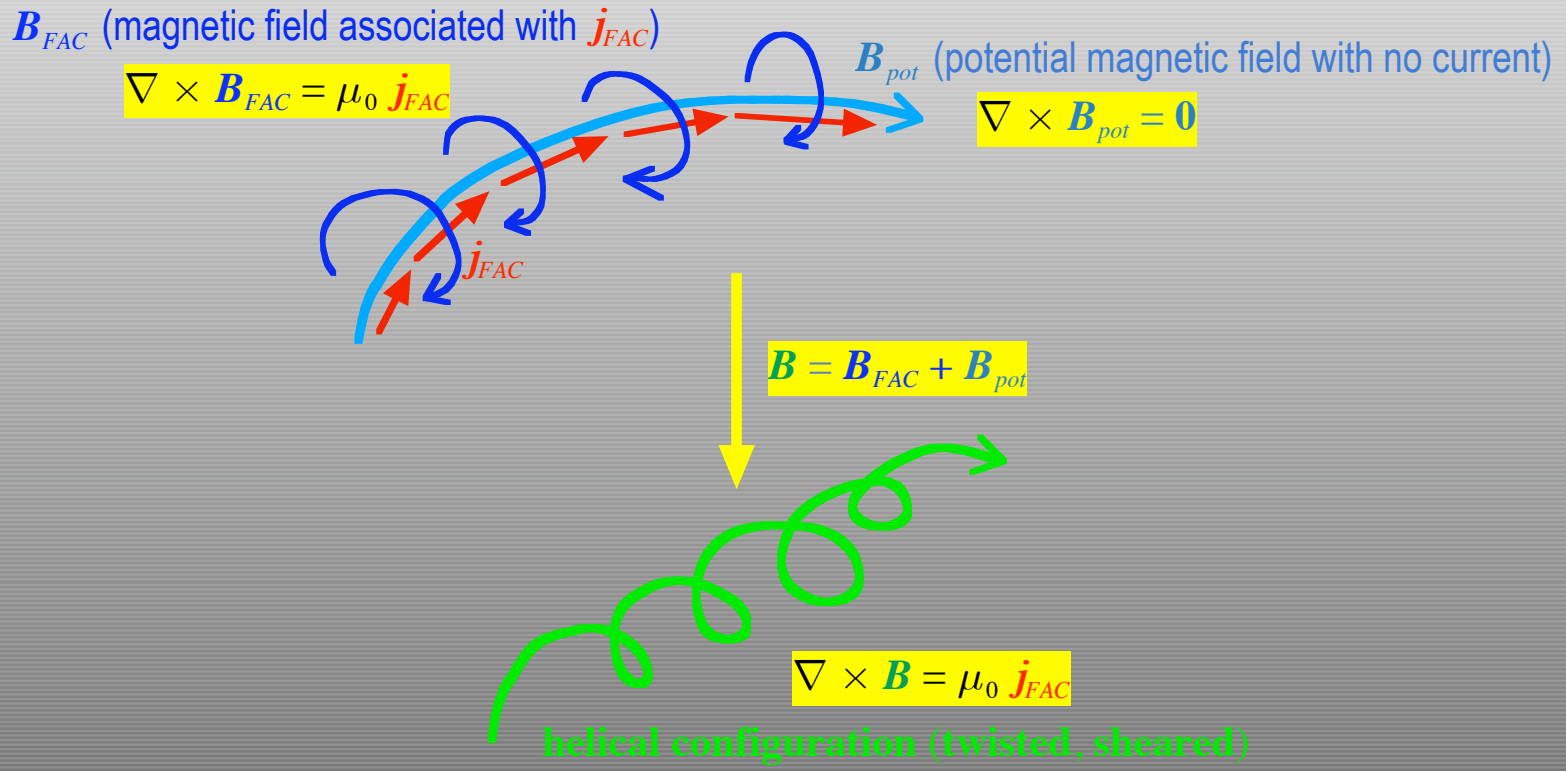
FAC produces a helical magnetic field configuration...

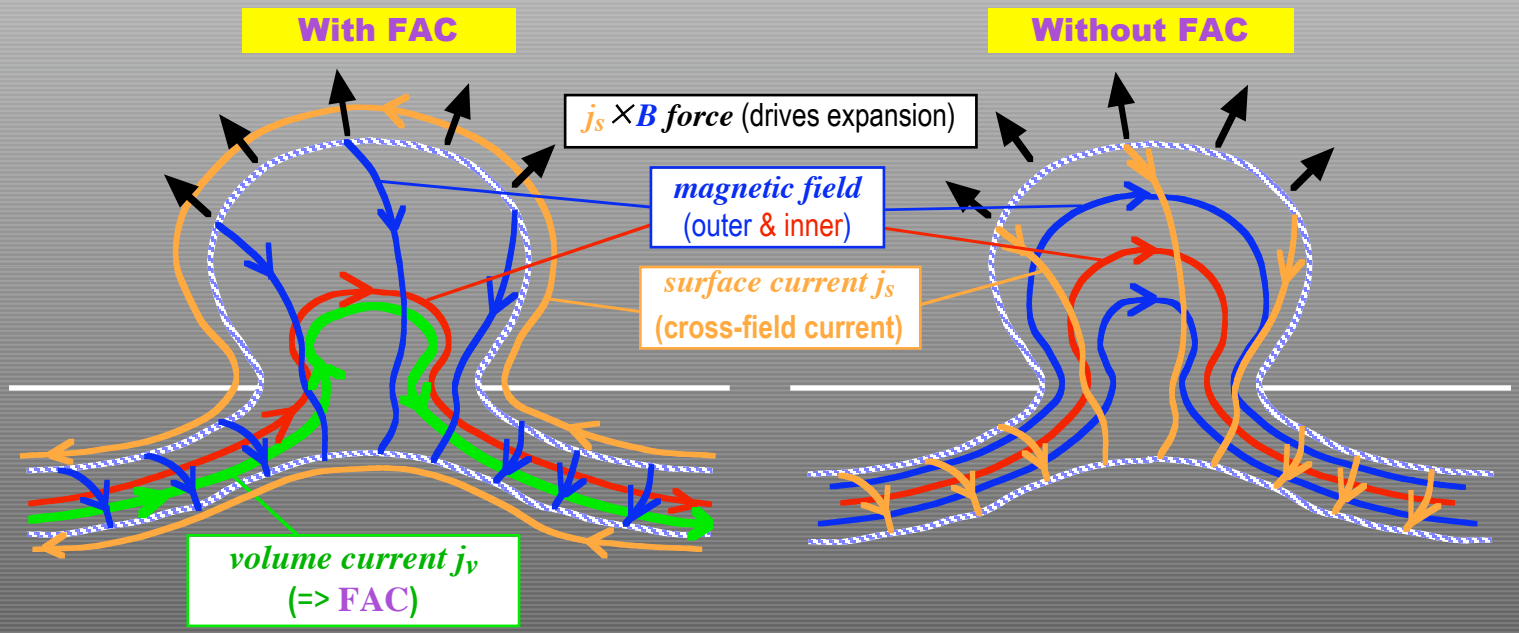


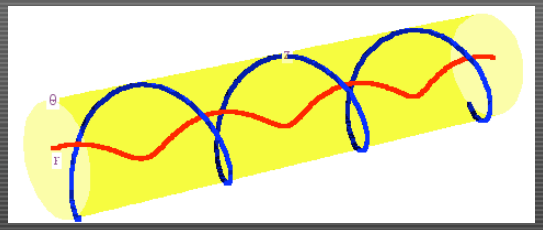
Force-free field with FAC ($\nabla \times B = \alpha B$):

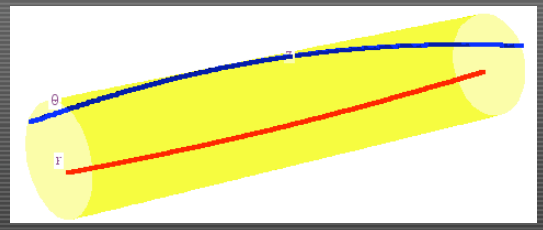
When FAC and magnetic field are parallel (right-handed twist) => $\alpha > 0$

When FAC and magnetic field are antiparallel (left-handed twist) => $\alpha < 0$

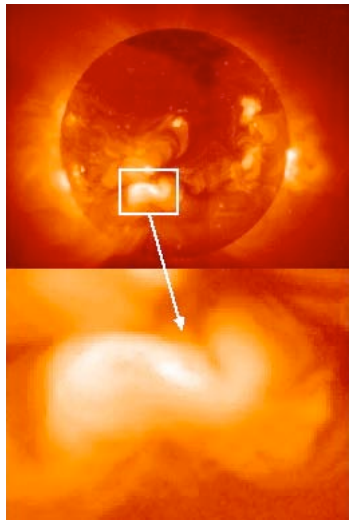
Magnetic structure with and without FAC...







Sigmoidal magnetic structure



Chirality rule of sigmoids observed on the Sun

TABLE II

CHIRALITY OF SOLAR ACTIVE REGIONS [37] AND SHAPE OF THE CORONAL SIGMOIDS [38] BY HEMISPHERE.

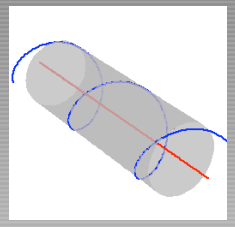
	N-hemisphere	S-hemisphere
Positive α	38%	66%
Forward S	41%	68%
Negative α	62%	34%
Backward S	59%	32%

Canfield, Hudson, McKenzie (1999)

O... dominant part

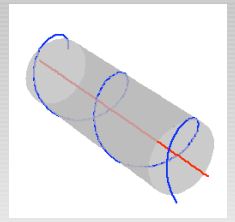
Northern hemisphere...

Left-handed twist (negative α), inverse S

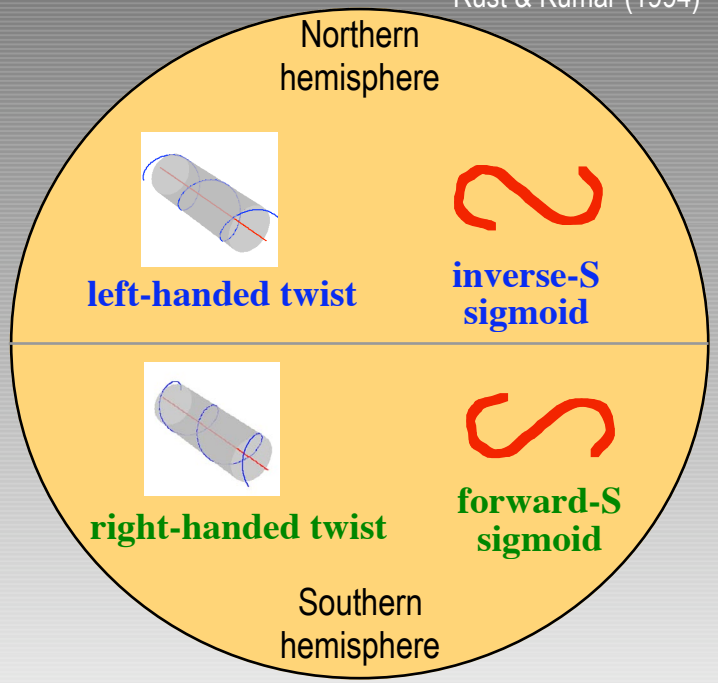


Southern hemisphere...

Right-handed twist (positive α), forward S

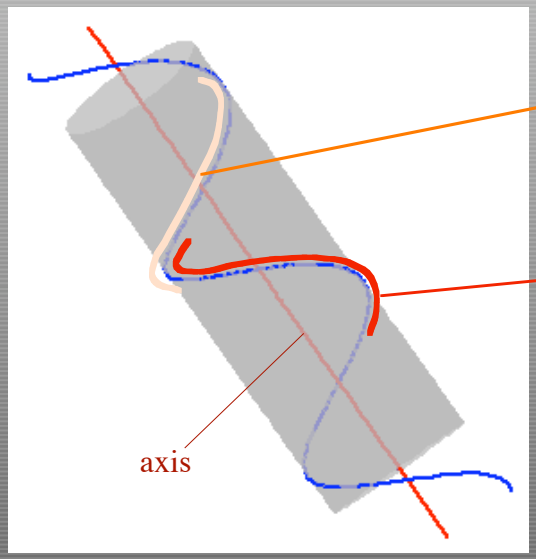


Rust & Kumar (1994)



Coexistence of forward and inverse S-shaped field lines (loops)

Left-handed twist case (northern hemisphere)



Underlying loop (**below the axis** of flux tube)

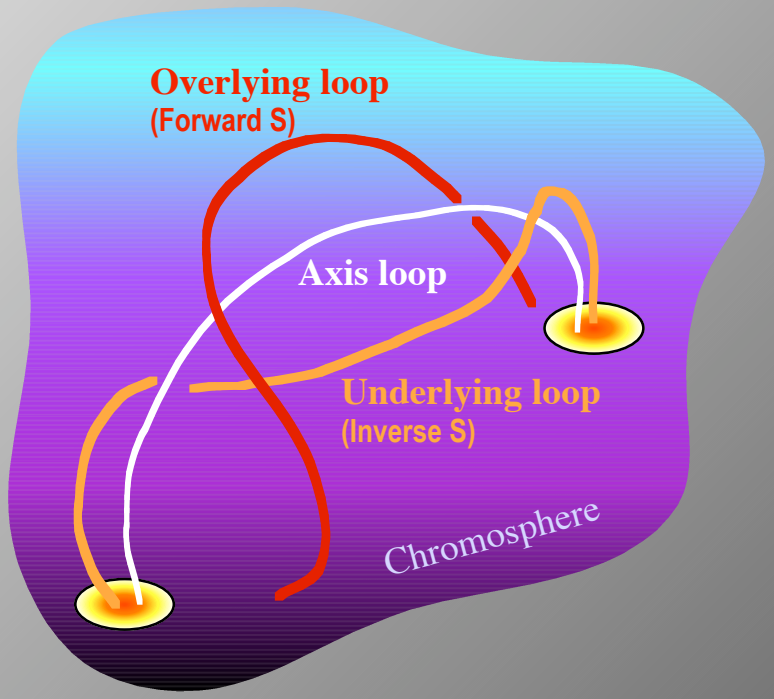
→ **inverse S-shape**

Overlying loop (**above the axis** of flux tube)

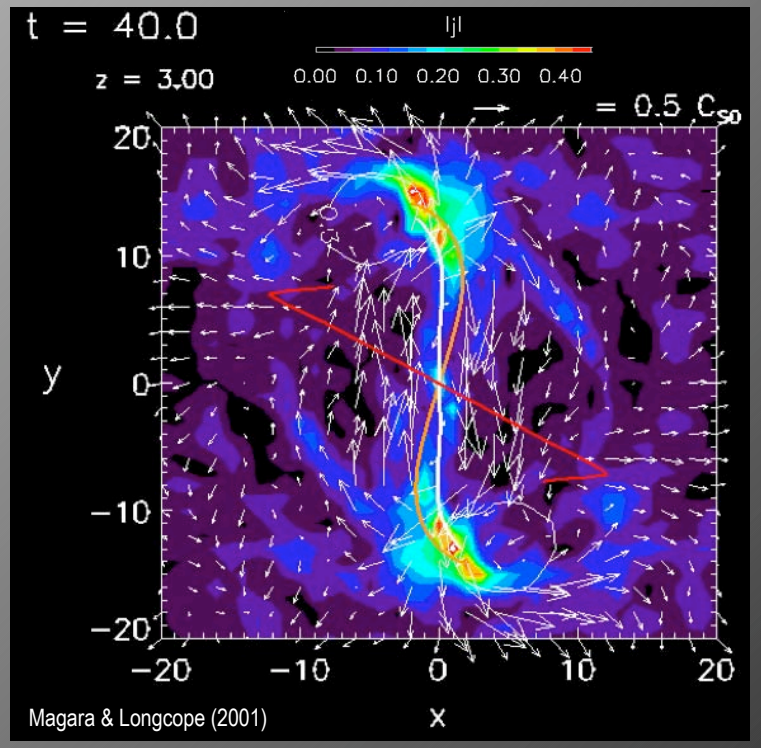
→ **forward S-shape**

Question: *Why is an inverse S-shaped sigmoid preferentially observed?*

Distribution of current density



... region where high current density is distributed



High current density is distributed at footpoints of the underlying loop.
This suggests that the current could be dissipated to heat a plasma distributed along the underlying loop, thereby illuminating an inverse S-shaped sigmoid.

3D configuration of multiple overlying/underlying loops, & axis loop

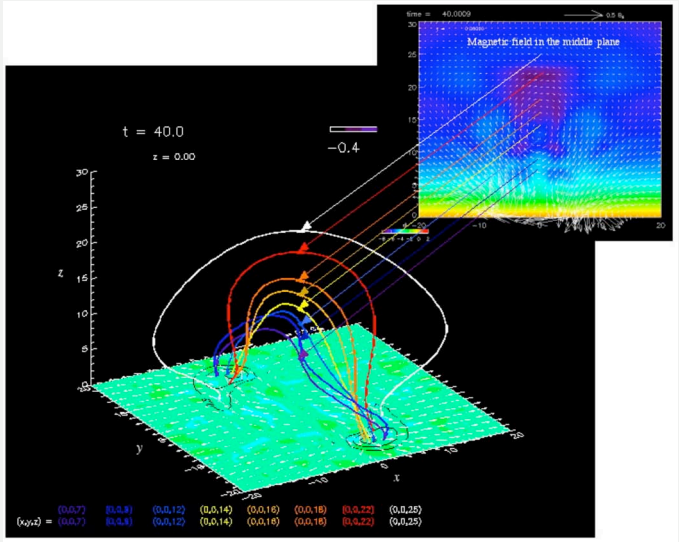


Fig. 1- Field lines of emerging magnetic fields. The height (start point of line integration) of each field line is shown at the bottom of the figure in the same color as the field line. Top-right panel shows the distribution of the magnetic field projected onto the middle plane (y = 0).

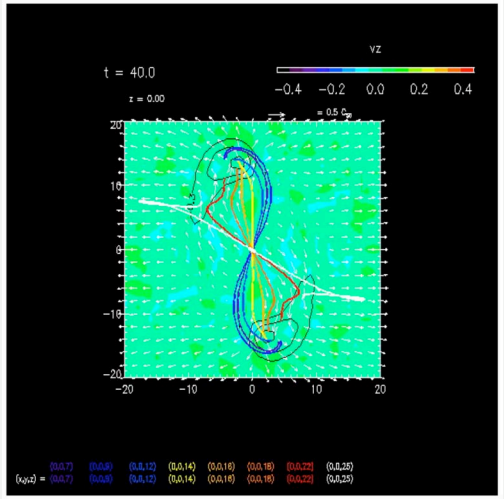
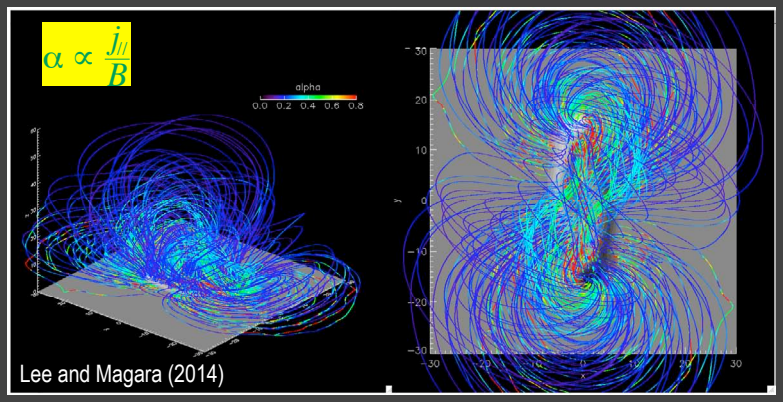
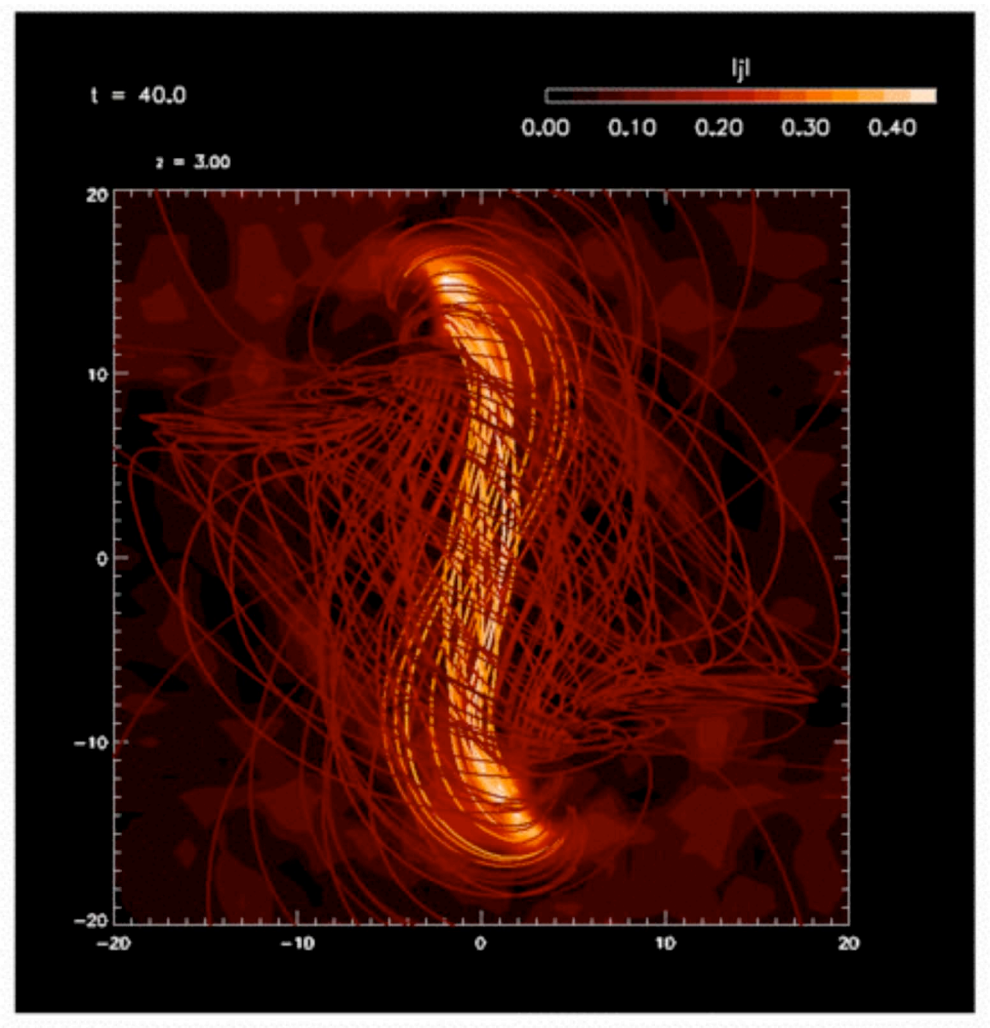


Fig.2- Top view of the field lines shown in Fig. 1.



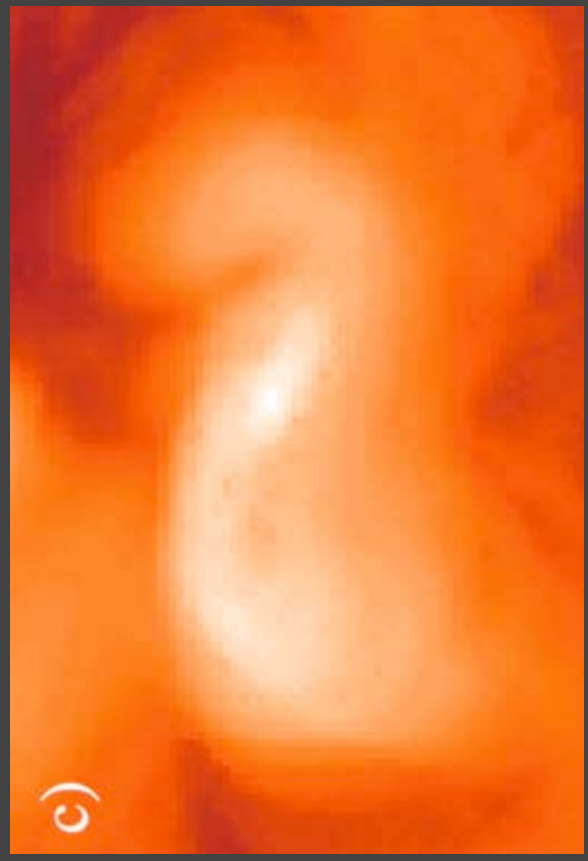
Distribution of α (FAC normalized by |**B**|) along overlying/underlying loops...

strong FAC tends to be distributed along the underlying loops



Inverse S-shaped sigmoid produced by an emerging flux tube of left-handed twist (*MHD simulation*)

(field-line color is adjusted depending on the value of $|j|$ measured at one footpoint of each field line)

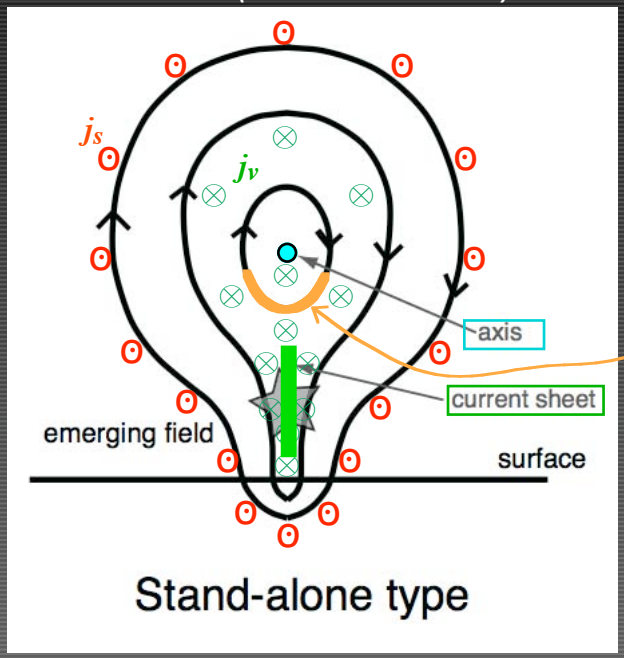


Inverse S-shaped sigmoid observed in soft X-ray (*Yohkoh*)

Appearance of a sigmoid (precursor of a flare)

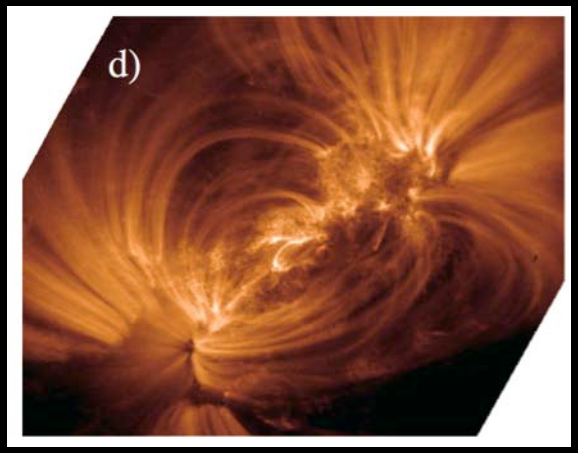
=> *suggests* ***emergence of underlying loop*** (*and* ***axis***) ***into the corona***

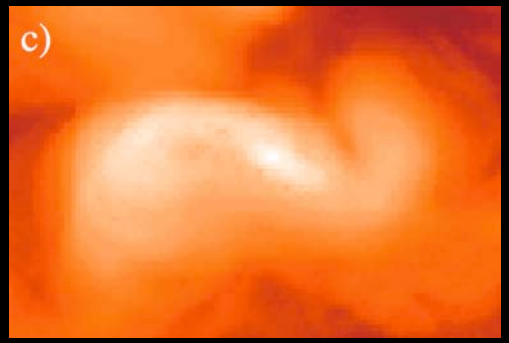
Side view (cross sectional view)



=> ***formation of a current sheet below the axis*** via DST

=> ***onset of a flare*** via MR





To make a quantitative comparison between magnetic structure having different appearances and activity levels, we need physical quantities representing magnetic field configurations of the structure.

=> http://163.180.179.74/~magara/meetings/KAS2026spring.mp4