Post-flare phase

transport of released energy and

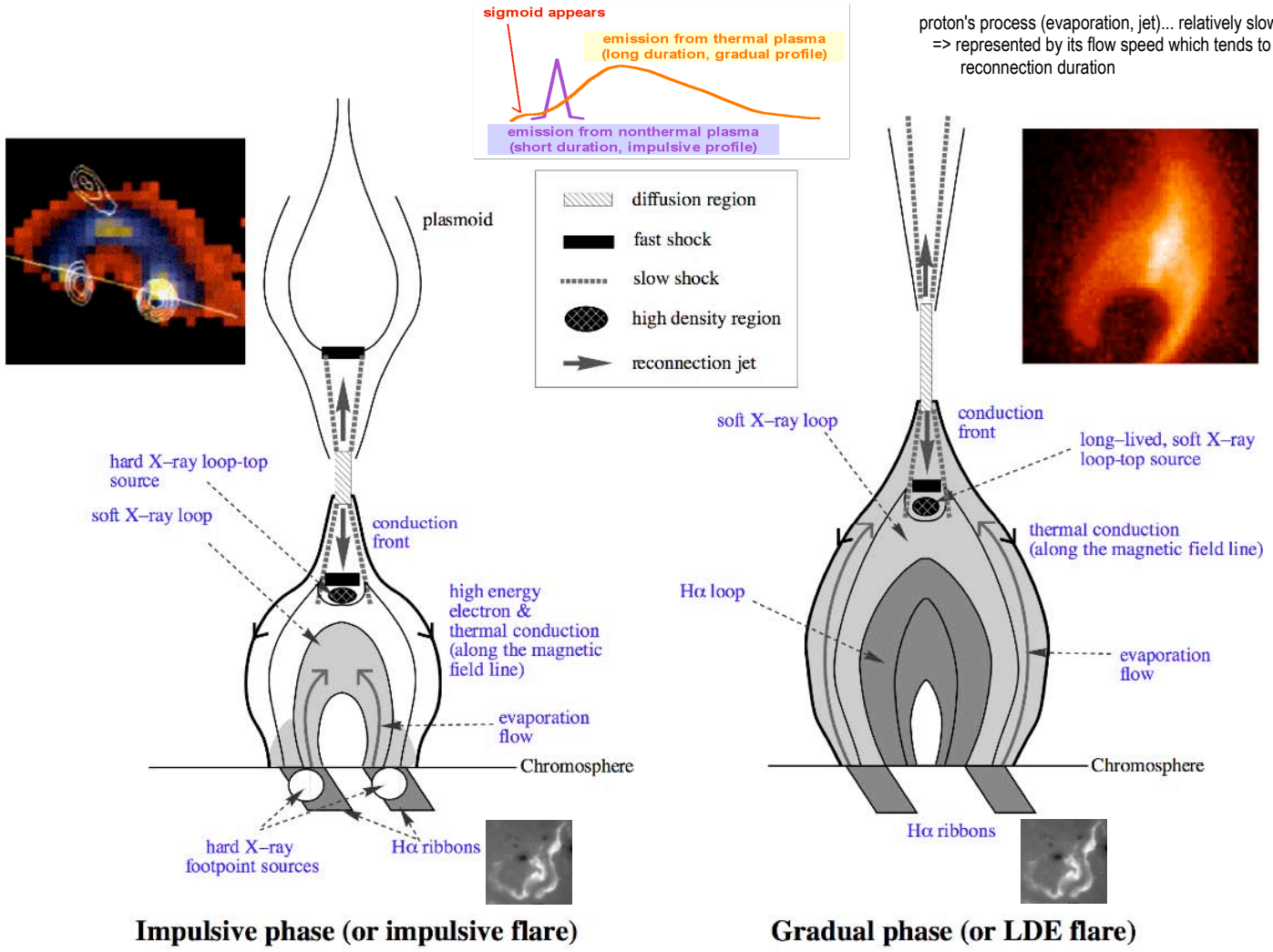
atmospheric response

Energy transport and atmospheric response

(impulsive flare vs. LDE flare; impulsive phase vs. gradual phase of an LDE flare)

electron's process (conduction)... relatively fast
=> represented by its thermal or non-thermal speed wihch tends to reflect reconnection speed

proton's process (evaporation, jet)... relatively slow
=> represented by its flow speed which tends to reflect reconnection duration



Shibata & Magara (2011)

Future researches on solar flare

3D modeling

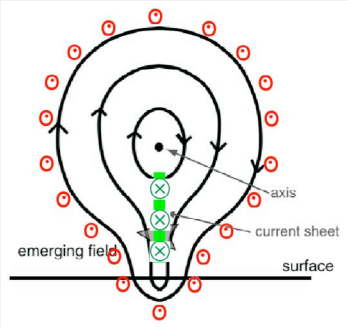
&

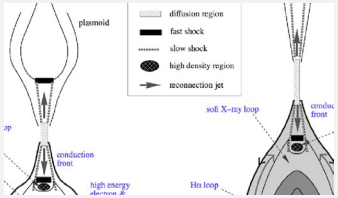
Prediction

3D modeling

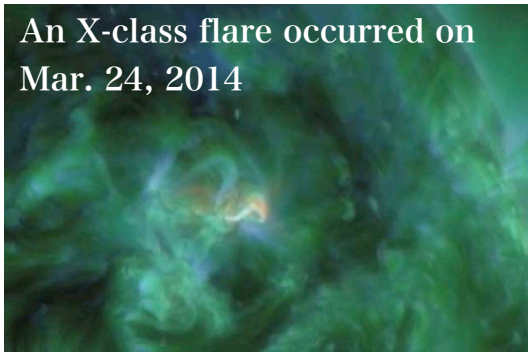
Previous studies...

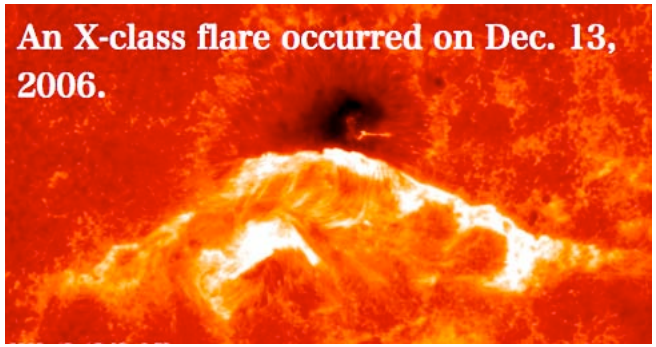
focused on **2D features** to derive **basic physical processes involved in a flare**





In reality, flares occur in **3D space**.

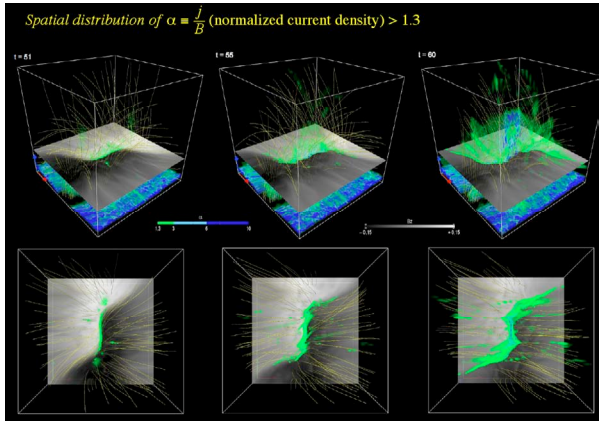




Investigate the basic processes in 3D space...

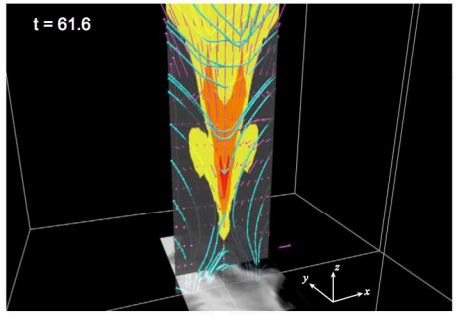
Construct a **3D model** that reproduces the **evolution of an emerging flux tube (energy buildup, preflare, main phases)** to investigate **how the basic physical processes derived from 2D models work in 3D space**.

Dynamic formation of a 3D current sheet (preflare phase)



Magara (2017)

3D reconnection (main phase)



2D illustration

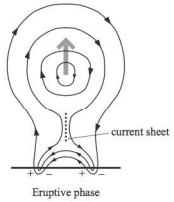


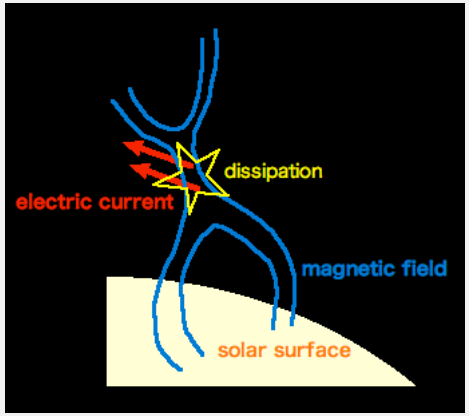
Fig. 3. Left: snapshot of the region of magnetic reconnection in the same domain as figure 2. Time is $t = 61.6$. Magnetic field lines are represented by arrowed cyan lines, while distribution of vertical magnetic flux is illustrated by the horizontal gray-scale map placed at $z = 2$, ranging from −0.3 (black) to 0.3 (white). Distribution of temperature is illustrated by the vertical map placed at $y = 0$, where colors represent $1 \leq T < 20$ (dark gray), $20 \leq T < 70$ (yellow), $70 \leq T < 150$ (orange), and $150 \leq T$ (red). Pink arrows indicate flow velocity field at $y = 0$, and a unit vector scaled to 10 c_{ph} is displayed as the pink horizontal arrow placed near the base. Right: schematic illustration of current sheet formation caused by flux rope eruption. Adapted from Magara et al. (2011). (Color online)

Magara (2015)

Prediction

Previous studies...

Magnetic reconnection is a key mechanism for producing a flare.



The next step...

To find out when & where this mechanism operates to produce a flare

- Perform **observation data-based simulation of a flare**
- Derive a **key quantity(es) indicating the occurrence of a flare**

Observation data-based simulation...

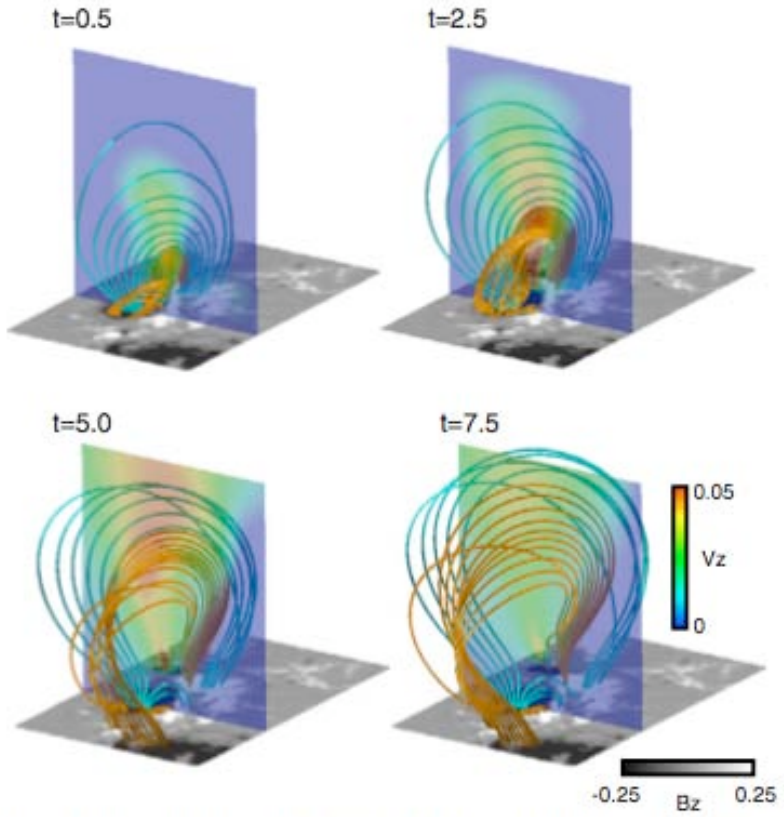


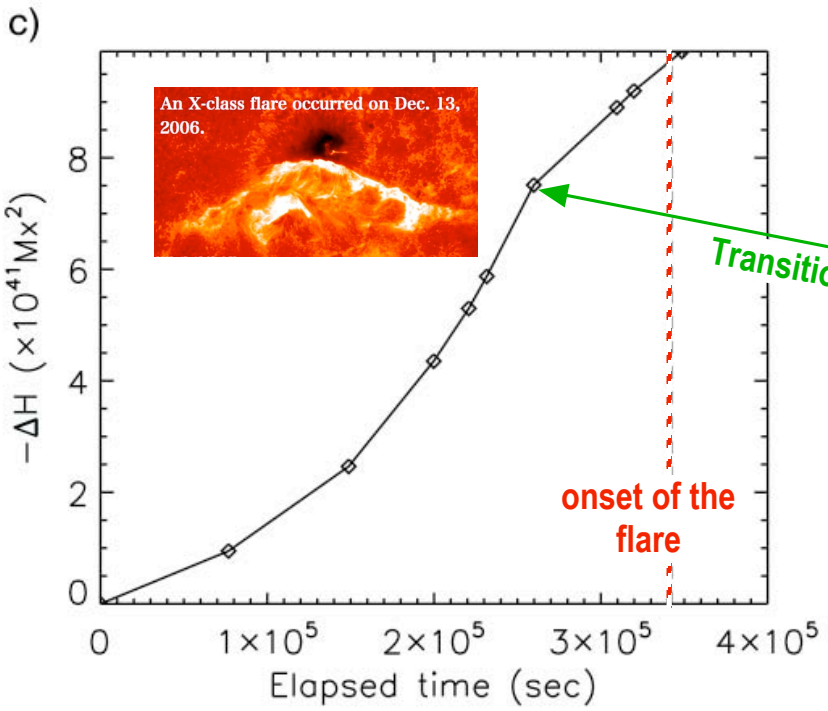
Figure 5. Three-dimensional dynamics of the magnetic field lines. Orange lines represent the twisted field lines with more than a half-turn twist at $t = 0$ in Run D, i.e., $t = 1$ in Run C, while blue lines represent overlying field lines surrounding the twisted lines in orange. The B_z distribution is drawn in gray, and the vertical velocity distribution is mapped in color.

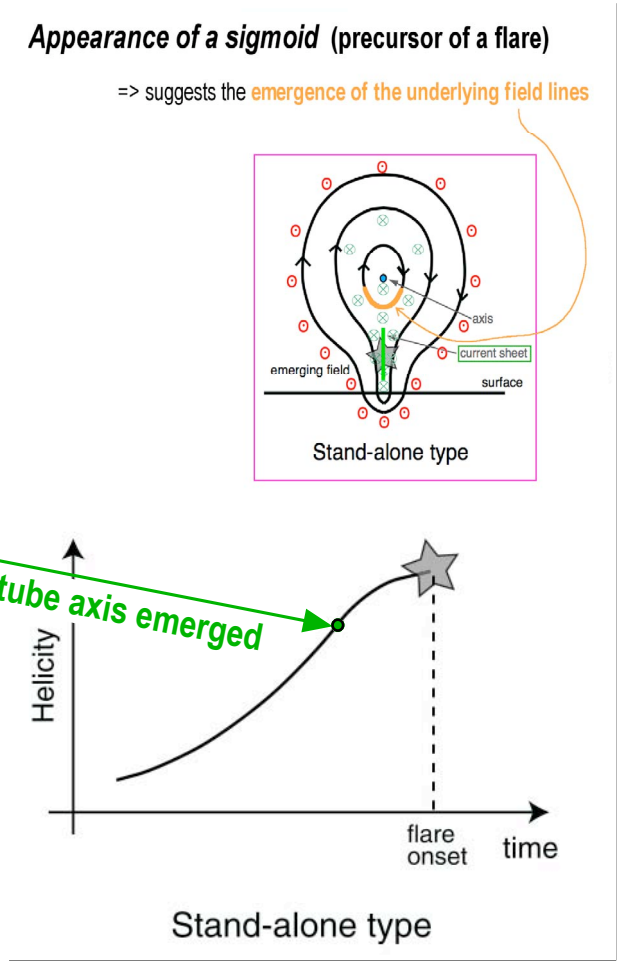
Inoue et al. (2014)

Key quantities indicating the occurrence of a flare...

Magnetic helicity is one of the key quantities, whose temporal profile may be used as an indicator for the occurrence of a flare.

http://163.180.179.74/~magara/page31/Research_ARevo.html





Magara & Tsuneta (2008)