

Flare Energy Release by DC Electric Fields Resulting from Electric Charges in the Sheared Magnetic Fields

Tadashi HIRAYAMA National Astronomical Observatory of Japan

1. Because the rising velocity of a flare inducing prominence is $\leq 300 \text{ km s}^{-1}$, plasmas cannot continuously eject with Alfvén velocity of 3000 km s^{-1} , but only with $V_z \approx 100 \text{ km s}^{-1}$. Hence we better discard the slow-shock and also fast-shock.

2. Overall Scenario

Sheared Fields \rightarrow e-Charge \rightarrow Electric fields along B_{\parallel} \rightarrow 10keV~MeV

3. When there is a **substantial sheared field** as expected in every flare, there should be y-components parallel to a long direction of the magnetic neutral line. Then Gauss law leads **non-zero electric charges σ**

$$4\pi\sigma = \text{div}E = -\text{div}(V \times B)/c \approx B_y \partial V_z / c \partial x.$$

Charges create large electric fields parallel to the magnetic Field

Due to large electric fields, the inflowing Poynting energy flux is immediately converted to a kinetic energy of electron beams along the magnetic field (areas are S_x and S_z);

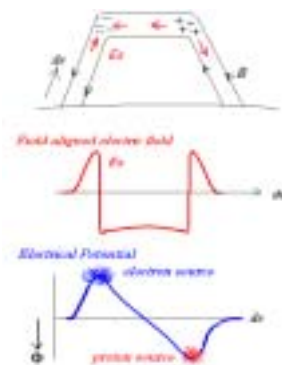
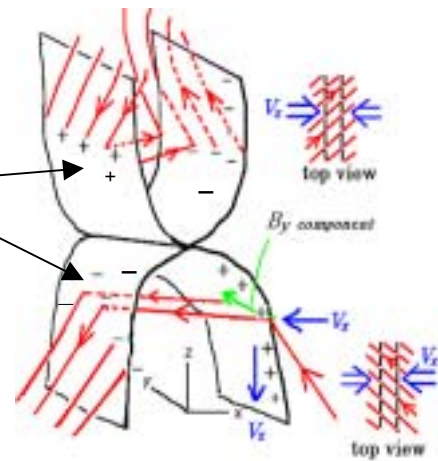
$$V_x B^2 S_x / 4\pi = \frac{1}{2} m_e n_{\text{beam}} V_{\text{beam}}^3 S_z$$

The total flare energy can be supplied by $\approx 10 \sim 20 \text{ keV}$ electrons and $n_{\text{beam}} = 2 \times 10^7 \text{ cm}^{-3}$ for $V_x = 40 \text{ km s}^{-1}$. This V_x ensures short time scales of flares.

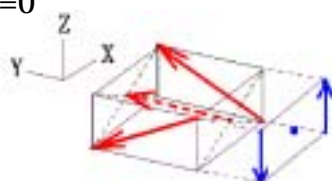
4. Back-flowing bulk electrons solve 'charge pile-up' and 'number-problem'

$$\because -\partial n_{\text{total}} / \partial t = \text{div}[\int f_{\text{beam}} v dv + \int f_{\text{bulk}} v dv] = 0$$

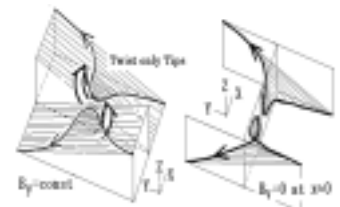
5. In the sheared tiny neutral point, there should be **no diffusion region**, but instead the reconnection region in a potential field without current, by unwinding shears.



Electrons precipitate into both of the two ribbons from a high hill of electrostatic potential like a roller-coaster, so do protons.



Shears make almost parallel fields in the neutral line; impossible to reconnect !!



Unwinding motions lead to potential fields of a lowest energy state, resulting in easy reconnection.