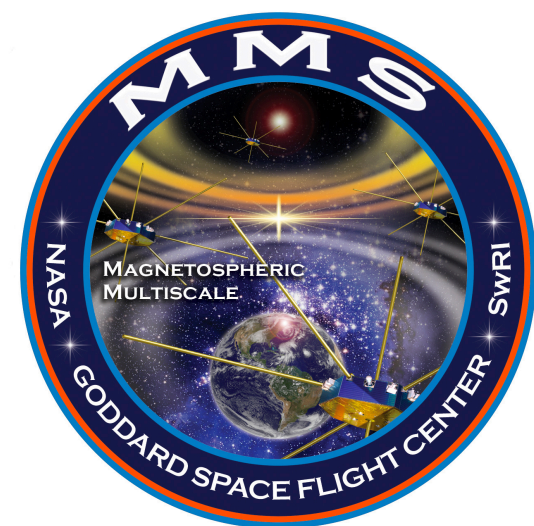# Magnetic Curvature Analysis
on Reconnection Related Structures at Earth's Magnetopause

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Curvature vector and the radius of curvature
Definition and the physical interpretation

- $\vec{\kappa} = \vec{b} \cdot \nabla \vec{b}$

  The curvature vector can demonstrate the direction towards which the magnetic field lines curve.

- $Rc = \dfrac{1}{\left| \vec{b} \cdot \nabla \vec{b} \right|}$

  The radius of curvature can demonstrate the strength of the field line curving; the smaller is the Rc, the stronger is the curving.

- The curvature vector will reverse in the normal direction crossing a Harris current sheet (B_0 tanh(x/L)) with a constant normal Bn. L is the current sheet half-width

- At the center of this kind of current sheet: the ratio of the Rc to one type of particle's gyro radius can be approximated by: $\left(\dfrac{B_n^2}{B_0^2} \right) \dfrac{L}{\rho_s}$ [Buchner and Zelenyi, 1989]; this ratio can be a proxy of the current sheet thickness relative to a certain type of particle's kinetic scale.

Application 1: Radius of curvature can be a quantitative indicator of the proximity of the x-line with small guide field

- Far away from the x-line, when the particles are well guided by the magnetic field
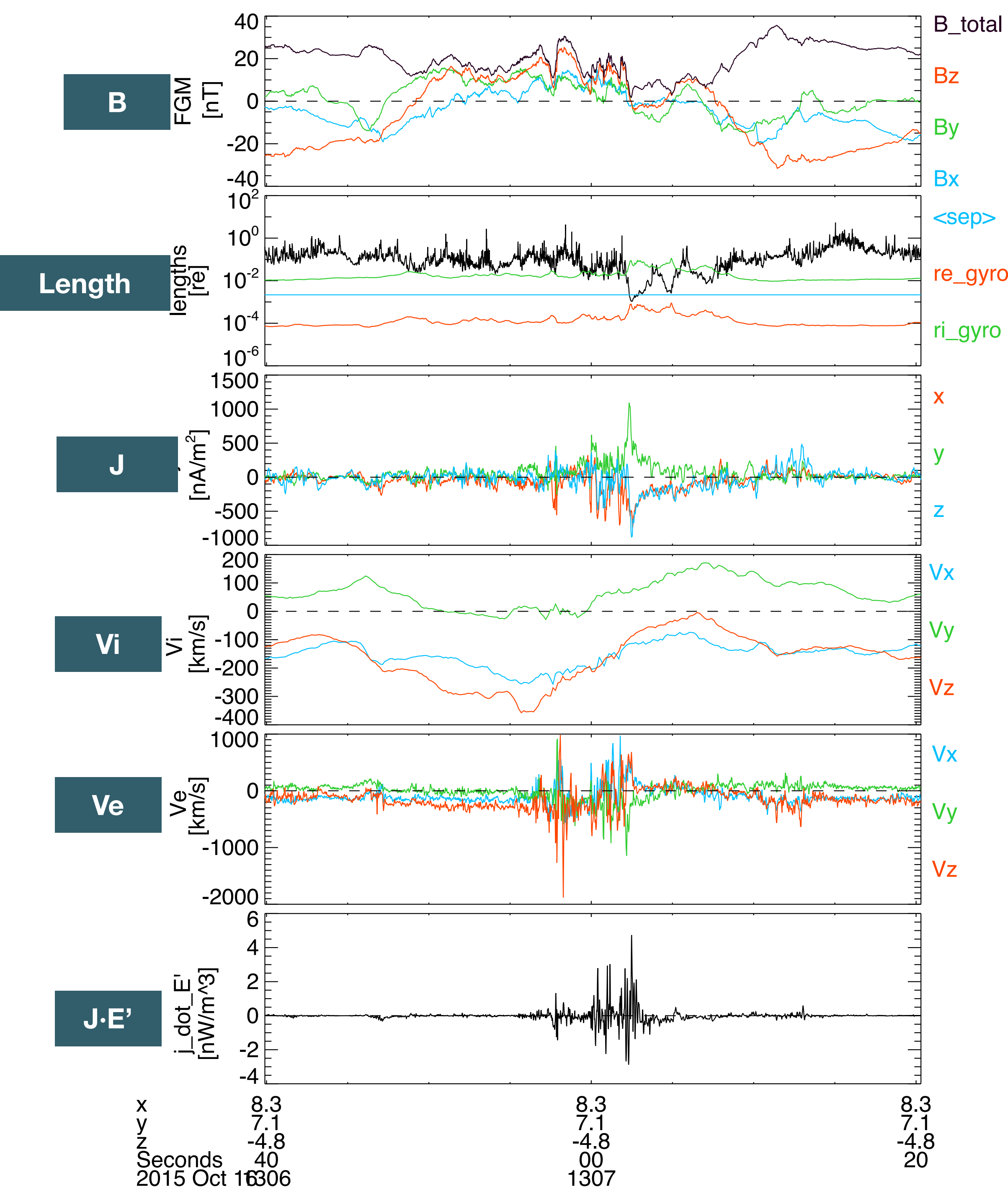
$$R_c \gg R_{gyro}$$

- Near the reconnection line in the ion diffusion region, Ions are decoupled while electrons remain magnetized
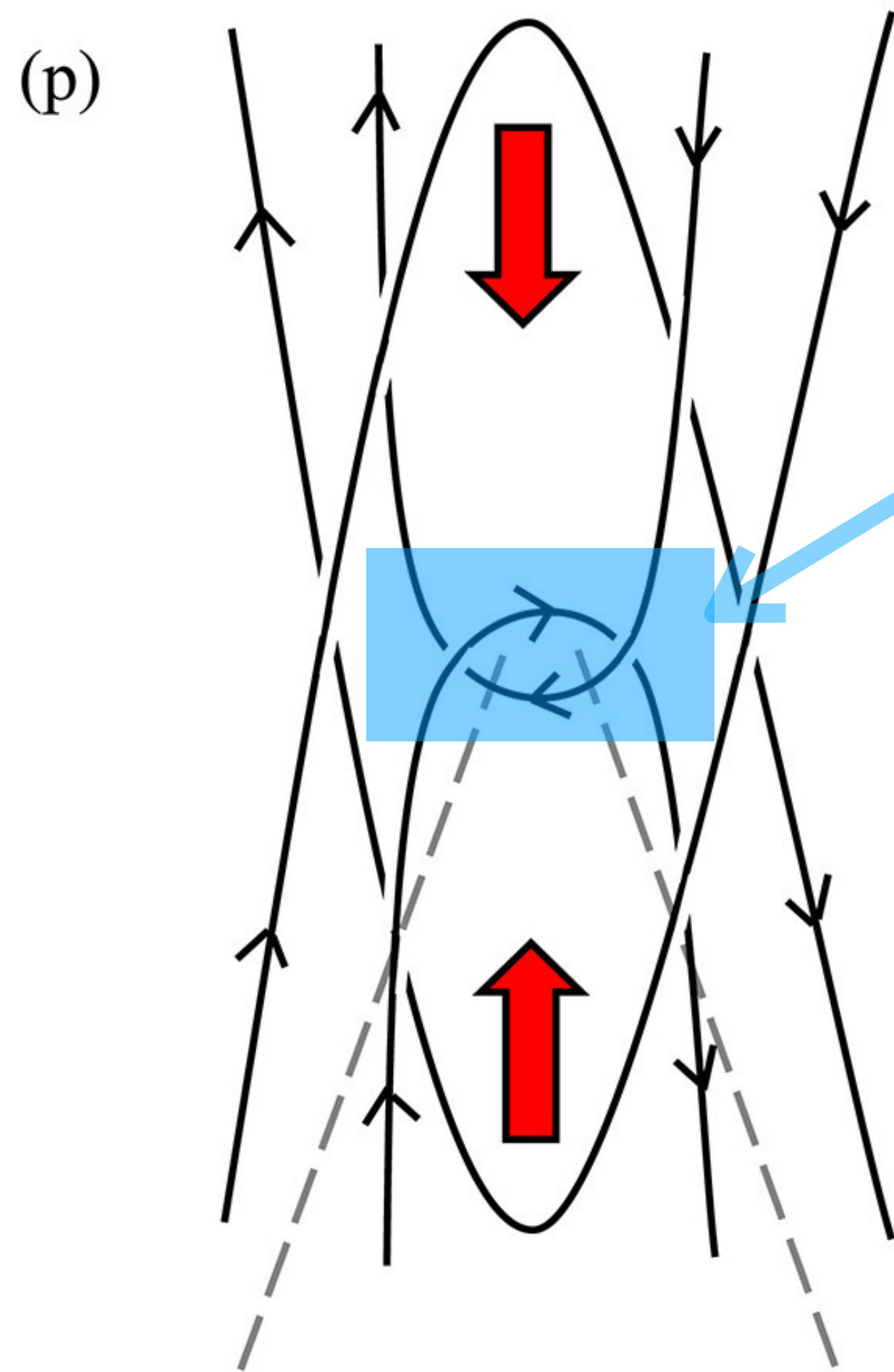
$$R_c \sim R_{i,gyro}$$

- Closer to the x-line, in the electron diffusion region

$$R_c \lesssim R_{e,gyro}$$

Application 2: Curvature features around the current sheet between two interlinked flux tubes

Schematic plot of two interlinked tubes

Figure 2 of [Oieroset et al., 2019]

- When a spacecraft crosses the interface of the interlinked flux tubes, it will see significantly increased curvature.

- The curvature vector switches its direction across the current sheet

- The increased curvature force helps to balance the sum of magnetic and plasma thermal pressure.