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Core field formation and axis orientation of magnetic flux ropes in space plasma

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Magnetic flux ropes are of a helical magnetic field structure, consisting of a circular field and an axial/core field component. Since magnetic reconnection can produce magnetic flux ropes, they are therefore considered as a signature of reconnection in space plasma. The formation of core field and the axis orientation of flux rope are a long-standing issue in the flux rope studies.

Figure 1 illustrates two magnetic flux ropes accompanied with a different core field polarity observed within 15 minutes by Cluster spacecraft in the reconnection ion diffusion region. Their core field polarities were consistent with the surrounding Hall magnetic fields. During the event, the reconnection guide field was directed in the −**M** direction. It is indicated that the core field polarity of flux rope is different from the reconnection guide field, which cannot be happened in the 2-D reconnection simulations. Furthermore, recent MMS observations found that the axis orientation of flux rope was significantly oblique to the **M** direction, in agreement with the results from the 3-D kinetic simulation of reconnection.

In this talk, I will address these questions: How is the core field of a flux rope produced and evolved? How is its core field polarity determined? How is its axis oriented? Simulation and observational results will be demonstrated.

References

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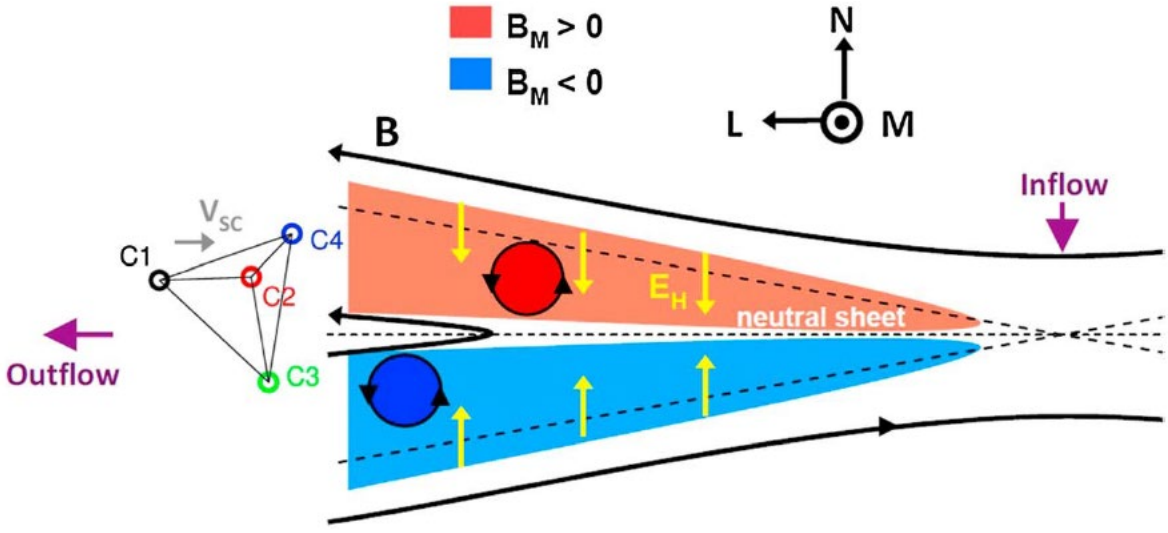

Figure 1. Illustration of two magnetic flux ropes (shown by the circles with arrows) accompanied with a different core field polarity observed by Cluster spacecraft in the reconnection ion diffusion region. The **L** axis is directed along the reconnected magnetic field, the **N** axis is normal to the neutral sheet, and **M** = **N** × **L**. The yellow arrows denote the bipolar Hall electric fields and the shading regions are the ion diffusion region where the Hall magnetic fields are in the **M** direction.