The Internal Structure of a Magnetic Flux Rope

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Abstract

We investigate a magnetic flux rope (MFR) observed by Cluster in the magnetotail during a substorm on 2001 August 22. The MFR was aligned with its principal axis closely along the dawn-dusk direction and had a small size of ~2 Re with a total current of ~0.8 MA. The four spacecraft traversed the MFR at different distances from the center of the MFR based on the magnetic signature. This fortuitous situation reveals the internal structure of the MFR, showing the irregular magnetic field structure close to its center, which is a feature reported here for the first time. At the leading edge, the y-component of the electric field was dawnward against the current density direction (dynamo action) and the x-component of the Lorentz force was Earthward. These parameters reversed in direction at its trailing edge (load).

Introduction

Most previous investigations of magnetic flux ropes are based on observations from a single satellite traversing such a current structure. The general expectation is that MFR consists of layers of helical magnetic field lines. In this paper, we investigate in detail the encounter of a MFR by the four Cluster satellites, revealing the internal structure of the MFR to show significant deviations of the expected helical nature of magnetic field lines within its inner core.