

A unique capability of the Cluster mission is the ability to infer local electric current densities through a direct application of Ampère's law. The technique, known as the curlometer, has been used to infer the structure of the current within the Earth's magnetopause.

Figure 1 shows an example of a Cluster magnetopause crossing when the four spacecraft were only ~ 100 km apart. The top panel shows time series of the dominant magnetic field component, as recorded by the magnetometers on the four spacecraft. It changes from a stable value in the magnetosphere (on the left) to a different stable value in the magnetosheath (on the right). The transitions between the two levels mark the passage of the magnetopause current layer over the four spacecraft. From the differences between the magnetic fields measured at the four spacecraft locations, together with the known spacecraft separation vectors, one can estimate $\Delta \times B$, which according to Ampère's law yields the current densities. The middle panel shows the three components of the electric current vector, calculated with this technique, known as the curlometer.

It is evident from the three traces in the middle panel that the current within the magnetopause is not constant but highly structured. This fact is better illustrated by the two hodograms shown at the bottom. These hodograms are obtained by drawing all currents measured during the magnetopause traversal as vectors from the origin and connecting the arrowheads by line segments. As they occupy three dimensions, the current vectors have been projected into two orthogonal planes, one (left) being the plane of the magnetopause, the other (right) a plane orthogonal to the magnetopause. From inspection of the hodograms it is evident that the current changes not only in magnitude but also in direction, rotating by almost 180° . The determination of spatial structure of the current sheds new light on the different large-scale current systems closing within the magnetopause.

From the hodogram, one can also infer the magnetopause orientation. Then, by integrating Ampère's law across the magnetopause current layer, one also obtains the motion of the magnetopause relative to the spacecraft.

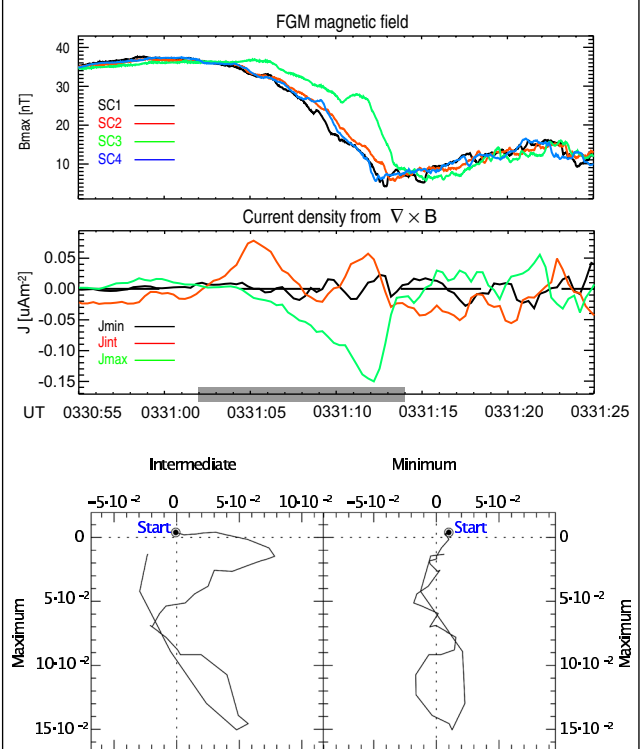


Fig 1. Top panel: Main component of the magnetic field as measured by the four Cluster spacecraft during a magnetopause crossing on 2 March 2002. Bottom panel: the three components, of the current density vector, determined from the differences between the magnetic field vectors at the four spacecraft.

Since the crossing duration is known (indicated by the shaded bar in the middle panel of Figure 1), the magnetopause current sheet thickness can then be calculated. For this case, we found a velocity of ≈ 35 km/s, and a thickness of 160 km, corresponding to 2-3 ion gyro radii.