Geophysical Research Abstracts, Vol. 7, 00691, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00691

Study of time varying tilts of the rapidly oscillating tail current sheet with Cluster

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Applying Minimum Variance Analysis (MVA) with sliding time window and B-gradient estimations gives possibility to control the tail current sheet (CS) orientation. We investigate rapid CS crossings (flapping motions) using Cluster data to compare these methods, to resolve the time variations of the current sheet tilt and to learn about the structure of these oscillations. Two independent methods usually agree in conditions when B-gradient is large and gradient estimations are applicable. Optimal parameters to get reliable MVA estimates of the current sheet tilt (optimal length of the window size and the intermediate to minimal eigenvalue ratio threshold) have been evaluated statistically. Good agreement of two methods confirms a usefulness of four-point linear gradient estimation technique and justifies applying MVA method based on single spacecraft observations. Analysis of varying tilts in individual rapid crossings and in the series of flapping motions confirms generally the kink-like character of these oscillations and large tilts (with normals swinging mostly in the YZ plane) but indicate their variable appearance, ranging from nearly harmonic oscillations to strongly-nonlinear overturned kinks. These results can be useful for explanation of flapping motion nature, its creation and propagation mechanism.