Magnetic field rotation analysis and the applications

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An approach, based on magnetic rotation analysis (MRA), has been developed to investigate the 3-D nature of the magnetic field measured by the multi-spacecraft Cluster mission. The symmetrical magnetic rotation tensor is first constructed, and then the rotation rate of magnetic field along one arbitrary direction is deduced. In particular, the maximum, medium, and minimum magnetic rotation rates along the corresponding characteristic directions can be obtained. The value of the curvature of a magnetic field line is the magnetic rotation rate along the magnetic unit vector and its curvature radius is readily obtained. Here, MRA has been applied to analyze the geometrical structure of two distinct magnetospheric structures, i.e., tail current sheet and tail flux rope. The normal of the current sheet is determined by MRA, which is the direction at which the magnetic field has the largest rotation rate. With MRA, we can easily determine the half thickness of the 1-D neutral sheet, which is the reciprocal of the maximum magnetic rotation rate. With this method, we can explicitly demonstrate that the thickness of the neutral sheet varies with time even during rather quiet time, and providing the detailed picture of the magnetic rotation point by point through the crossing of the current sheet. By using MRA, the detailed features of magnetic field variations inside of a flux rope can also be illustrated. The principal axis of the flux rope is the direction at which the magnetic filed rotates at the least rate. The magnetic scale of the flux rope can also be determined, which is about . It is found that there are both frontside-backside and dawn-dusk asymmetries for the flux rope in study. MRA could have more applications, such as the determination of the magnetic structure of bow shock, magnetic reconnection, flux transfer events, and rotational discontinuities, etc.