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Tail Current Sheet with Strong Guide Field and its Roles in Substorms

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In this research, the properties of a tail current sheet, which has a flattened geometry, and its evolution during substorm activity have been investigated. The geometrical configuration of the magnetic field and the spatial distribution of the current density in a flattened current sheet have been revealed with certainty for the first time. It is found that such a flattened current sheet has sufficiently strong By (GSM) within its neutral sheet that the magnetic field lines (MFLs) in the neutral sheet are lie almost in the GSM equatorial plane and that the normal directions are generally northward. Detailed analyses show that, the magnetic field lines are spiral-like, not plane curves, which are left-handed or right-handed spiral for By$>$0 or By$<$0. This magnetic rotation occurs predominantly in the neutral sheet. The flattened current sheet may be very thin, and the thickness of the neutral sheet is much less than the minimum radius of the curvature of the MFLs in the current sheet. The analysis also suggests that the neutral sheet current is field-aligned and lies mainly duskward. The curvature current makes little contribution to the total current in the flattened current sheet. The main current carriers in the neutral sheet of the flattened current sheet are electrons. A statistical survey shows that, there is one positive correlation between By in the flattened current sheet and IMF By and penetration efficiency is 0.67. Flattened current sheets may occur in both quiet and disturbed periods and may appear at all phases of the substorms. During the growth phase of a substorm event, the neutral sheet of the flattened current sheet is shown to become progressively thinner, while the associated current density is increasing gradually. It is found that the northern turning of the IMF has triggered the explosive growth phase at the end of the growth phase, which lasts several minutes. At the explosive growth phase, the flattened current sheet becomes much thinner and the current density in the neutral sheet then increases considerably and reaches a value larger than $0.017 \mu A m^{-2}$. Just after the onset of the substorm, the current density in the neutral sheet drops abruptly and varies turbulently.