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Evidence for quasi-adiabatic motion of plasma particles in strong current sheets in the solar wind

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We investigate the quasi-adiabatic dynamics of charged particles in strong current sheets (SCSs) in the solar wind, including the heliospheric current sheet (HCS). A self-consistent hybrid model of a SCS is developed in which the dynamics of ions is described using the quasi-adiabatic approach, while the electron motion is assumed to be magnetized and described by the guiding center approximation. The model shows that the SCS profile is determined by the relative contributions of two currents: (i) the current supported by demagnetized protons which follow open quasi-adiabatic orbits, and (ii) the electron drift current. The simplest SCS is found to be a multi-layered structure that consists of a thin current sheet embedded into a much thicker analogue of plasma sheet. This result is in good agreement with observations of SCSs at $\sim$1 AU. The fine structure of different SCSs, including the HCS, is shown, independently of the SCS origin, to consist of a narrow current layer (with thickness of $\sim$10 000 km) embedded within a wider region of about 105 km at 1 AU. Also, multi-scale structure is shown to be an intrinsic feature of SCSs in the solar wind.