Reconstruction of streamlines in Kelvin-Helmholtz vortices at the flank magnetopause

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We present a new data analysis method [Sonnerup et al., 2006] for generating a two-dimensional (2D) map of the flow velocity field, namely, streamlines from single-spacecraft observations of the plasma bulk parameters and magnetic field. For dissipationless flow transverse to a unidirectional magnetic field, the MHD equation of motion can be reduced to a Grad-Shafranov-type (GS-type) equation for the streamline function, provided that the plasma structure is 2D and time-independent in a proper frame. In this situation, three physical parameters, namely entropy, generalized enthalpy, and the frozen-flux function, remain constant along the streamlines. We show how this GS-type equation, along with the streamline invariants, can be used to recover the velocity field in regions surrounding a spacecraft trajectory, as in the GS reconstruction of the magnetic field [Sonnerup and Guo, GRL, 1996; Hau and Sonnerup, JGR, 1999]. The new technique is benchmarked by use of a numerical solution of the GS-type equation and is further applied to an encounter by the Geotail spacecraft of a train of Kelvin-Helmholtz (KH) waves in the boundary layer of the flank magnetosphere. The reconstruction result demonstrates that a chain of vortices was present along the flank magnetopause, which is supported by other signatures showing the overturning of KH waves. We also describe how the proper frame and the orientation of two-dimensionality could be determined.