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Reconstruction of an evolving magnetic flux rope in the solar wind from single-spacecraft data

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In situ measurements, often made by single spacecraft, have a difficulty in revealing spatiotemporal evolution of space plasma structures. We present a single-spacecraft method for decomposing spatial and temporal variations of physical quantities at points along the path of a spacecraft in spacetime, which can be used for reconstruction of slow evolution of two-dimensional (2D) and magneto-hydrostatic structures (namely, Grad-Shafranov equilibria) (Sonnerup and Hasegawa, 2010). The method is applicable to structures that are in Grad-Shafranov equilibrium and in which the flow is incompressible and the frozen-in condition is satisfied. Benchmark tests are conducted by use of synthetic data taken by a virtual spacecraft that traverses, at a constant velocity, a magnetic flux rope growing in a 2D magnetohydrodynamic simulation of magnetic reconnection. It is demonstrated that the new method can better recover the quantities in spacetime than does an earlier version, in which time aliasing effects had not been removed (Hasegawa et al., 2010). The application to a flux rope observed on 25-26 March 1998 by the ACE spacecraft in the solar wind suggests that its core part was evolving in an intriguing way during the ˜17 hour interval of traversal.

Sonnerup, B. U. O., and H. Hasegawa (2010), On slowly evolving Grad-Shafranov equilibria, J. Geophys. Res., 115, A11218, doi:10.1029/2010JA015678.

Hasegawa, H., B. U. O. Sonnerup, and T. Nakamura (2010), Recovery of time evolution of Grad-Shafranov equilibria from single-spacecraft data: Benchmarking and application to a flux transfer event, J. Geophys. Res., 115, A11219, doi:10.1029/2010JA015679.

Keywords: solar wind, magnetic flux rope, Grad-Shafranov equation, magnetohydrostatic equilibrium