Modeling of self-organization of ULF electromagnetic wave structures into nonlinear vortex structures at interaction with shear flows in the geospace environment

Oleg Kharshiladze, Khatuna Chargazia
oleg.kharshiladze@gmail.com
Department of Physics, Faculty of Exact and Natural Sciences, Iv. Javakhishvili Tbilisi State University, 3 Chavchavadze ave., 0179 Tbilisi

The physical and mathematical model of generation and further linear and nonlinear evolution of ultra low frequency (ULF) electromagnetic wave structures is investigated in the geospace (ionosphere, magnetosphere) environment at interaction with inhomogeneous winds (shear flows), which represents itself a new mechanism of energy redistribution in the medium. Self organization of the considered waves into nonlinear strongly localized vortex structures (monopole and dipole vortices, vortex chains) is studied theoretically in the different regions of the ionosphere and magnetosphere. Plasma vortices are often detected by spacecraft in these regions, for instance in the magnetosheath and in the magnetotail. Large scale vortices may correspond to the injection scale of turbulence, so that investigation of their origin is important for understanding the energy transfer processes in the geospace environment. In a work (Keiling et al., J. Geophys. Res., 114, A00C22 (2009), doi:10.1029/2009JA014114) the THEMIS mission has detected vortices in the magnetotail in association with the strong velocity shear of a substorm plasma flow, which have conjugate vortices in the ionosphere. By analyzing the THEMIS data for that event, we find that several vortices in the magnetotail can be detected together with the main one, and that the vortices indeed constitute a vortex chain. For computer modeling of mentioned processes requires solution of the inhomogeneous equations with partial derivatives with strong Jacobian nonlinearity. Inhomogeneity of coefficients is caused by the perpendicular direction of spreading of shear instability. Gauss type inhomogeneous flows are considered, which occurs in the magnetotail equatorial plane due to magnetic reconnection (BBF - Bursty Bulk Flow). The results of modeling in 2D case are obtained. These results are in good agreement with the flow and magnetic fields satellite measurements.