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# Scale hierarchy and self-organization in magnetospheric plasma

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Inhomogeneous magnetic field gives rise to interesting properties of plasmas which are degenerate in homogeneous (or zero) magnetic fields. Magnetospheric plasmas, as observed commonly in the Universe, are the most simple, natural realization of strongly inhomogeneous structures created spontaneously in the vicinity of magnetic dipoles. In this talk, we describe the experimental results form a "laboratory magnetosphere" RT-1, and theoretical modeling of its spontaneous confinement.

The RT-1 device produces a magnetospheric plasma by a levitated superconducting magnet. Stable confinement (particle and energy confinement time = 0.5 s) of high-beta (local electron beta $>$0.7); electron temperature $>$10 keV) plasma has been demonstrated (which are promising characteristics for an innovative concept of advanced fusion; it is also applicable as a particle trap for experimental particle physics or atomic physics). The radial profile of the electron density n(r) is highly peaked. Fitting the data by a function n(r) = $n_0$ $r^{-p}$,we estimate p=2.8$\pm$0.4 for a wide range of operating parameters. Multiplying n(r) by the magnetic flux tube volume, we can estimate the particle number N(r) in a unit magnetic-flux tube. While n(r) is a steep increasing function towards the center of the dipole magnetic field, N(r) is a decreasing function, hence interchange modes are stable. Whereas the simple kinetic model predicts a flat distribution of N(r) [1], the model of grand-canonical equilibrium explains the observed equilibrium state [2].

Theoretically, we can describe the self-organized confinement of the magnetospheric plasma as a grand-canonical equilibrium in a "foliated phase space" of magnetized particles [3]. What makes the distribution function fundamentally different from the conventional Boltzmann distribution is the topological constraints on the phase space which limits the actual domain where the particles can occupy; the adiabatic invariants pose such constraints. Taking into account the constancy of the magnetic moment and the parallel action, we obtain a foliated phase space of coarse-grained variables, on with the invariant measure is distorted by the inhomogeneous magnetic field. The grand-canonical equilibrium has an inhomogeneous density when it is immersed in the laboratory flat space. Hence, the creation of a steep-density clump is a natural consequence of equipartition in the magnetic-coordinate phase space.

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