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Experimental analysis of self-organized structure and transport on magnetospheric plasma device RT-1

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The dipole plasma exhibits strong heterogeneities in field strength, density, temperature, etc., while maintaining the holistic balance. Enquiring into the internal structures, we reveal the fundamental self-organizing mechanisms operating in their simplest realization (as commonly observed in astronomical systems) [1, 2]. Three new findings are reported from the RT-1 experiment: (i) Creation of a high-energy electron core (similar to the radiation belts in planetary magnetospheres) is observed for the first time in a laboratory system. High-energy electrons (3 - 15keV), produced by an electron cyclotron heating (ECH), accumulate in a "belt" located in the low density region (high-beta value ~ 1 is obtained by increasing the high-energy component up to 70% of the total electrons). (ii) The dynamical process of the "inward diffusion"(a spontaneous mechanism of creating density gradient) has been analyzed by perturbing the density by gas injection. (iii) By a system of coherence-imaging spectroscopy, the profiles of the ion temperature and flow velocity have been measured. The effect of the ion cyclotron resonance frequency (ICRF) heating [3] has been visualized. These results advance our understanding of transport and self-organization not only in dipole plasmas, but also in general magnetic confinement systems relevant to fusion plasmas.

[1] A. Hasegawa, Comments Plasma Phys. Contr. Fusion 1 (1987) 147.

[2] Z. Yoshida, Adv. Phys. X 1 (2016) 2.

[3] M. Nishiura et al., Nucl. Fusion 57 (2017) 086038.

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