26aA01

流体的旋回度を伴うドリフト波乱流による平行運動量輸送
Parallel momentum transport by drift wave turbulence with hydrodynamic helicity

小菅佑輔[1,2]、伊藤早苗[2,3]、P.H. Diamond[4]、伊藤公孝[3,5]
Y. Kosuga[1,2], S.-I. Itoh[2,3], P.H. Diamond[4], K. Itoh[3,5]

[1]九州大学高等研究院、[2]九州大学応用力学研究所、[3]九州大学極限プラズマ研究連携センター、[4]UCSD、[5]核融合科学研究所
[1]Institute for Advanced Study, Kyushu Univ., [2]Research Institute for Applied Mechanics, Kyusyu Univ., [3]Research Center for Plasma Turbulence, Kyushu Univ., [4]UCSD, [5]National Institute for Fusion Science

Flows along the magnetic field are ubiquitous in nature and laboratory plasmas. In particular, parallel flows play important role in magnetic fusion, by stabilizing harmful MHD and/or regulating transport. Recent experiments report generation of intrinsic flows, which are likely to be linked to momentum transport by turbulent fluctuation[1]. More recently, the reversal of parallel flows is reported from basic experiments[2]. In these experiments, simultaneous measurements of parallel flow profile and momentum flux clearly indicate the role of turbulent momentum transport to cause the flow reversal.

In order to understand its generation mechanism, several theory has been developed to model parallel momentum transport. One mechanism for generating parallel flows is via a residual stress - a component of the momentum flux that remains finite as parallel flow shear and parallel flow goes to zero[3]. It is formulated that the residual stress arises as a consequence of parallel momentum transport by drift wave turbulence.

In this work, we discuss the relation of parallel momentum of waves and helicity of the underlying fluctuation. Here we define the helicity for drift wave turbulence by

$$h = \langle \tilde{q}\tilde{v}_z \rangle, \qquad (1)$$

with $q = (n_e/n_0) - \rho_s^2 \nabla_\perp^2 (e\varphi/T_e)$. Note that the helicity and the wave momentum is related with one another, since

$$h \sim k_z (1 + \rho_s^2 k_\perp^2) |\varphi_k|^2 / \omega_k \sim k_z N_k, \qquad (2)$$

where N_k is the action density of drift waves. The evolution of the helicity is calculated by using the Hasegawa-Wakatani equation with parallel flow coupling[4] and is given by

$$\partial_t \langle \tilde{q}\tilde{v}_z \rangle + \partial_r \langle \tilde{v}_r \tilde{q} \tilde{v}_z \rangle = -\langle \tilde{v}_r \tilde{q} \rangle \langle v_z \rangle' - \langle \tilde{v}_r \tilde{v}_z \rangle \langle q \rangle' - c_s^2 \left\langle \frac{\tilde{q} \nabla_z \tilde{n}_e}{n_0} \right\rangle - \langle \tilde{q} \nabla_z \tilde{v}_z \rangle. \qquad (3)$$

Here we followed the standard notation. Based on the helicity balance, the role of spreading of fluctuation helicity (the second term in the lefthand side) in driving parallel momentum transport is discussed. The parallel momentum transport via the spreading of fluctuation helicity is complementary to the parallel momentum transport by drift waves. The former corresponds to the parallel momentum transport by the nonlinear radial propagation of turbulence, while the latter corresponds to that by wave propagation. The calculation of the flux of fluctuation helicity is on-going, by using the two-scale direct interaction approximation[5].

We acknowledge Prof. Inagaki, Dr. Kobayashi, Dr. Z. Guo, Dr. L. Wang, and the participants in the Festival de Theorie for stimulating discussion and encouragement. This work was partly supported by the Grants-in-Aid for Scientific Research of JSPS of Japan (23244113, 15K17799, 15H02155), Asada Science Foundation, Kyushu University Interdisciplinary Programs in Education and Projects in Research Development (26705).

[1] K. Ida and J.E. Rice, *Nucl. Fusion* **54** 045001 (2014)
[2] S. Inagaki, et al. submitted to *Sci. Rep.* (2015)
[3] P.H. Diamond, et al. *Phys. Plasmas* **15** 012303 (2008)
[4] Y. Kosuga, S.-I. Itoh, and K. Itoh, submitted to *Contrib. Plasma Phys.* (2015)
[5] Lu Wang, Tiliang Wen, and P.H. Diamond, *Phys. Plasmas* **22** 052303 (2015)