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低アスペクト比RFP装置RELAXにおける揺動起因起電力の定量的評価
Estimate of Turbulence-Induced Electromotive Force in RELAX

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1. Introduction

The RFP is one of the toroidal magnetic confinement systems for high β plasmas. The RFP configuration is characterized by the toroidal field reversal at the edge, which causes strong mageticshear. This toroidal field reversal can be sustained (against resistive diffusion) as long as the toroidal plasma current is sustained. This characteristic is often referred to as the self-organization. The resistive MHD instabilities play important roles in the self-organization process, and therefore, electromotive forces arising from turbulence are important in sustaining the current.

2. Generalized Ohm's law and turbulence induced electromagnetic force terms

In the RFP, the reversed toroidal magnetic field is sustained as long as the toroidal plasma current is sustained. The mechanism for current sustainment may be interpreted as follows. When we decompose the physical quantities (such as electric field, magnetic field, velocity field, current density, etc.) in averaged and fluctuating components, the generalized Ohm's law can be written down as follows,

$$\eta\bar{j} = \bar{E} + \langle \tilde{v} \times \tilde{B} \rangle - \frac{1}{en_e}\langle \tilde{j} \times \tilde{B} \rangle \quad (1)$$

where $\bar{j}$ is the mean (time-averaged) current density, $\bar{E}$ the mean electric field, and η the electric resistivity. The quantities with ~ are the fluctuating components. The bracket < > stands for the averaging over time. The second term in the right hand side is the MHD dynamo term, arising from nonlinear interaction of fluctuating velocity and magnetic fields, and the last term, the Hall dynamo term arising from nonlinear interaction of fluctuating current density and magnetic fields. The diamagnetic dynamo term is neglected for the sake of simplicity. Interaction between the fluctuating quantities generates current in the direction of the average magnetic field.

3. Experimental Apparatus

As a first step, we are preparing a dynamo probe to estimate the MHD dynamo term arising from interaction between velocity and magnetic field fluctuations in RELAX.

RELAX is an RFP machine with major radius of 0.5m and minor radius of 0.25m, the aspect ratio A being 2. The plasma parameters attained to date are as follows: toroidal plasma current I_p~40-120 kA, electron density n_e~10^{18}-2×10^{19} m^{-3}, Thomson electron temperature T_{e0}~100-200 eV. The discharge duration is ~3.5 ms.

The dynamo probe structure is shown in Fig.1. It consists of electrostatic triple probes, three triple probes of Mach probes, and a magnetic probe inside the ceramic shield. The electrostatic triple probes provide electric field, electron temperature, and electron density. Three components of the flow is provided by the three Mach probes [3].

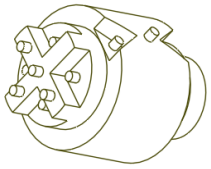

Fig.1. Structure of the complex probe to estimate the dynamo term.

Reference

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