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Poloidal Rotation Driven by Turbulent Residual Stress in the Edge of HL-2A Tokamak Plasmas

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Abstract

The poloidal Reynolds stress can be decomposed into three terms[1, 2], as shown in equation (1).

$$\langle \tilde{v}_r \tilde{v}_\theta \rangle = -\langle \tilde{v}_r^2 \rangle \tau_c \frac{\partial \langle v_\theta \rangle}{\partial r} + v_r^{eff} \langle v_\theta \rangle + S_{r\theta}^{Res} \qquad (1)$$

The first term on the right-hand-side (RHS) of equation (1) represents the diffusive stress due to turbulent momentum diffusion, the second term represents the stress component due to radially directed poloidal momentum pinch, and the third term is the residual stress. As a certain consequence of wave-particle momentum exchange, residual stress is neither diffusive stress nor convective stress, but it defines a significant local momentum source related to the intrinsic rotation[3].

The first measurement of turbulent poloidal residual stress profile in the edge of tokamak plasmas is reported in this article. A reciprocating Langmuir probe array on the out mid-plane of HL-2A tokamak was used to measure turbulent momentum transport. As is shown in figure 1.

Figure 2(a)-(h) show the inferred residual stress and all relevant terms from equation (1). Experimental results show that a finite nondiffusive poloidal residual stress with certain radial distribution was found at the edge of ohmic plasmas. The measured residual stress indicates that poloidal momentum source exists at the boundary of plasma, and its radial gradient can serve as an intrinsic torque to drive poloidal rotation.

Keywords: turbulence, poloidal momentum transport, poloidal rotation, residual stress, tokamak

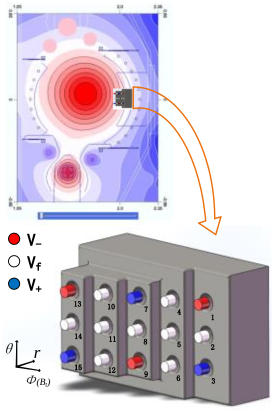

Figure 1 A specially designed Langmuir probe array is able to measure electron density, temperature and plasma potential.

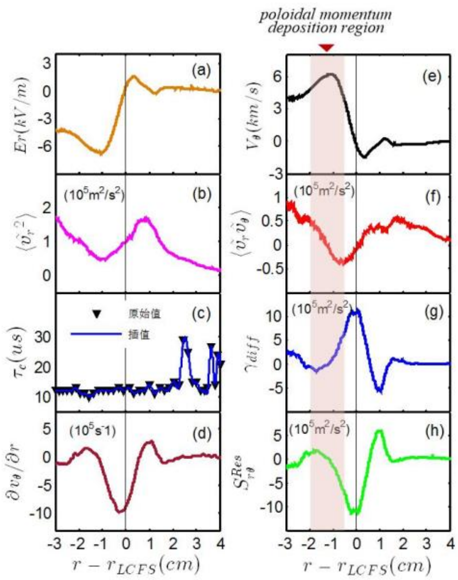

Figure 2 Inferring of poloidal residual stress.

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