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Experimental study of cross phase influence on Reynolds stress in the HL-2A tokamak

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The cross phase between radial velocity perturbation $\tilde{v}_r$ and poloidal velocity perturbation $\tilde{v}_\theta$ has long been suspected to play an important role in the radial distribution of Reynolds stress (*Rs*). In this study *Rs* is divided into three parts for the first time mathematically and we examined this by experiment data. These three components are turbulence fluctuation $\langle\sigma_{\tilde{v}_r}\sigma_{\tilde{v}_\theta}\rangle$, cosine of cross phase average $cos\langle\varphi\rangle$ and coherence $\langle\gamma\rangle$ between $\tilde{v}_r$ and $\tilde{v}_\theta$. The profile of Rs and its three components are measured separately using multi tipped langmuir probe array. Results show that radial distribution of *Rs* is consistent with the production of the three terms. Experimental observation shows that these three terms have different functions to the radial distribution of *Rs*. According the profile of poloidal velocity v_θ computed by Time Delay Estimation (TDE), the whole profile is divided into two regions: the shear layer and viscous layer. We find that cross phase is the dominant reason to determine the variation of *Rs* in the shear layer and turbulence fluctuation and coherence are more important in the viscous layer as shown in Fig.1. In addition, we discussed the **E**×**B** shear influence on cross phase and its scattering. Experimental analysis (Fig.2) show that there is a direct relation between coherence and scattering level of cross phase: the coherence value between $\tilde{v}_r$ and $\tilde{v}_\theta$ works as an index of the scattering level of cross phase. When the value of coherence increases, the scattering level of cross phase decreases which means that the cross phase becomes more concentrated with less perturbation and vice versa. And E×B shear would influence the coherence between $\tilde{v}_r$ and $\tilde{v}_\theta$ and as a result the scattering of cross phase would change. The stronger the shear is, the higher level of phase perturbation would be.

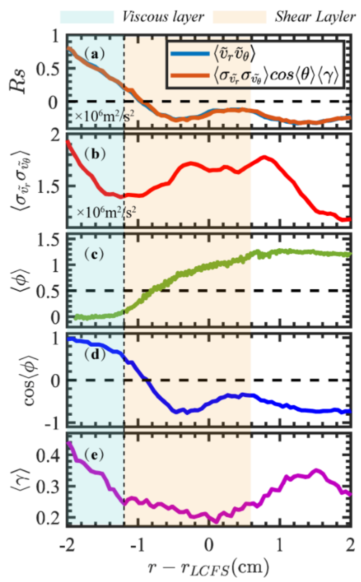

Fig.1. Spatial evolution of. (a) Reynolds stress computed by $<\tilde{v}_r\tilde{v}_\theta>$ and $\langle\sigma_{\tilde{v}_r}\sigma_{\tilde{v}_\theta}\rangle\cdot cos\langle\varphi\rangle\cdot\langle\gamma\rangle$; (b) Turbulence fluctuation $<\sigma_{\tilde{v}_r}\sigma_{\tilde{v}_\theta}>$. Here we use the standard deviation of each window to stand for the turbulent fluctuation amplitude. < > means the window average results over 1024 points. (c) Cross phase average (d) Cosine of average cross phase (e) Average coherence.

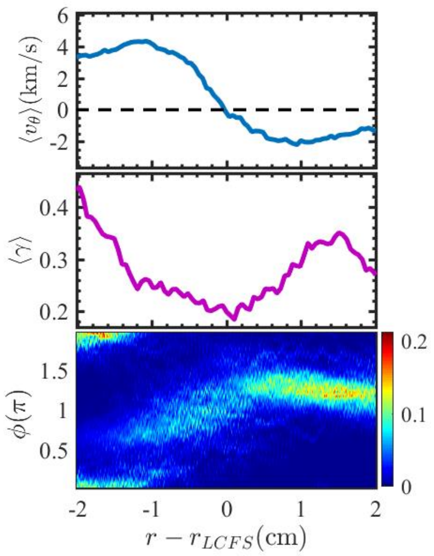

Fig.2. Profile of (a) poloidal velocity v_θ (b) coherence average $\langle\gamma\rangle$ (c) cross phase evolution between $\tilde{v}_r$ and $\tilde{v}_\theta$