§4. Experimental Study on Turbulence Transition with an Axial Vector Field

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Self-organizations in turbulence are often observed in nature with axial vector fields such as rotation, magnetic field. The axial field affects on the turbulence and structure formation, however, the physics mechanism is not well understood. In this study, we will try to investigate the effects of axial vector field on turbulence transition due to experimental study using electrohydrodynamic convection (EHC) turbulence on rotating stage.

The EHC turbulence is a turbulence state excited in liquid crystal fluid between electrodes which is biased with much higher voltage than the minimum voltage to drive convection of liquid crystal (so-called 'critical voltage': $V_{\rm crit}$). The turbulence transport characteristics were investigated and the diffusive process dominated in the highly developed turbulence regime, so far. In this year (2014), the effects of rotation was analyzed using rotary stage shown in Fig. 1 and the turbulent spectra was analyzed.

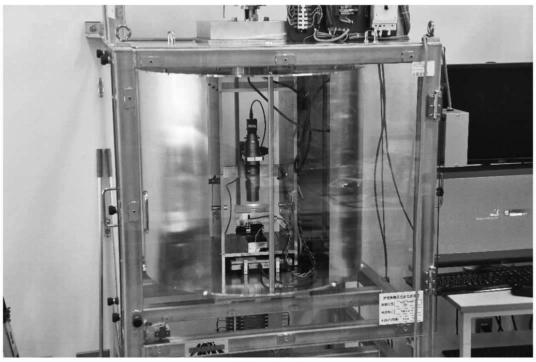

Fig. 1: A picture of rotary stage developed for EHC turbulence experiment.

The two EHC turbulent states were compared, one is weak turbulence with $\epsilon(= (V_{\rm appl}^2 - V_{\rm crit}^2)/V_{\rm crit}^2) = 1.9$ and the other is strong turbulence with $\epsilon = 20.0$, where $V_{\rm appl}$ is the applied voltage to the liquid crystal cell.

Figure 2 shows the comparisons of wave number spectra between $\Omega = 0$ Hz and $\Omega = 2.5$ Hz, where the Ω is a rotation frequency. In order to see the difference clearly, the wave number spectra with rotation were normalized by that without rotation ($\Omega = 0$), which are shown in Fig. 3. The reduction of spectrum with the increase of the rotation frequency are observed in the region of $k = 0.03 - 0.12$, which corresponds the scale of the sickness of the cell. The scale length of this low wave number is considered as a energy input scale in this EHC turbulence. This experimental observation suggests that the rotation affect the energy input to the turbulence, for example, weakening the drive of turbulence. The detailed comparison and the further analyses such as bi-coherence analysis are under way. The extension of the experiment toward lower Rossby number regime and transport studie using tracer particles in the EHC cell are also being prepared.

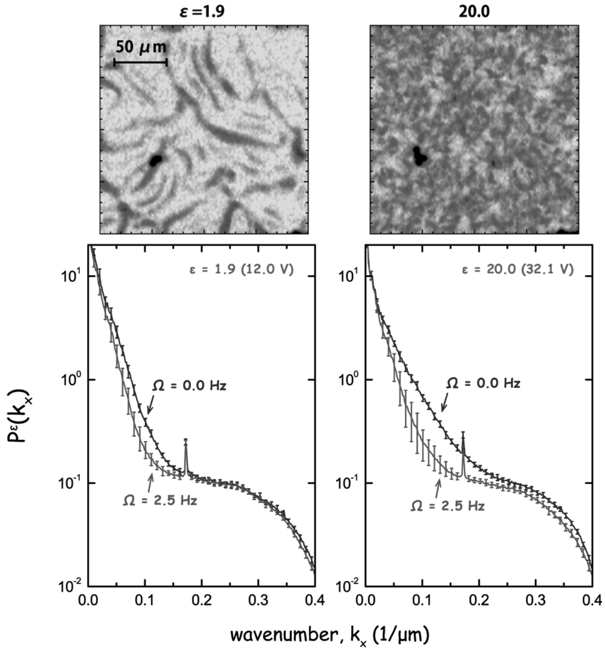

Fig. 2: (upper) Snap shots of EHC turbulence with $\epsilon = 1.9$ and 20.0. (bottom) the wave number spectra with and without rotation for each turbulent states

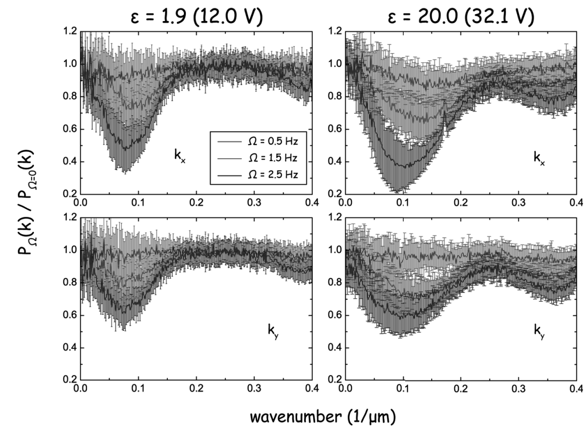

Fig. 3: Comparisons of wave number spectra normalized by that obtained with $\Omega = 0$ for the cases of weak turbulent state ($\epsilon = 1.9$) and strong turbulent state ($\epsilon = 20.0$.)