§4. Experimental Evaluation of Turbulent Diffusion Coefficient in a Rotating Electroconvection Turbulence

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Turbulent transport is a general subject in a wide research field such as normal fluids, astrophysical plasmas, space plasmas as well as magnetically confined fusion plasmas. In an isotropic and homogeneous fluids, Kolmogorov scaling appears. However, in many targets of our interests, the anisotropy and/or inhomogeneity exist in the system. In particular, the existence of axial vector such as rotation / magnetic field changes the basic characteristics of turbulence, because the 2 dimensional properties appears. In this fiscal year of 2015, we had two collaborations in this study. First is a joint experiment at NIFS to investigate the effect of rotation on the turbulent transport characteristics. Second is meeting held at Kyushu University for discussion about the result obtained by the joint experiment and new experimental technique using luminescence particles for particle tracing in the turbulence.

<Joint experiment at NIFS, Oct. 2015> A rotary stage with the maximum rotation of 200 rpm is operational at NIFS. The effective diffusion coefficient was evaluated by the particle tracing technique in the electroconvection (EC) turbulence. The EC turbulence is driven in a planar liquid crystal cell by applying AC electric voltage with the frequency of 500Hz. The turbulence transport is characterized by diffusive process and the effective diffusion coefficient is confirmed to be proportional to the Rayleigh number of EC turbulence, which is the same property with Navier-Stokes systems. Therefore this experiment may have a potential to reveal general properties of rotating fluids. The experiment was performed and the dependence of rotation frequency (f = 0 rpm – 110 rpm) and the intensity of the turbulence (Rayleigh number / Rynolds number scan) were investigated. Figure 1 shows a typical case of particle tracing. The small particles with the radius of 3μm were distributed to the liquid crystal cell and the local flow velocity became visible. The trace of the particle shown in Fig. 1 indicates the random walk (Brownian motion) in the Turbulence.

<Meeting at Kyushu Univ., Feb. 2016> Analyses of the joint experiment were carried out at both Kyushu Univ. and NIFS, and the results were discussed at the meeting held at Kyushu Univ. The diffusive nature was confirmed and the effective diffusion coefficient was observed to be changed between with and without the application of rotation (f = 110 rpm), which is shown in Fig. 2. This is the first observation of the effect of rotation in the turbulent transport property in our experiment. The strategy of further analysis and the experimental plan were also discussed in the meeting. The installation of luminescence tracer particles is a candidate for improvement of the experimental evaluation of the transport coefficient. The preliminary experiment was successfully demonstrated in Kyushu Univ.

In the next fiscal year, we will try to install the luminescence tracer particles and systematic experiment will be carried out in this collaboration program.

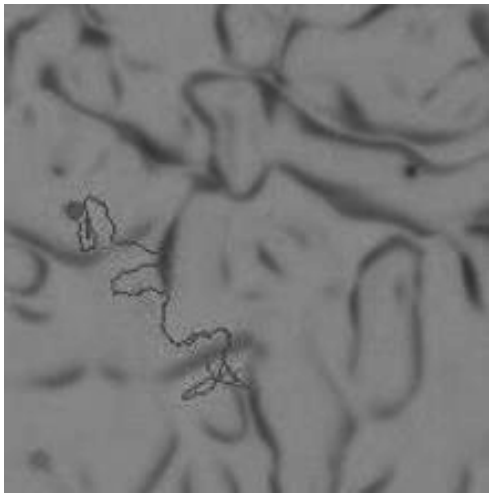

Fig. 1. A snap shot of EC turbulence. The solid line indicates the trace of the particles traveling via Brownian motion.

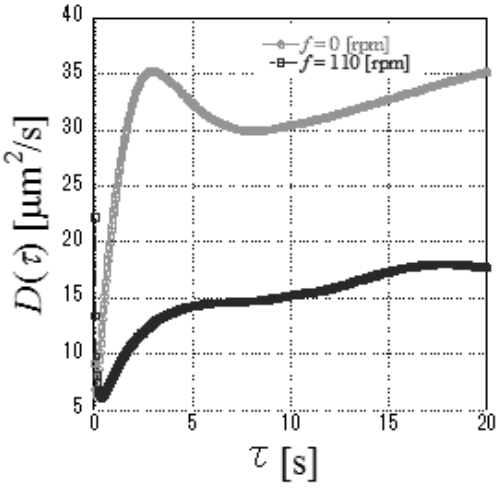

Fig. 2. The effective diffusion coefficient evaluated in the EC turbulence with and without the application of the rotation. The horizontal axis is traveling time.