Current Status and Problem of Numerical Studies for Quantum Turbulence

M. Machida[1,2], N. Sasa[1], and T. Kano[1,2]

[1] *CCSE, Japan Atomic Energy Agency, Tokyo 110-0015, Japan*
[2] *CREST(JST), Kawaguch, Saitama 330-, Japan*

The turbulence is an important issue for not only physicists but also engineers. Especially, its understanding is crucial for various engineering fields, e.g., construction of power plants from nuclear to wind energy. The classical turbulent flow of normal fluids has still remained unsolved, while quantum fluids have offered another challenging target, "Quantum Turbulence", which may be more fundamental and significant in a sense.

In Quantum Turbulence, there are interesting questions. The typical one is how the quantum effects simplify and complicate turbulent flows. In order to solve the problem, Kobayashi and Tsubota performed direct numerical simulations for a modified version of the Gross-Pitavskii equation and found Kolmogorov spectrum as a statistical feature of the turbulent state similar to the classical turbulent flow [1]. Finally, they claimed that quantum turbulence is a quite clear prototype in understanding the inertial range, the Kolmogorov spectrum, and the Richardson cascade process.

One of our project's missions is to examine the picture in a larger scale regime and confirm the scale invariant property of the characteristic spectrum and the related structure as seen in the classical turbulence. We believe that the step is important for further understanding of Quantum Turbulence. In order to carry out the purpose, we independently construct a code simulating the modified Gross-Pitaevskii equation and perform large-scale simulations.

In the previous fiscal year, we have started 3-D numerical simulation for a trapped rotating atomic gas [2]. The employed equation is the same as the one suggested by Kasamatsu et al., and the damping is assumed to be constant [3] to fit the experimental time sequence after the switch of the rotation reported by ENS group. The simulation revealed the existence of the moment, in which the Kolmogorov spectrum appears, and the vortices showing an explosive extension feature at that time. Moreover, we found that the turbulent state shows an anomalous expansion when releasing the gas into the free space by removing the trap.

In addition to further studies for the trapped gas, we have started a decay turbulence simulation under the periodic boundary condition as the last mission of this project according to the plan since the beginning of the present year. We have succeeded in reproducing the results of Kobayashi and Tsubota on 256^3 and 512^3 grids. The remaining is performing the simulation on larger grid. In the meeting, we hope that we can report preliminary results on 1024^3 and more grids.

[1] M. Kobayashi and M. Tsubota, Phys. Rev. Lett. **94**, 065302 (2005).
[2] N. Sasa, M. Machida and H. Matsumoto, J. of Low Temp. Phys. **138**, 617 (2005).
[3] K. Kasamatsu, M. Tsubota and M. Ueda, Phys. Rev. A **67**, 033610 (2003).