Emergent Isotropy in a Matter-Wave Turbulent Cascade

Y Sano[1] and M Tsubota[1,2,3]

[1] *Department of physics, Osaka City University, 558-8585, Osaka, Japan*
[2] *The OCU Advanced Research Institute for Natural Science and Technology (OCARINA), Osaka City University, Osaka, Japan*
[3] *Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP), Osaka City University, Osaka, Japan*
Contact Email: sanoyuto@ab.osaka-cu.ac.jp

Turbulence is one of the most well known nonlinear dynamics around us and is characterized by universal laws describing cascade of conserved quantities from large to small scales or vice versa. Navon *et al.*[1,2] observed a direct cascade by anisotropic oscillating force at the large length scale to a quasi-uniform Bose gas. The turbulent cascade was numerically confirmed by simulations of the Gross-Pitaevkii(GP) model and characterized by a power-law momentum distribution. The purpose of this work is to study the emergence of isotropy in matter-wave turbulence, and we present a detailed numerical investigation of anistropy of the momentum distributions by the GP model. Our simulations uncover the dynamics that the distribution becomes isotropic from low toward high wavenumbers in spite of the anisotropic energy injection. Moreover, our numerical calculations show the isotropy emerges in the turbulent steady-state independently of the amplitude of the oscillating force within the range we explore. This story in the wavenumber space has relevance to the dynamics in the real space, and we observe numerically the generation and reconnection of quantized vortices during the transition to turbulence. We also discuss the influence of the dynamics of vortices on the emergent isotropy.

References

[1] N Navon, A L Gaunt, R P Smith and Z Hadzibabic, Nature **539**, 72 (2016)

[2] N Navon, C Eigen, J Zhang, R Lopes, A L Gaunt, K Fujimoto, M Tsubota, R P Smith and Z Hadzibabic, Science **366**, 382 (2019)