Quantum Turbulence in atomic superfluid: characteristics and presence of universality

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Quantum turbulence, occurs in quantum fluids and has several natures. Its origin can be the formation and tangling of vortices as well as the formation of non-linear waves in the system, or even a combination of them. These excitations can evolve over time, promoting energy migration from the largest to the smallest scales in a process called cascade, which has mechanisms of occurrence. Starting with a Bose-Einstein condensate of Rb-87, trapped in a harmonic potential, we perform temporal excitations that consist of deformation and slight rotation of the potential, causing the system to evolve to a turbulent regime. Using time of flight techniques, we measure the moment distribution, n(k, t) and from it we obtain the energy spectrum E (k, t). This makes it possible to identify the inertial regions, where E (k, t) is clearly dependent on the power law (inertial region) characteristic of turbulent regime, and to measure the energy flow migrating between the scales and their preservation from the absence of dissipation. Finally, the temporal evolution of the moment distribution allows to verify the presence of a space-time scalability, which indicate the presence of a class of universality in the phenomenon. The problem is investigated on the basis of the theory of the existence of non-thermal fixed points in the system and a discussion around these aspects is offered. This work received support from FAPESP, CNPq and CAPES, all Brazilian development agencies. Thanks to students and PD: L. Madeira, A. Cedrin, A. G. Orosco, G. D. Telles.

Recent (2020) works related to the theme:

[1] L. Madeira, A. D. García-Orozco, F. E. A. dos Santos, V. S. Bagnato, *Entropy of a Turbulent Bose-Einstein Condensate*, Entropy **22**(9), 956 (2020).

[2] L. Madeira, A. Cidrim, M. Hemmerling, M. A. Caracanhas, F. E. A. dos Santos, and V. S. Bagnato, *Quantum turbulence in Bose-Einstein condensates: Present status and new challenges ahead*, AVS Quantum Sci. **2**, 035901 (2020).

[3] A. V. M. Marino, L. Madeira, A. Cidrim, F. E. A. dos Santos, V. S. Bagnato, *Momentum distribution of Vinen turbulence in trapped atomic Bose-Einstein condensates*, arXiv: 2005.11286.

[4] A. D. García-Orozco, L. Madeira, L. Galantucci, C. F. Barenghi, V. S. Bagnato, *Intra-scales energy transfer during the evolution of turbulence in a trapped Bose-Einstein condensate*, Europhys. Lett. **130**, 46001 (2020).