Time evolution of a far-from-equilibrium BEC: turbulence, scalability, reversing cascade, and thermalization

Vanderlei S. Bagnato

IFSC-University of São Paulo, Texas A&M University - Biomedical and Physics Department, Caixa Postal 369, São Carlos, Brazil

In this presentation, we combine many of the experiments carried out in Brazil related to the production and characterization of a Bose Condensate of Rb atoms, far- from equilibrium. The trapped BEC after excitation, can evolve, promoting a migration of energy/particles from the largest to the smallest scales in a cascade process. We perform temporal excitations that consist of deformation and potential rotation, causing the system to evolve into a turbulent regime. Simulations demonstrated the generation of solitons, vortices, and waves in the sample. Using time-of-flight techniques, we measure the distribution of moments, n(k,t) and from this, we obtain the energy spectrum E(k,t). This allows identifying the inertial regions, where E(k, t) is dependent on the power law (inertial region) characteristic of the turbulent regime, and measuring the energy flow that migrates between the scales and its preservation from the absence of dissipation. We have developed a new way of analyzing the problem by looking at the distribution of lower-moment modes. Using differential equation analysis based on the spatial-time variation of the moment distribution, many properties are determined and compared to the experiment, including the power law relationship with the presence of scalability. The temporal evolution of the moment distribution for the lower modes allows the determination of different intervals where process specifics in the route to equilibration occur. We observe the establishment of turbulence, and it decays, taking the system back to pre-thermalization followed by final thermalization, recovering the condensate in its final conditions. Interpretations are offered for all stages of the time evolution to offer more interpretation to the challenge problem of the time evolution of a non-equilibrium quantum many-particle system.

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