NEW YORK CITY COLLEGE OF TECHNOLOGY
Physics Department
Seminar in Theoretical Physics

Nonlinear Dynamics and Energy Transport in Quantum Condensed Systems Far from Equilibrium

Presented by:

Dr. German V. Kolmakov
University of Pittsburgh

Friday, February 5, at 11:00 AM
Namm 805 (Conference Room in Dean's Office)

Abstract

We review recent achievements in the understanding of kinetic phenomena in quantum condensed systems, focusing on new theoretical and experimental results on nonlinear energy transfer and relaxation in non-equilibrium systems. Although the behavior of quantum systems far from equilibrium is very complicated, and can be hardly described in a completely general way, we show that a wide range of phenomena may be understood in terms of the "wave turbulence" concept, where energy relaxation and transfer are considered as occurring through a nonlinear evolution in the bath of coupled waves of the condensate density and in-or out-of-phase waves in the quasiparticle density. This approach allows us to describe the energy balance and fluctuations in a nonequilibrium quantum system in terms of fluxes of the integrals of motions of the corresponding dynamical equations. In particular, this concept permits us to explain the formation of the direct and inverse energy cascades recently observed in experiments with superfluid ^{4}He at the University of Lancaster. We also discuss the influence of topological defects (quantized vortices) in the condensate wave function on energy transfer and relaxation. We argue that, because the equilibrium properties of superfluid helium are already well understood, it presents a unique "model medium" suitable for investigations of general nonlinear phenomena in condensed matter in an experimentally convenient range of temperatures, frequencies and perturbation amplitudes. In particular, these investigations have resulted in the first observations of acoustic rogue waves. These take the form of temperature spikes/quasiparticles density waves propagating through the bulk superfluid, in the Lancaster ^{4}He experiments. By using the corresponding formalism, we show that the underlying mechanism responsible for the creation of these waves is similar to that proposed as an explanation of freak waves (or killer waves), huge waves on the ocean surface that endanger ships, and of traveling singularities in optical media. Finally, we discuss open questions and perspectives for future investigations in this area.