DFD08-2008-020002

Abstract for an Invited Paper
for the DFD08 Meeting of
the American Physical Society

Classical Vs. Superfluid Turbulence

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Thanks to a zero-viscosity, superfluids offer a unique testing ground for hydrodynamic models, in particular for turbulence ones. In Kolmogorov's turbulence model, viscosity is well known to damp the kinetic energy of the smallest eddies, and thus to introduce a cut-off at one end of the turbulent cascade. Significant differences between this "classical" turbulence and the turbulence of a superfluid are therefore expected, but –surprisingly- most experiments rather evidenced strong similarities. We will give an overview of a set of experiments designed to compare in details the classical versus superfluid turbulences, up to a record mass flow of superfluid (700g/s of He @ 1.6K). Then, we will focus on some unexpected vorticity measurements, which can be interpreted assuming that the superfluid vortices are passively advected by the largest scales of the flow, in contrast with the "classical" turbulence counterpart. Numerical simulations -based on regular DNS- will be presented to complete this interpretation. In collaboration with C. Barenghi, University of Newcastle; B. Castaing and E. Levèque, ENSL, Lyon; S. David, IEF, CNRS, Orsay; B. Rousset, SBT/CEA, Grenoble; and P. Tabeling, H. Willaime MMN, ESPCI, Paris.