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ANISOTROPY IN TURBULENCE: THEORY, EXPERIMENTS AND SIMULATIONS

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In this lecture I will review the recent progress in understanding the role of anisotropy in the statistical description of turbulence. Until recently most of the analysis of experimental and simulational data was based on assuming that the statistical objects, like correlation functions and structure functions, pertain to homogeneous and isotropic flows. In fact, most of the flows that one encounters in experiments and simulations are anisotropic on the large scales, and these anisotropies decay, if at all, rather slowly with decreasing scales. Disreagarding the effects of anisotropy may lead to serious errors in the interpretation of data.

A useful approach to these issues is based on expressing the statistical objects in terms of the irreducible representations of the SO(3) symmetry group. It has been shown that correlation functions are characterized by universal exponents in each sector of the symmetry group, and in general one has contributions from a number of sectors, with nonuniversal weights depending on the boundary conditions. It is important to learn how to extract information about each sector. Thus for example structure functions which appear not to scale in simple log-log plots exhibit clean scaling once decomposed into their appropriate contributions from different sectors of the symmetry group.

An important theoretical issue is what are the values of the scaling exponents in the various sectors. For simple models like the Kraichnan model of passive scalar and passive vector advection one can compute the scaling exponents explicitly, and demonstrate universality with a discrete, stricIty increasing spectrum as a function of the index of the sector and the order of the correlation function. For Navier-Stokes turbulence scaling exponents were measured in the first sectors of the symmetry group. Results will be reported and discussed.

Finally, the role of this advance in terms of understanding the rate of isotropization with decreasing scales will be explained.