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VI. The turbulence theory group

The projects of the "Theory" group deal with the most fundamental aspects of turbulence dynamics: the source, transfer, and dissipation of turbulent kinetic energy, and their structure in space and scale. These aspects are of intrinsic interest, and an understanding of them is required for the development of accurate and robust subgrid (and supergrid) models for large-eddy simulation.

Chasnov analyzes the short-time evolution from rest of the velocity field produced by the action of gravity on an initially homogeneous isotropic density perturbation. The resulting large-scale energy spectrum is then used as the initial state for a *linear* analysis of the final period of decay. The solution indicates that some of the energy lost to viscous dissipation is replaced by the action of buoyancy forces, and the net energy decay rate is reduced to the point that the growth of the length scale is more rapid than the decay of the velocity scale. The turbulence Reynolds number then increases with time, the assumption of linearity fails, and the final decay is presumed to be nonlinear, and possibly self similar. The rapid growth of length scales presents a challenge to the Fourier spectral numerical methods employed for homogeneous simulations because the spatial period is fixed to adequately resolve the largest scales initially present and the turbulence scales are soon constrained by this fixed length. At present we do not have an acceptable solution to that problem.

Domaradzki, in a continuation of his work at the 1988 summer program, investigated inter-scale interactions and energy transfer in homogeneous turbulence. The processes observed in homogeneous shear flow were the same as those observed previously in the isotropic case. The physical-space distribution of transfer by nonlocal interactions is observed to be intermittent and to coincide more closely with regions of high large-scale energy than with those of high large-scale strain rate. The transfer spectra also collapse better when scaled with large-scale energy rather than with strain rate. This is counter to what one would expect from a disparate-scale analysis in which the large scales are expanded locally in Taylor series. There the lowest term, uniform velocity, would not contribute to transfer and the next term, a uniform velocity gradient, would be the relevant large-scale parameter. The notion that transfer among the small scales is directly influenced, at high Reynolds numbers, by the large scales is counter to the classical hypothesis of Kolmogorov and its acceptance will require a convincing explanation. At present, analyses based on triad interactions (EDQNM and the works of Brasseur & Corrsin (1987, *Advances in Turbulence*, Springer-Verlag) and Yeung & Brasseur (1990, submitted to *Physics of Fluids A*) do predict the observed nonlocal interaction, but the corresponding analyses in physical space have not appeared. In view of the increasing interest in this problem, I expect that it will soon be resolved.

Farge *et al.* use a continuous wavelet analysis to study the space-scale structure of two basic inhomogeneous flows. Wavelet analysis allows one to move between physical space and scale space in a systematic way that provides access to spatial and scale information simultaneously. It is then possible to measure such fundamental quantities as the spatial intermittence of energy transfer and the spatially local flow Reynolds number. The latter is related to the question of whether the spatially local transfer is the result of local instability, or simply the result of straining by larger scales. The computational evidence suggests the latter, but this may be simply because the achievable local Reynolds numbers are too low to allow the former. This question is obviously related to the conflict mentioned above between the local cascade hypothesis of Kolmogorov and the transfer measured in simulations. Wavelets also provide an alternative closure space for large-eddy simulation where today there is some debate about whether one should close (model) in physical or wave space.

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