Boulder Fluid Dynamics Seminar Series

Tuesday, March 31, 2015
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado at Boulder

Wavelet analysis of vortex dynamics in 3D rotating helical turbulence

Aimé Fournier

We introduce four novel methods to analyze joint location-scale energetics (i.e., energy, enstrophy, helicity and Lamb-vector distributions), for turbulent flows with intermediate-scale helical Beltrami forcing. Our data are direct numerical simulations on up to 1536^3 grid points with Reynolds numbers above 5600, with or without imposed rotation down to Rossby number 0.06. Using a classical method, we decompose the flow into orthogonal coherent and incoherent parts: the former always comprises less than 5% of the wavelets, almost all energy, and an enstrophy share depending on the vorticity distribution; the latter is noisy, much less space-filling in the helical rotating case, and very weak near the strong Beltrami coherent-vortices (BCV) formed in rotating helical flows. Two-dimensionalization is indicated by weak incoherent vertical-velocity kurtosis. Coherent parts account for almost all the energy and helicity spectra, while incoherent parts suggest equipartition in a statistical-equilibrium sense (Kraichnan 1973). The threshold defining (in)coherent partition varies strongly between experiments. Our novel methods are: 1, 4D location-scale energetics, showing extrema at all scales, at 3D locations enabling physical interpretation; 2, to identify Lamb-vector spectrum as rotational momentum transfer between phase-space atoms; 3, to sum partially that vector transfer over scale, to get a spatially localized vector flux across scales; and 4, to average azimuthally to get a radially dependent wavelet spectrum. Method 3 reveals the spatial structure of upscale vector-momentum transfers related to structures near the BCV, and method 4 quantifies increasing smoothness of BCV with decreasing distance to its core.

Coupled level set volume of fluid method for incompressible two-phase flow

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Computational modeling of two-phase flow requires, among other things, an efficient means of tracking the interface between the phases. For incompressible two-phase flows, there are several existing methods for tracking the interface, including the level set and volume of fluid methods, but they have significant weaknesses. The level set is a signed distance field (that is 0 at the interface, positive in one phase, and negative in the other) that is advected with the flow; because it directly tracks the interface, it readily provides curvature information and naturally handles merging interfaces, however it is not strictly volume conserving. Conversely, the volume of fluid method is strictly volume conserving, but since it tracks the interface only indirectly, it does not readily provide curvature information or handle merging interfaces. Coupled level set volume of fluid (CLSVOF) methods combine the level set and volume of fluid methods in such a way as to keep the advantages of each method while eliminating their weaknesses. We are developing a CLSVOF method for parallel computing on unstructured meshes. This talk will cover the mechanics of level set, volume of fluid, and CLSVOF methods, our early development progress for CLSVOF, and our plan for completing the development and testing the performance of our CLSVOF method.