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Session Ab - Turbulence Theory.
ORAL session, Sunday, November 23
302, Moscone Center

[Ab.08] Local Self-Similarity and Finite-Time Singularity in a High-Symmetry Euler Flow

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The dynamical consequence of a positive fourth-order pressure derivative (p_xxxx) at the origin [C. S. Ng and A. Bhattacharjee, Phys. Rev. E 54 1530, 1996] in a high-symmetry Euler flow (the Kida flow) is considered. It is shown that the third order spatial derivative u_xxx of the x component of the velocity u at the origin is always decreasing in this situation. By assuming that u_xxx always attains a minimum possible value consistent with a given spectral profile, it is found that the flow is locally self-similar near the origin and collapses as energy cascades to Fourier modes with higher wavenumbers k. Moreover, it is found that the self-similar p(x) and u(x) profiles (as well as their derivatives) near the origin are very similar in shape to what were found in numerical simulations [O. N. Boratav and R. B. Pelz, Phys. Fluids 6 2757, 1994]. It is shown that a finite-time singularity (FTS) must appear in this case if the spectral index \nu of the energy spectrum E(k) \propto k^-\nu of the locally self-similar flow is less than 6. A self-similar solution satisfying the Kelvin's theorem of circulation trivially has \nu = 2 with vortex filaments and a FTS.

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