Interscale energy transfer in turbulent axisymmetric wakes

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Turbulent wakes behind bodies are ubiquitous - from engineering applications to geophysical flows. Classical theory predicts a self-similar solution of the axisymmetric wake with a single power-law scaling for the defect velocity U_d and half-width L. However, experimental and, more recently, numerical evidence has accumulated for self-similar evolution with non-classical power laws for defect velocity and wake width as well as non-equilibrium scaling of dissipation. This self-similar state is established much earlier than the loss of memory of the wake generator, a requirement for the classical 'sufficiently far' wake.

Large-scale coherent structures (CS) are found to persist from the near to the far wake ($x/D = O(100)$), coinciding with the range that non-classical scalings are observed. An example is the vortex-shedding mode at $St = fD/U = 0.135$ in the present disk wake at $Re = UD/\nu = 50\,000$. Here U is the free-stream velocity, D is the disk diameter, ν is the kinematic viscosity, and f is the temporal frequency. The imprint of the CS on the interscale energy transfer is assessed as follows. A triple decomposition divides the velocity into the mean, large-scale, and small-scale components through spectral filtering, and the interscale energy transfer rate between these two components is evaluated and compared to other terms in the energy balance of each component. Implications are drawn for the energy-cascade picture that interscale energy transfer rate is balanced by molecular dissipation at the small scales.

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