Multi-scale analysis of shock-driven turbulence

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Under the Navier-Stokes equations, turbulent energy cascades from large to small scales by scale local means. Despite this, numerical simulations of shock-driven turbulence show an immediate increase in turbulent energy at all scales. We resolve the apparent contradiction by noting that a shock front is a small real-space structure is broad in Fourier space, and already contains kinetic energy at all scales. The shock front is not a special case: a straightforward consequence of the uncertainty principle is that a function with finite real-space support cannot have finite Fourier-space support. In addition, we show that other schemes of multi-scale analysis have analogous uncertainty relations: We present these for the discrete and continuous wavelet transforms.

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