Spiral small-scale structures in compressible turbulent flows

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Abstract We extend the spiral vortex solution of Lundgren 1982 to compressible turbulent flows following a perfect gas law. Lundgren's model links the dynamical and spectral properties of incompressible flows, providing a $k^{-5/3}$ Kolmogorov spectrum. A similar compressible spatio-temporal transformation is now derived, reducing the dynamics of three-dimensional (3D) vortices stretched by an axisymmetric incompressible strain into a 2D compressible vortex dynamics. It enables to write the 3D spectra of the incompressible and compressible square velocities u_s^2 and u_d^2 in terms of, respectively, the 2D spectra of the enstrophy and of the square velocity divergence, by use of a temporal integration (Gomez & *al.* 2001). New numerical results are presented now using 1024^2 gridpoints; initially, the *r.m.s.* Mach number is 0.32, with local values up to 0.9, the Reynolds number is $1,400$, and $\chi = u_s^2/u_d^2 = 0.1$. A $k^{-5/3}$ inertial behaviour is seen to result from the dynamical evolution for both the compressible and incompressible three-dimensional kinetic energy spectra.

I'll try to put it in words:
You may think I'm away with the birds!
Turb'lence compressible
Gives spectrum of decibel
K to the minus five-thirds.

1. Introduction

To study turbulence through the dynamics of the small scale structures which develop and of their spectral counterpart, Lundgren (*op. cit.*) introduced a model based on the intermittent fine scales of incompressible turbulent flows thought as consisting in a collection of uncorrelated stretched spiral vortices, randomly oriented in space and individu-