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Turbulence on locally-concave isentropes

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A key property of turbulence is to redistribute a supplied amount of kinetic energy over a broad range of length and time scales (the celebrated energy cascade). It occurs in virtually any deformable substance whose dynamics obey the fundamental conservation laws (i.e. mass, momentum and energy) provided that the energy is supplied on scales where dissipative processes are relatively negligible. Yet, the seemingly general picture of the energy cascade is restrictive: it rests on the assumptions that (a) fluid elements cannot change volume and (b) are made of spherical molecules undergoing elastic collisions. However, many engineering, geophysical and astrophysical flows involve substances which violate these assumptions. The ability of thermodynamics to interfere with the energy cascade is rooted in the actual shape of the isentropes, i.e. the speed of sound. Substances in which the speed of sound undergoes large variations (e.g. multiphase, near critical-point or phase-transition phenomena) not only offer richer dynamical properties (e.g. expansion shocks) but also avenues by which turbulence may be controlled other than through boundary conditions or body forces. In this talk, we will introduce a flow structure that owes its existence to the local concavity of the isentropes (in p-v space) and is capable of transferring a significant amount of kinetic energy to a new (inviscid!) length scale. Some examples of complex systems (e.g. biology, astrophysics) potentially benefiting from such a bypass of the energy cascade will be discussed.

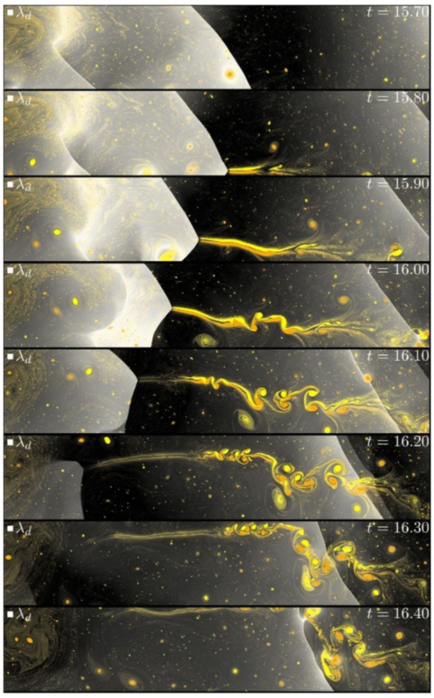

Illustration of an intense vorticity (in colours) deposit at a specific scale within the inertial range produced by the interaction of expansion shocks. The black and white field represents the sound speed (with white regions highlighting local dips in the sound speed).

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