Abstract Submitted
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Exact Theory of Compressible Fluid Turbulence THEODORE DRIVAS, Princeton, GREGORY EYINK, Johns Hopkins — We obtain exact results for compressible turbulence with any equation of state, using coarse-graining/filtering. We find two mechanisms of turbulent kinetic energy dissipation: scale-local energy cascade and "pressure-work defect", or pressure-work at viscous scales exceeding that in the inertial-range. Planar shocks in an ideal gas dissipate all kinetic energy by pressure-work defect, but the effect is omitted by standard LES modeling of pressure-dilatation. We also obtain a novel inverse cascade of thermodynamic entropy, injected by microscopic entropy production, cascaded up-scale, and removed by large-scale cooling. This nonlinear process is missed by the Kovasznay linear mode decomposition, treating entropy as a passive scalar. For small Mach number we recover the incompressible "negentropy cascade" predicted by Obukhov. We derive exact Kolmogorov 4/5th-type laws for energy and entropy cascades, constraining scaling exponents of velocity, density, and internal energy to sub-Kolmogorov values. Although precise exponents and detailed physics are Mach-dependent, our exact results hold at all Mach numbers. Flow realizations at infinite Reynolds are "dissipative weak solutions" of compressible Euler equations, similarly as Onsager proposed for incompressible turbulence.

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