Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Compressible Turbulence: Cascade, Locality, and Scaling HUSSEIN ALUIE, Los Alamos National Laboratory — While Kolmogorov's 1941 phenomenology forms the cornerstone for our understanding of incompressible turbulence, no analogous results exist for compressible flows. We present a rigorous framework to analyzing highly compressible turbulence. We show how the sole requirement that viscous effects on the dynamics of large-scale flow be negligible naturally leads to a density weighted coarse-graining of the velocity field, also known as Favre averaging. We prove that there exists a range of scales over which viscous and large-scale forcing contributions are negligible in the kinetic energy budget. An important part of our work proves that the non-linear transfer of kinetic energy to small scales is in the form of a local cascade process. Using scale-locality, we show that the *average* pressure-dilatation only acts at large-scales and that the mean kinetic and internal energy budgets statistically decouple beyond a "conversion" scale-range. We rigorously prove that over the ensuing inertial range, scaling exponents of velocity structure functions $\langle|\delta\mathbf{u}|^p\rangle^{1/p} \sim \ell^{\sigma_p}$ are constrained by $1/3 \geq \sigma_p$ for all $p \geq 3$. By assuming self-similarity, we show semi-rigorously that $\sigma_p = 1/3$ for $p > 0$ which implies a Kolmogorov spectrum $E^u(k) \sim k^{-5/3}$ for the velocity field.

Hussein Aluie
Los Alamos National Laboratory

Date submitted: 06 Aug 2010 Electronic form version 1.4