From a mass invariant in the compressible gravoturbulent ISM to the characteristic mass of the prestellar cores

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Abstract

Supersonic compressible turbulence is ubiquitous in star-forming regions. However, predicting measurable statistical properties of density fluctuations in such flows, and understanding their connection to the formation of dense structures, remains a major challenge due to the strong nonlinearities and the large range of spatial scales involved. In 1951, Chandrasekhar derived a mass time-invariant under the assumption of statistical homogeneity of the turbulent field. This invariant depends on the variance and the correlation length of the density field. Using high-resolution numerical simulations of compressible turbulence, we demonstrate that this invariant is preserved in media subject to decaying turbulence or self-gravity.

We then present several applications of this invariant that provide new insights into the statistical properties of compressible turbulent flows and the formation of structures in the interstellar medium. We show that the invariant makes it possible to relate the evolution of the slope of the density power spectrum directly to the Mach number, without introducing any free parameters. This statistical quantity is essential for characterizing the initial conditions in turbulent star-forming regions.

From a star formation perspective, we further show that the invariant can be used to predict the characteristic mass of prestellar cores and to explain its apparent universality across Milky Way-like star-forming environments. We also discuss how variations in this characteristic mass naturally arise in more extreme star-forming conditions, such as high-mass star-forming regions and high-redshift galaxies.