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Supersonic Turbulence and Star Formation[1]

PAOLO PADOAN[2], UC San Diego

Ever since Jeans (1902) astronomers have built their theories of star formation around gravitational instability. For the typical conditions in star forming clouds, the Jeans mass is about 0.3 times the mass of the Sun. While the most numerous stars are indeed of this mass, their mass distribution spans a large range from 0.08 to 100 solar masses. The precise distribution, called the initial mass function (IMF), is found to be universal. The origin of the IMF is a fundamental problem in astronomy and not one that gravitational instability theory can readily explain. Within the past decade, a new theory of star formation has been developed which posits a direct connection between the turbulence statistical properties of the star-forming clouds and the stellar IMF. It is postulated that supersonic MHD turbulence provides an appropriate framework for analytic and numerical modeling these clouds. I present results of large-scale 3D numerical simulations that investigate the properties of supersonic hydrodynamic (HD) and MHD turbulence. Our HD simulations are large enough to isolate the inertial range in density and velocity statistics. We find strong departure from incompressible Kolmogorov velocity scaling. We propose a natural extension of Kolmogorov's phenomenology that takes into account compressibility by mixing density and velocity statistics. We show that the density-weighted velocity statistic v=d**(1/3)u obeys Kolmogorov scaling and is Mach number independent. We discuss how magnetic fields modify these results. Finally, we discuss the origin of the stellar IMF in light of our new results.

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[2]In collaboration with Michael Norman, UC San Diego.