Magnetohydrodynamic Marginally-Supersonic Turbulence

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Magnetohydrodynamic turbulence plays an important role in many astrophysical environments including magnetosphere, interstellar medium, and intergalactic medium. It involves non-linear dynamics in wide range of scales, and hence numerical studies require high spatial resolution to get quantitatively correct results. Here, we describe high- resolution, two-dimensional numerical simulations using up to 1024^2 grids. In a medium with a weak, large scale magnetic field (plasma $\beta > 1$), marginally-supersonic turbulence (average Mach number $\langle M \rangle \sim 1$) is generated. After saturation, different behaviors have been observed depending on local average magnetic field strength described with Alfv\'enic Mach number as $\langle M_a \rangle \sim 1$, $\langle M_a \rangle \gtrsim 1$ and $\langle M_a \rangle >> 1$. In the first case, the magnetic field plays an dominant role restraining full development of turbulence. In the third case, the effect of the magnetic field is negligible. The second case is most interesting. It is naively expected that the magnetic field can play only a minor role since the magnetic energy is small compared with the kinetic energy. However, the magnetic field which is amplified on small scales suppresses turbulent motion on larger scales in this case. It is well known that two-dimensional hydrodynamic turbulence exhibits the inverse cascade with the energy power spectrum proportional to k^{-3}. However, the above procedure modifies the power spectrum, so the total energy power spectrum becomes close to $k^{-5/3}$. Difference and similarity between incompressible turbulence and compressible turbulence with $\langle \delta \rho / \rho \rangle \sim 1$ (marginally supersonic) are also described. The current work will serve as preparation for three-dimensional study which has initiate.