Turbulent Dynamo Amplification of Magnetic Fields in Molecular Clouds

Terrence Tricco[1], Daniel Price[1], and Christoph Federrath[1]

[1]Monash Centre for Astrophysics, Monash University, Melbourne, Australia;
email: terrence.tricco@monash.edu

May 2, 2014

We present results from simulations of driven supersonic turbulence ($\mathcal{M} = 10$) to study the small-scale dynamo amplification of magnetic fields in molecular clouds, comparing results between grid-based methods and smoothed particle magnetohydrodynamics (SPMHD). The initial magnetic field strength is set to be very weak, and we study the properties of the magnetic field during its growth and after it has reached saturation. This comparison has only recently been made possible through developments made to the SPMHD method, in particular, in enforcing the divergence-free constraint of the magnetic field and in capturing strong magnetic shocks in super-Alfvénic turbulence.

In our simulations, the strongest magnetic fields occur in the densest regions of the gas. The small-scale dynamo grows the whole magnetic field equally, though the smallest scales saturate first. The turbulence remains super-Alfvénic once the magnetic field is saturated ($\mathcal{M}_{\rm A}{\sim}20$). While the magnetic field is dynamically weak, the probability distribution function (PDF) of the density contrast has an extended low-end tail that deviates from log-normal. However, strong magnetic fields (once the dynamo has reached saturation) tend to shape the distribution more towards log-normality.

The PDF of magnetic field strengths is log-normal during the amplification phase. It's width remains constant, with the mean smoothly translating to higher field strengths. As the magnetic field approaches saturation, the dynamo is unable to continue amplifying the strongest regions of the fields and the high-end tail of the distribution anchors in place. However, the low-end tail continues to increase, leading to a lop-sided distribution as the high-end tail becomes 'squeezed'.