Supplement for Three Projects in Astrophysical Magnetohydrodynamics

PI: David C. Collins (Florida State University)

We are requesting 4352 SU to supplement our grant. This supplement will allow us to continue progressing while we await the next proposal review.

During the work on the *turbulence* project, it was discovered that these results extend nicely to magnetized studies. We have begun four MHD simulations, and will continue these during the period between August and October.

The four simulations are driven turbulence with uniform mean magnetic fields. In these simulations, kinetic energy is added to the simulation at a controlled rate. This energy is added to the large scale of the simulation, and the nonlinear dynamics of the system cause the energy to cascade to smaller scales. Energy is then dissipated by the numerics at the smallest scale. The important information carrying regime is the *inertial range*, between the driving and dissipation scales. The simulations all have an r.m.s. velocity of 5 c_s, where c_s is the speed of sound in the cloud, magnetic fields such that the ratio of the r.m.s. velocity to magnetic velocity is 1/2, 1, 2, and 3. Thus the simulations range from strongly magnetized to weakly.

The resolution of these simulations is 512^3. This resolution represents a balance between cost and benefit; large enough to resolve a inertial range, but small enough to be run relatively quickly.

The simulation time for the simulations is based on the pattern turn-over time, the time for the large-scale velocity pattern to replace itself. We define the dynamical time as $t_{dyn} = L/V$, where L is the pattern size and V is the r.m.s velocity in the box. During a simulation, it takes roughly two t_{dyn} for the energy to fully cascade to small scales. We then run for another three t_{dyn} to establish statistics. Turbulence is a chaotic process, and any given snapshot is not necessarily representative of the trends. Averaging over three dynamical times allows us to have converged statistics.

The four simulations are being run on *Stampede 2*. They are each using 8 nodes, with 64 cores per node. They have each had one day of simulations and are at $t = 1t_{dyn}$, so will need four more restarts each. A more elaborate estimate of the timing can be found in the original proposal. Thus the total supplement request is

$$8\text{nodes} \times 4\text{sims} \times 4\text{restarts} \times 24\text{hrs} = 3072\text{SUs}. \tag{1}$$

In addition to simulation time, we are requesting an additional 1440 SU for analysis. Analysis is done both with interactive and batch sessions, and is done one node at a time. There are roughly 40 business days in August and September, the period the supplement will cover, and if the three grad students and one PI are working for 8 hours per day, that yields

$$40\text{days } \times 4\text{people} \times 8\text{hours} = 1280\text{SUs} \tag{2}$$

hours for analysis time.