Abstract

It is generally accepted that all planets form in so-called “proto-planetary disks” which orbit forming stars. It also is through these disks of material that almost all material which forms the star passes. Understanding the dynamics of these disks is therefore critical to understanding both planet formation and star formation.

Proto-planetary disks are very weakly ionised disks of gas and dust. They are intrinsically “multi-fluid” systems, comprising fluids which are neutral, electrically charged and also a population of dust grains. While it is believed that magnetic fields play a dynamically important role throughout large parts of the disk, the extent of this role depends critically on the precise level of ionisation or, equivalently, the relative density of the electrically charged fluids. This ionisation level is determined by complex processes within the disk, one of which may be the dissipation of magnetic energy: such energy can heat the disk locally and lead to a higher degree of ionisation, and thus a greater role for magnetic fields.

The only way to study these disks is through numerical simulations. Simulations of multi-fluid disks, though, are extremely computationally demanding requiring the calculation of the properties of multiple fluids at millions of points in the disk, for tens of thousands of time-steps. Thus, high performance computing is a pre-requisite for these kinds of studies.

We present the results of fully multi-fluid simulations of turbulence in weakly ionised plasmas, with a particular focus on the nature of the magnetic energy dissipation structures. Parameters for the simulations are chosen so that Hall dominated turbulence can be compared with both ambipolar dominated and ideal MHD turbulence. Our results are applicable in a variety of different contexts in proto-planetary disks. We link our results with similar previous studies of dissipation in ambipolar dominated turbulence.

We anticipate coupling these simulations with more realistic chemical and radiative transfer physics in order to gain more precise insight into the possible effects of ionisation through local heating by magnetic energy dissipation.