COMPUTATIONAL MODELS OF MOLECULAR CLOUDS : CONNECTION WITH OBSERVATION AND THEORY

ABSTRACT

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The physical processes involved in star formation are not completely understood and are hotly debated in the literature. Star formation occurs in molecular clouds, which are turbulent, dense environments with strong magnetic fields and very low ionization fractions. Early models of star formation relied on strong magnetic fields and ambipolar diffusion to regulate star formation. Later models suggested that turbulence was the primary driver of star formation. Recent models suggest that both play an important role.

Recent observations have shown a difference between ion and neutral line widths in some molecular clouds; specifically the ion line-widths were narrower than the neutrals. This was attributed to the effect of ambipolar diffusion on the turbulence in the ions. We present high resolution simulations which include the full dynamics of both ions and neutrals. This has only previously been done at relatively low numerical resolutions. This sort of simulation, which tracks the full dynamics of both ions and neutrals, is necessary to reproduce observations that show any difference between ions and neutrals.

The results show that the magnetic fields present in molecular clouds influence the velocity and density distributions of the ions and neutrals in a way which would be observable. When viewed with the mean magnetic field in the plane of the sky, the line widths of the ions are preferentially narrower than those of the neutrals. The line widths are nearly the same when viewed along the direction of the magnetic field. The probability distribution functions of the column densities of ions and neutrals are different when observed along the direction of the magnetic field, and they are the same when observed perpendicular to the mean field. Thus, the simulations predict complementary observables each sensitive to different components of the magnetic field.

These effects have implications in the observation of magnetic field strengths and could be used to deepen our understanding of the magnetic fields in molecular clouds. The simulations also show that the turbulent cascade in the ions is not damped at the ambipolar diffusion length scale, but continues to smaller length scales depending on the magnetic field strength.