Discussion: Magnetic fields and Polarimetry

Magnetic fields are important for different stages of star formation and polarimetry has been used to study them.
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Point 1. Weak versus Strong Magnetic Field
Point 2. Problem of Flux Freezing

Idea of magnetic flux being frozen in a highly conducted fluid was at the heart of star formation paradigm.

Alfven theorem 1942:

Paradigm: to change magnetic field to flux ratio one must have ambipolar diffusion
Flux Freezing is not applicable in the presence of fast reconnection!

Lazarian & Vishniac 1999

Eyink, Lazarian & Vishniac 2011 demonstrated that LV99 means violation of flux freezing
Questions for first 2 points

1. Can one ignore magnetic fields if they are weak and they are diffusive in turbulent medium?

2. What do we need to settle the issue of weak versus strong magnetic fields?
   a. in terms of predictions; b. in terms of observations

3. What is the role of ambipolar diffusion process in the ISM?
   a. for diffuse ISM; b. molecular clouds; c. accretion disks

4. What is better: use codes with ambipolar diffusion and lose turbulence or not use it?
Point 3. Magnetic Turbulence in ISM

Density fluctuations

Slope $\sim -5/3$

Scintillations and scattering

Armstrong et al. 1994

Evidence:

1. High Re numbers -- turbulence
2. Linewidths
3. Spectral slopes

Guido Munch
Questions for point 3

1. Do we have interstellar turbulence?
2. Is it superAlfvenic or subAlfvenic?
3. Is the GS95 theory applicable? Is theory of compressible MHD turbulence applicable?
4. What does cause fast dissipation? Is coupling of compressible and incompressible motions important?
5. What is the purpose of studying ISM turbulence?
6. What is the inertial range and how to define it?
Transfer of energy from Alfven modes to slow and fast modes is rather marginal for many total, i.e. $M_{\text{total}} = \frac{v}{(v_A^2 + v_s^2)^{1/2}}$, Mach number.

FIG. 1. (a) Decay of Alfvenic turbulence. The generation of fast and slow waves is not efficient. Initially, $\beta \sim 0.2$ and $B_0/\sqrt{4\pi \rho_0} = 1$. (b) The ratio of $(\delta V)_f^2$ to $(\delta V)_A^2$. The ratio is measured at $t \sim 3$ for all simulations. The ratio strongly depends on $B_0$, but only weakly on (initial) $\beta$. The initial Mach numbers span 1–4.5.

Cho & Lazarian 02
Point 4. New telescopes are available and we at last have testable grain alignment theory.
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Modified from A. Goodman
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Theory: Radiative torques (RATs) replaced the Davis-Greenstein process (orig. proposed by Dolginov & Mytrophanov 78, studied numerically Draine & Weingartner 96)

Analytical model in Lazarian & Hoang 2007 explains main properties of RATs:
Tracing of magnetic fields and measuring magnetic fields with CF technique

Basic idea

\[ \delta \phi = \frac{\delta V}{V_A} \]

Numerical studies:
Ostriker et al. 2001
Padoan et al. 2001
Heisch et al. 2001
Falceta-Goncalves et al. 2008
Questions for point 4

1. RATs align all grains > $10^{-5}$ cm in diffuse media, in molecular clouds, the efficiency decreases. Near stars we can align, but not further. Patchy alignment. What do we trace with aligned grains in molecular clouds (MC)? Is it useful?

2. Chandrasekhar-Fermi technique to get magnetic field intensity assumes homogeneous alignment. In MC this is not the case. What is the value of C-F for MC? How to improve?

3. What is the synergy between absorption and emission polarimetry?

4. What is the domain where grain alignment polarimetry is most useful and unique