Center for Astrochemical Studies

A Magnetized Prestellar Core

Polarization and Kinematics

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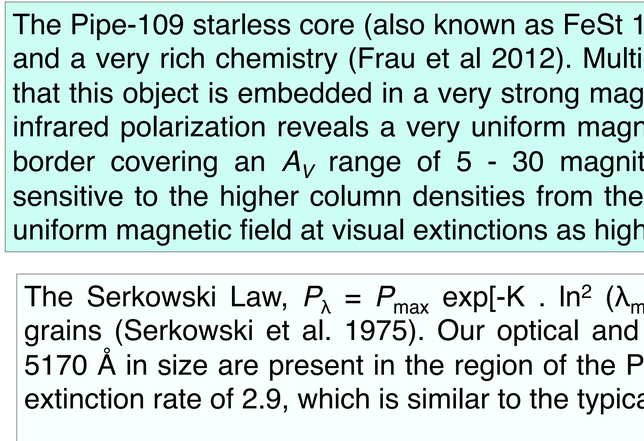
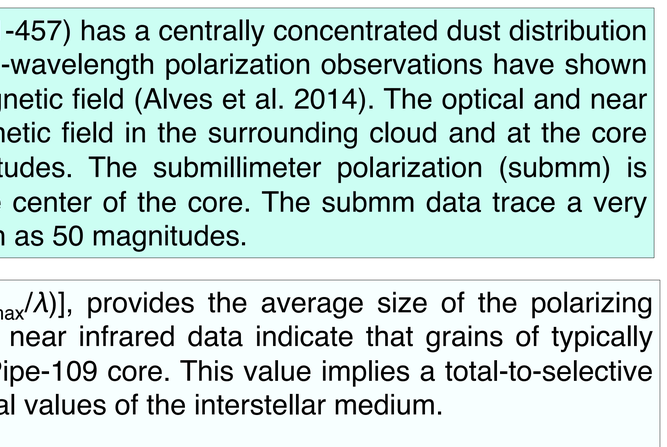
The Pipe-109 starless core (also known as FeSt 1-457) has a centrally concentrated dust distribution and a very rich chemistry (Frau et al 2012). Multi-wavelength polarization observations have shown that this object is embedded in a very strong magnetic field (Alves et al. 2014). The optical and near infrared polarization reveals a very uniform magnetic field in the surrounding cloud and at the core border covering an A_V range of 5 - 30 magnitudes. The submillimeter polarization (submm) is sensitive to the higher column densities from the center of the core. The submm data trace a very uniform magnetic field at visual extinctions as high as 50 magnitudes.

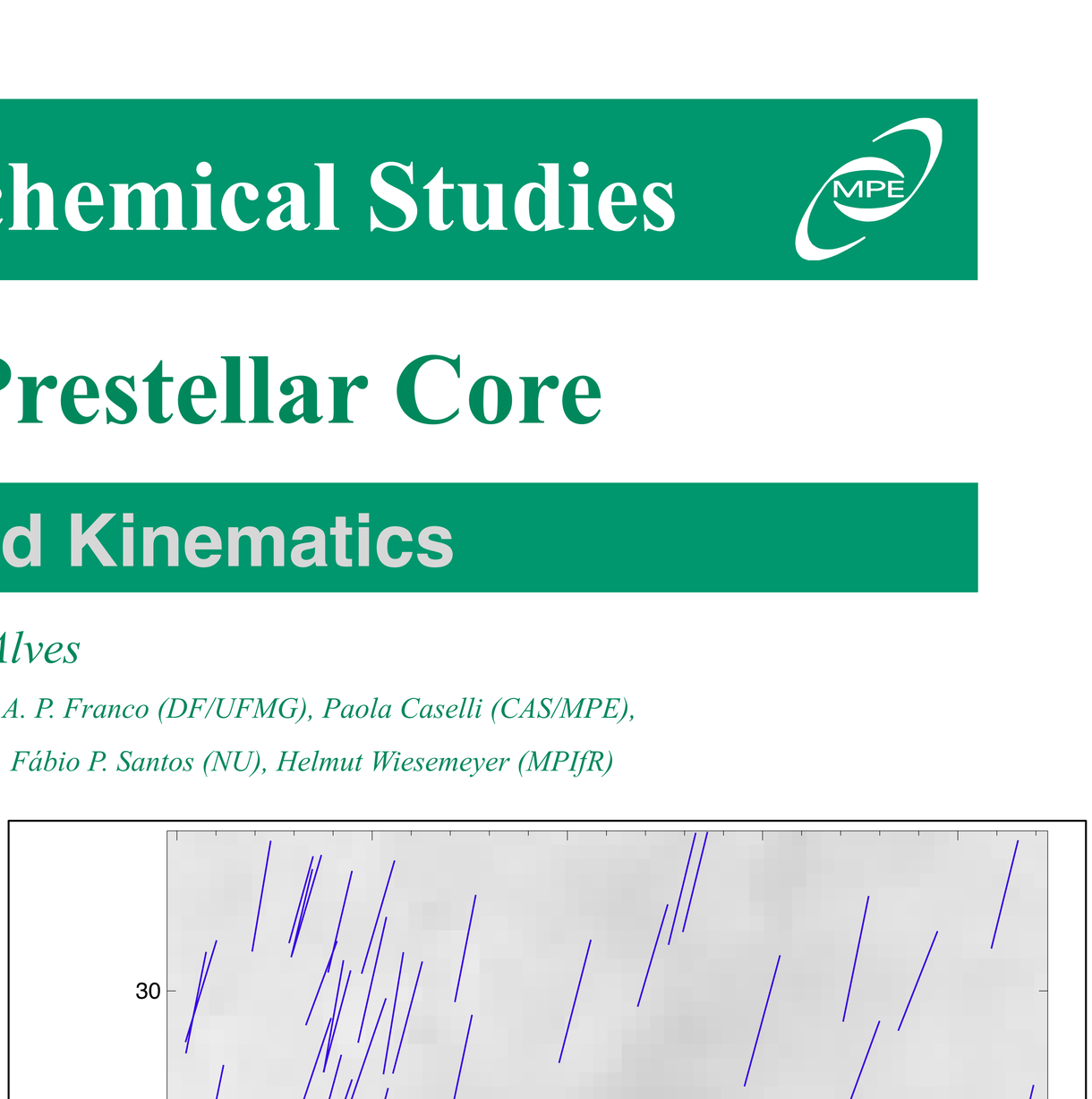
The Serkowski Law, $P_\lambda = P_{max}$ exp[-K . $\ln^2 (\lambda_{max}/\lambda)$], provides the average size of the polarizing grains (Serkowski et al. 1975). Our optical and near infrared data indicate that grains of typically 5170 Å in size are present in the region of the Pipe-109 core. This value implies a total-to-selective extinction rate of 2.9, which is similar to the typical values of the interstellar medium.

The decreasing in polarization efficiency, P/A_V, of the medium surrounding the core is consistent with turbulence and magnetic field topology. For the near infrared data with $A_V > 10$ mag, the polarization efficiency increases, implying that grains are better aligned to the magnetic field or that the uniform component of the magnetic field prevails over the random component. The steep decrease in submm polarization is interpreted as a polarization hole, since there is no internal source of photons to maintain the grains aligned with the magnetic field lines (Radiative Torques, Lazarian & Hoang 2007). The submm polarization is modeled using a magnetic field projected on the plane-of-sky and a grain alignment efficiency of 18% for densities smaller than 6 x 10^4 cm^{-3} and 0% for higher densities. Since grain misalignment may be also due to grain growth, this value is consistent with Forbrich et al. (2015), who proposes grain growth for densities higher than 10^5 cm^{-3} for the same object.



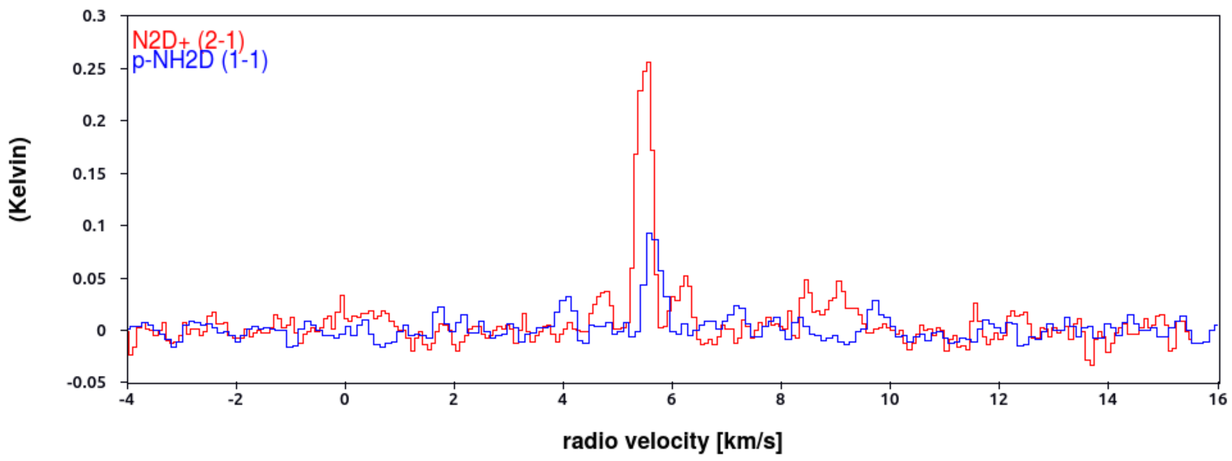


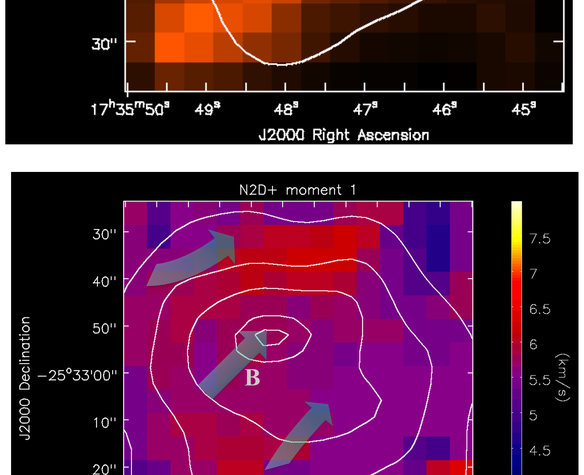
The left panel shows the dependence of the polarization efficiency (P/A_V for optical and near infrared, P for submm) as a function of the visual extinction A_V. The right panel shows the submm polarization as a function of the submm intensity normalized to its peak. The dashed, continuous and blue lines represent synthetic polarization data using models with distinct grain alignment efficiencies and magnetic field orientations.

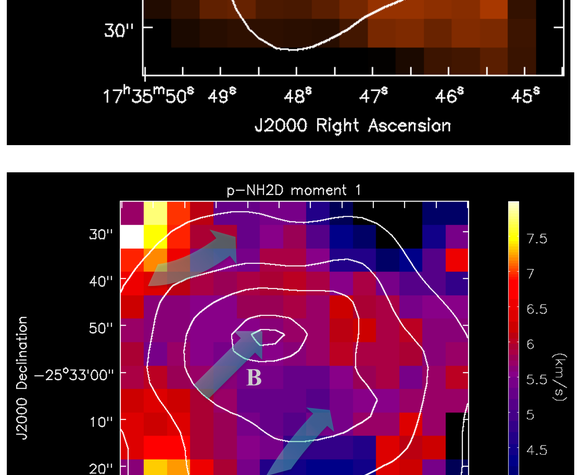


Multi-wavelength polarimetry toward Pipe-109: the optical (blue vectors) and the near infrared (red vectors) data were obtained with the 1.60 m telescope of the Observatório do Pico dos Dias (LNA/MCT, Brazil), while the submillimeter data (green vectors) were obtained using the PolKa polarimeter of the LABOCA camera at APEX (Alves et al. 2014). The polarization vectors are plotted over a deep visual extinction map of Pipe-109 (Román-Zúñiga et al. 2010).

Preliminary work done with the IRAM 30m telescope reveals the N_2D^+ (2-1) and NH_2D ($1_{1,1}$-$1_{0,1}$) emission from Pipe-109. Our goal is to study the core kinematics by comparing how ions and neutrals interact with the magnetic field. The main hyperfine components differ by ~ 0.2 km s^{-1} in V_{lsr}. If the bulk of neutral gas is decoupling from the ions (via, e. g., ambipolar diffusion, Mouschovias et al. 1976) and collapsing to form a protostar, the moment maps of both tracers will possibly indicate distinct velocity fields







Up panel: spectra of N_2D^+ (2-1) and p-NH_2D ($1_{1,1}$-$1_{0,1}$) revealing their hiperfine structure and the small shift in velocity between the two molecules. *Right panels*: moment 0 and moment 1 maps of the two species. The white contours show the dust continuum emission (from 10σ on) of the core (Frau et al. 2010). The direction of the magnetic field is indicated as arrows.

References: Alves et al. 2014, A&A, 569, L1; Forbrich et al. 2015, A&A, 580, 114; Frau et al. 2010, ApJ, 723, 1665, Frau et al. 2012, A&A, 537, L9; Lazarian & Hoang 2007, MNRAS, 378, 910; Mouchovias 1976, ApJ, 207, 141; Román-Zúñiga et al. 2010, ApJ, 725, 2232; Serkowski et al. 1975, ApJ, 196, 261

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