Magnetic field alignment with dense cores in the transition between cloud and core scales

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Are magnetic fields important in the dynamical evolution of dense cores?

Stars form in local overdensities of molecular clouds, known as dense cores. The dynamics of these dense cores are mainly driven by a combination of gravity, turbulence, and magnetic fields. If magnetic fields play an important role in core dynamics, then we expect to see correlations between core properties and the magnetic field. However, Pandhi et al. (2023) surveyed 399 dense cores and did not find any globally preferred orientation between core morphology, rotation, and magnetic fields, using the cloud-scale magnetic field as derived from Planck dust polarization data.

Does the **core-scale** magnetic field play a significant role in the formation of dense cores?

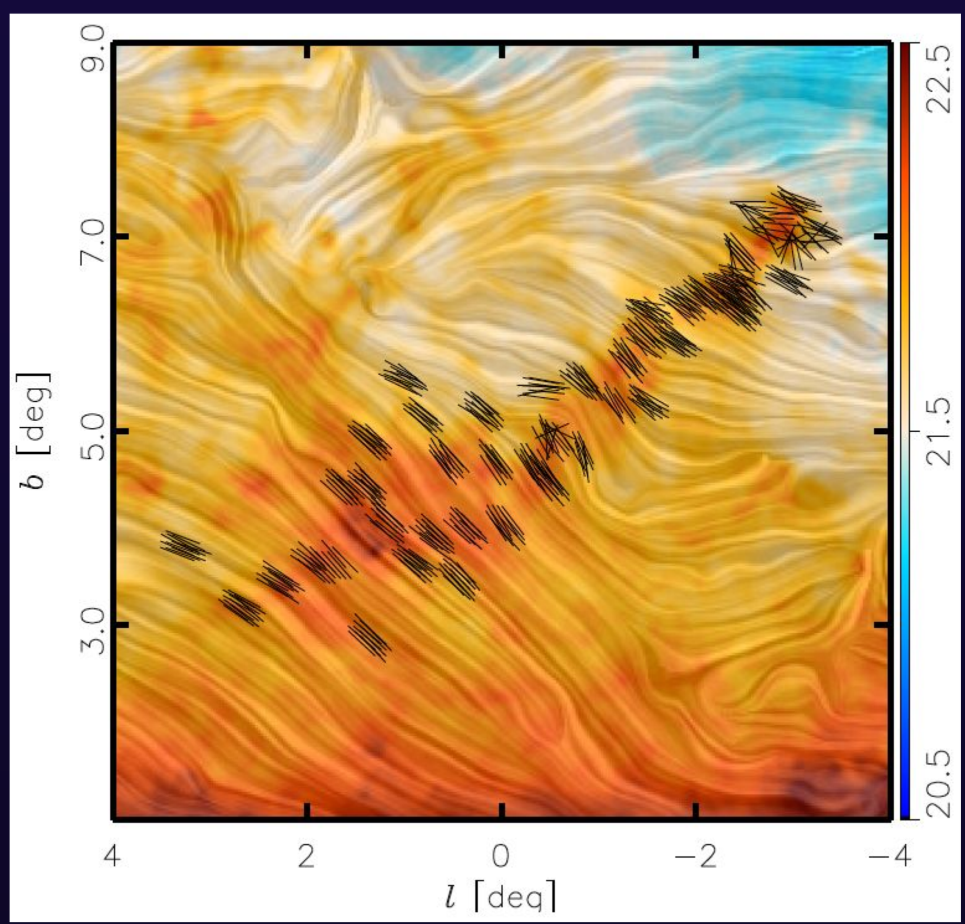

Figure 1: Magnetic field orientations of the Pipe Nebula (grey contours - Planck, black vectors - starlight; Soler et al. 2016)

Probing magnetic fields at core-scales with the JCMT

The James Clerk Maxwell Telescope (JCMT) provides higher-resolution polarization data via its polarimeter POL-2 (in the BISTRO survey) and the legacy polarimeter SCUPOL (15'' FWHM, 0.02pc @ 300pc), with an improvement of resolution by a factor of over 20 compared to Planck (6' FWHM, 0.52pc @ 300pc).

In combination with core catalogues from the Herschel Gould Belt survey (Andre et al. 2010) and Pandhi et al. (2023), we used the new BISTRO/SCUPOL data to create a new catalogue of 79 cores across 4 star-forming regions with both core- and cloud-scale magnetic field orientations, and core orientations and velocity gradients across the cores.

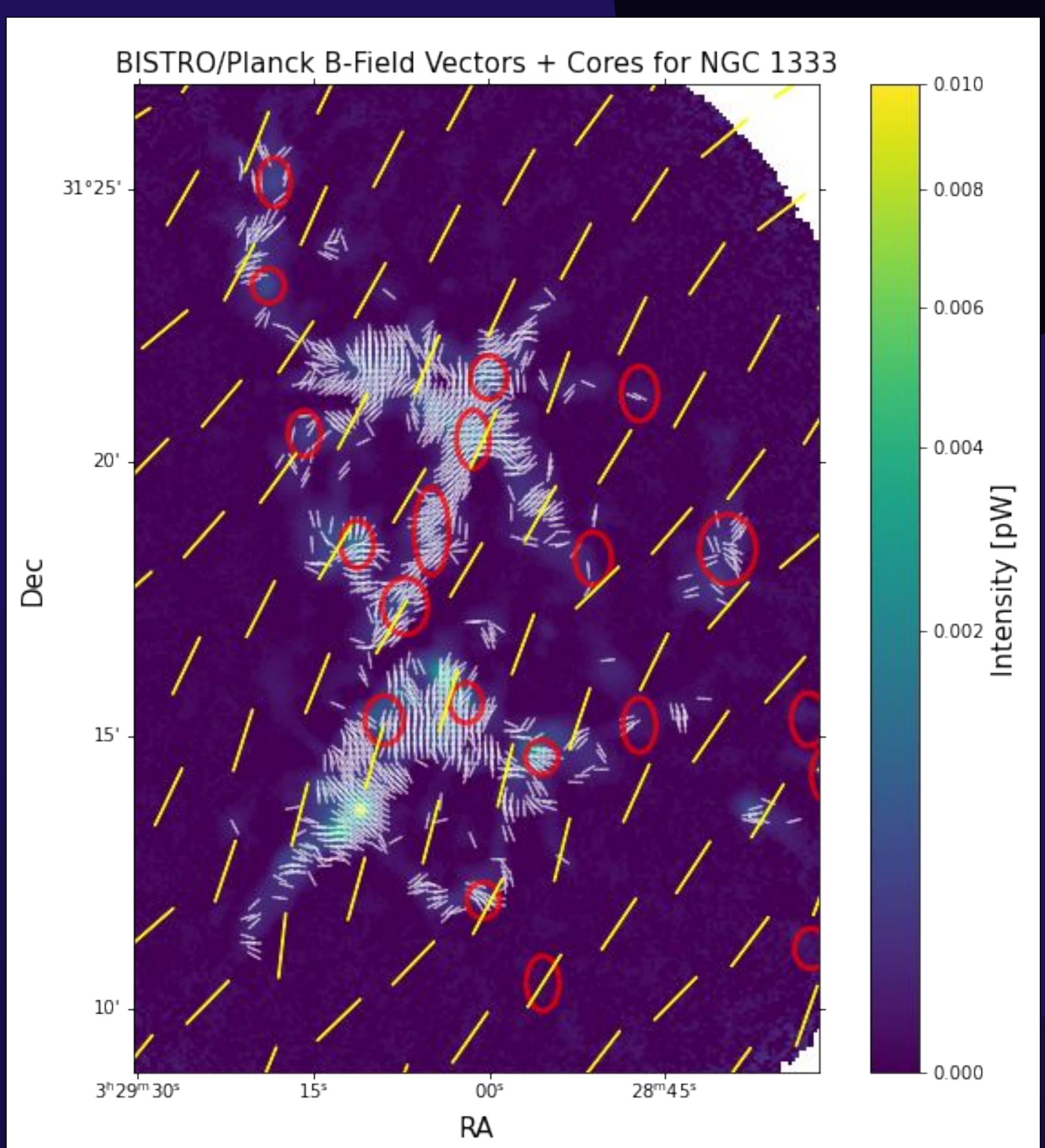

Figure 2: BISTRO (white) and Planck (yellow) magnetic field vectors in the NGC 1333 region, with cores overlaid in red.

References

André, P., et al. 2010, A&A, 640, A111
Chen C.-Y., Ostriker E. C., 2018, ApJ, 865, 34
Kuznetsova A., Hartmann L., Heitsch F., 2020, ApJ, 893, 73
Pandhi, A., et al. 2023, MNRAS, 525, 364
Soler, J. D., et al. 2016, Astronomy & Astrophysics, 596, A93

Core- and cloud-scale magnetic fields are different

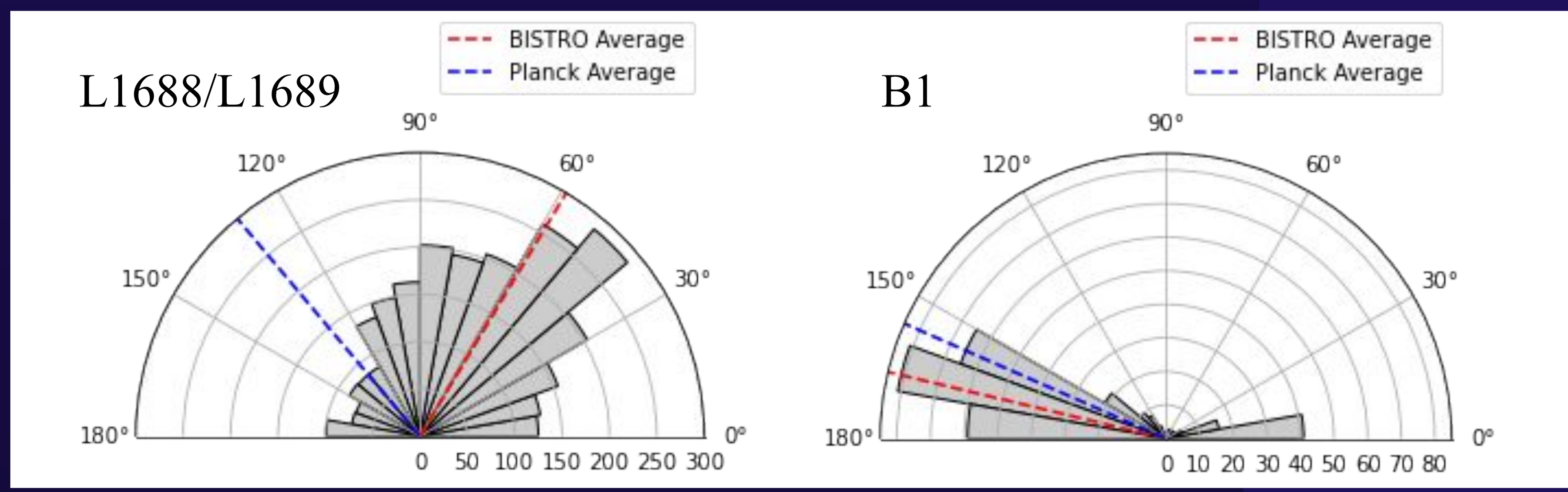

Figure 3: Polar histograms of the orientation of magnetic field vectors as found by BISTRO in L1688/L1689 (left) and B1 (right), with averages of the BISTRO and Planck vectors plotted in red and blue dashed lines respectively.

Generally, we find that as we transition from cloud-scales to core-scales, **the magnetic field becomes significantly more disordered.** As Planck and BISTRO/SCUPOL are sensitive to different physical scales of structures, we see that the ordered cloud-scale field becomes more disordered at higher column densities. However, the core-scale magnetic field angle distribution varies between regions, suggesting that **the star-forming environment is an important factor in the alignment between the core- and cloud-scale fields.**

Core-scale magnetic fields do not drive core formation

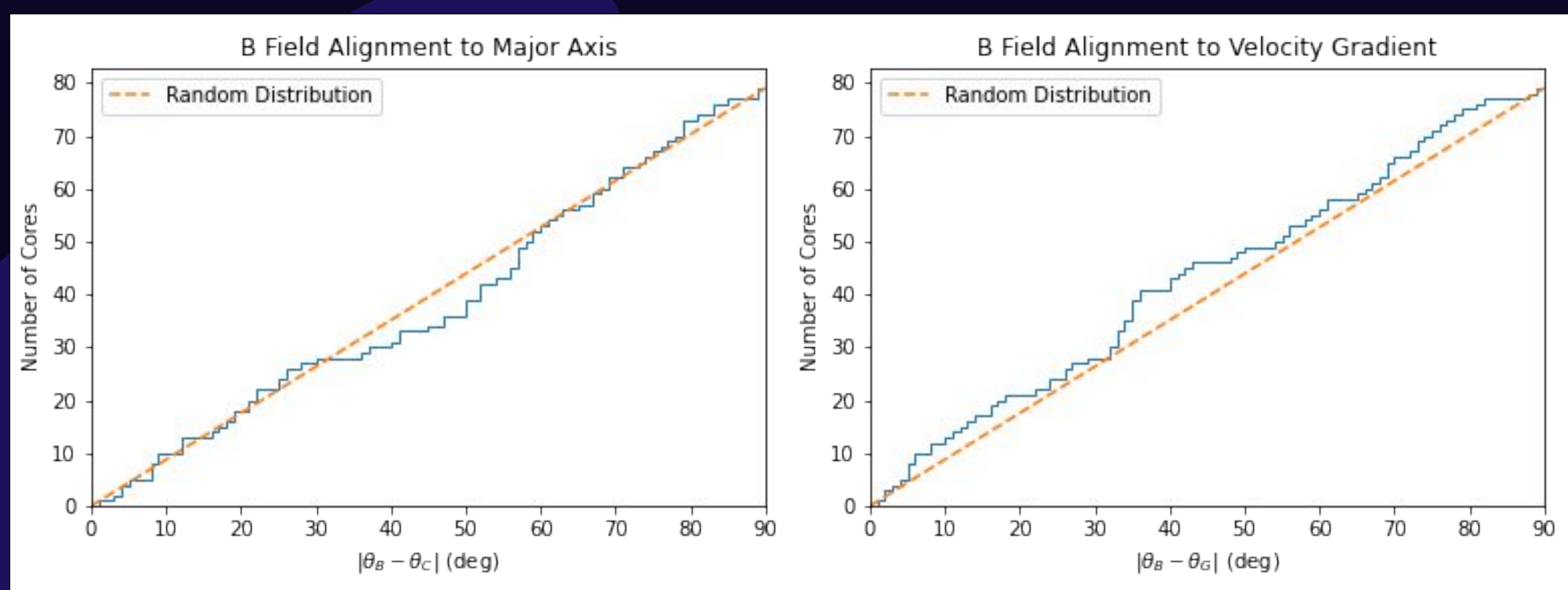

Figure 4: Cumulative distribution functions of the relative alignment between the magnetic field and core elongation axis $|\theta_B - \theta_C|$ (left), and the field and core velocity gradient $|\theta_B - \theta_G|$ (right).

We do not find any globally preferred orientation between the core-scale B-field and the core major axis and velocity gradient. Even with higher resolution data we don't see any correlations between the magnetic field and core properties ⇒ magnetic fields don't appear to drive the formation of dense cores.

Compared to simulations, our results agree with simulations done by Kuznetsova et al. (2020), which predict random alignment between the magnetic field and core velocity gradients, but disagree with simulations done by Chen & Ostriker (2018), which find that cores are elongated perpendicular to the magnetic field.

Conclusions and Future Work

- Produced new catalogue of 79 dense cores across various regions with new core-scale magnetic field data from BISTRO/SCUPOL
- Core-scale magnetic fields are much less ordered than cloud-scale fields, though this differs between regions
- Core-scale B-field does not show global alignment or anti-alignment to core properties, as found by Pandhi et al. (2023) for the cloud-scale field

Future work could involve folding in more data from other regions and investigating the effects of 3D geometry on our results.