Comparing Herschel dust emission structures, magnetic fields observed by Planck, and dynamics: high-latitude star forming cloud L1642

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Introduction
The major physical processes involved in molecular cloud and star formation are gravitation, turbulence, magnetic fields, and thermal pressure, but the full picture is not clear, especially regarding the relative importance of turbulence and magnetic fields. The nearby (~140 pc) cloud L1642 is one of only two known very high latitude (|b| > 30 deg) clouds actively forming stars. It is a rare example of star formation in isolated conditions, and can reveal important details of star formation in general, e.g., of the effect of magnetic fields. We have mapped this cloud with Herschel as part of the Galactic Cold Cores project (Juvela et al. 2012). We used multiwavelength observations (from NIR to mm) to examine the properties of this cloud, especially the large-scale structure, dust properties, and compact sources at different stages of star formation in Malinen et al. (2014). In this poster we present the results of Malinen et al. (subm. 2015), where we compare Herschel dust emission structures and magnetic field orientation revealed by Planck polarization maps in L1642.

Planck and Herschel maps
The high-resolution (~18-40") Herschel data reveal a complex structure including a dense, compressed central blob with elongated extensions, low density striations, and a spiraling “tail.” The Planck polarization data (at 10’ resolution) reveal an ordered magnetic (B) field pervading the cloud and aligned with the surrounding striations. There is a complex interplay between the cloud structure and large scale magnetic field. This suggests that magnetic field is closely linked to the formation and evolution of the cloud.

Relative orientation of magnetic fields and Herschel structures
The distribution of relative orientation between cloud structure and B field lines in diffuse medium (NH < 1.74 x 10²¹ cm⁻²) has one peak centered at ~0deg, indicating that diffuse striations and B field are clearly aligned. Dense medium presents a bimodal distribution of relative orientation centered at ~0 and 90deg, but separate regions have different behaviors. There is a clear transition from aligned to perpendicular structures approximately at a column density of NH = 1.6 x 10²¹ cm⁻². This equals ~4.8 x 10²¹ cm⁻² when using the same convention for dust opacity as Planck Collaboration (2015).

Comparison to CO dynamics
CO rotational emission confirms that the striations are connected to the main clumps and likely to contain material either falling into or flowing out of the clumps.

Conclusions
Comparing the high-resolution (~18-3-40") Herschel maps with the Planck polarization maps (at 10’ resolution) shows the close connection between the magnetic field and cloud structure. This connection is seen even at the finest details of the cloud, most notably in the striations.

Fig. 1. (1) Region surrounding L1642 in Planck 857 GHz intensity map with POS magnetic field orientation shown by the Line Integral Convolution (LIC, Cabral & Leedom 1993) texture at 30’ resolution. (2) L1642 in Herschel 250 μm map (at 18.3” resolution) with Planck magnetic field orientation (at 10’ resolution) shown by LIC texture. (3) Herschel column density map with regions A, B, C, and D, and contours at 1.74x10²¹ cm⁻² and 5.22 x 10²¹ cm⁻² used for analysis. S1, S2, and S3 mark striations, S4 marks elongated structures, “legs”, between regions B and C, and S5 marks another linear feature almost perpendicular to the “legs”. (4) Herschel 250 μm intensity map with sources from Malinen et al. (2014). (5) YSOs B-1, B-2, and B-3, cold clump B-4, and elongated “finger” N marked with black ellipses. Bound and unbound submm clumps from Montillaud et al. (2015) are marked with blue “legs”, between regions B and C, and S5 marks another linear feature almost perpendicular to the “legs”.

Fig. 2. (1) Structures extracted by Rolling Hough Transform (RHT, Clark et al. 2014) analysis of Herschel 250 μm map. The ellipses show two structures resembling a fishbone with “spine” and approximately perpendicular striations. The grey background shows the B field orientation with LIC. (2-3) Histogram of Relative Orientations (HRO) analysis comparing the relative orientation of magnetic field and cloud structure derived using RHT in the case of the whole data or dense and diffuse areas (2), and in the case of separate regions (3). (4) To examine NH dependency we calculate HROs for each NH bin separately resulting in the shown matrix M. (5) We use Non-negative matrix factorization (NMF, Lee & Seung 1999) to calculate the main components of M and their weights i.e., the contribution of each component to the 18 histograms as a function of NH. Component 1 corresponds to diffuse regions, and component 2 to dense regions. The dashed vertical line shows the transition from aligned to perpendicular structures obtained by Planck Collaboration et al. (2015) (converted to our convention of dust opacity).

Fig. 3. ¹²CO data of L1642, based on the observations of Russell et al. (2003). (a) Total integrated intensity. (b) intensity integrated between 0.9 < v(LSR) < 1.7 km/s, (c) peak velocity obtained by a Gaussian fit of the ¹²CO(1−0) line. (d) position-velocity diagram of ¹²CO(2−1) along a cut through Clump A and a striation. The cut is shown with grey arrow in the other figures.

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