*Highlights of Astronomy, Volume 16*
*XXVIIIth IAU General Assembly, August 2012*
*T. Montmerle, ed.*

doi:10.1017/S1743921314012241

# Galactic cold cores

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**Abstract.** The project *Galactic Cold Cores* is studying the early stages of Galactic star formation using far-infrared and sub-millimetre observations of dust emission. The *Planck* satellite has located many sources of cold dust emission that are likely to be pre-stellar clumps in interstellar clouds. We have mapped a sample of *Planck*-detected clumps with the *Herschel* satellite at wavelengths 100-500 $\mu$m. *Herschel* has confirmed the *Planck* detections of cold dust and have revealed a significant amount of sub-structure in the clumps. The cloud cores have colour temperatures in the range of 10–15 K. However, star formation is often already in progress with cold clumps coinciding with mid-infrared point sources. In less than half of the cases, the cloud morphology is clearly dominated by filamentary structures. The sources include both nearby isolated globules and more distant, massive clouds that may be off-the-plane counterparts of infrared dark clouds.

The *Herschel* observations have been completed and the processed maps will be released to the community in 2013.

**Keywords.** ISM: clouds, stars: formation, infrared: ISM, submillimeter; dust, extinction

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The main phases of star formation – from molecular clouds, via dense clumps to the formation and collapse of protostellar cores – are already understood (McKee & Ostriker 2007). Our knowledge is based mainly on detailed observations of the nearest star forming regions and on numerical modelling. However, the formation of each star is an individual process. For the full picture, we need to study sources in different environments and in different stages of their evolution.

The conditions within the cold molecular clouds must dictate the characteristics of star formation. These include the star formation efficiency, the mode of star formation (clustered vs. isolated), and the stellar initial mass function (Elmegreen 2011; Padoan & Nordlund 2011). The relationships can be examined in different environments to determine the interplay between turbulence, magnetic fields, kinematics, and gravity. The importance of external triggering has been demonstrated in individual cases but we are still lacking a global picture of its importance for present-day star formation.

The *Planck* all-sky sub-millimetre maps (Tauber *et al.* 2010) provide data for a global census of the coldest component of interstellar medium. The selection of compact cold sources has led to a list of over 10000 objects (Planck collaboration 2011a), mainly of $\sim$1 pc sized clumps and even larger structures. Because temperatures of $T$ <14 K are possible only in very dense and well-shielded cloud regions, *Planck* can pinpoint the regions where star formation is likely to take place. Many *Planck* clumps will correspond pre-stellar or already protostellar cores. This unbiased survey (in terms of sky coverage) provides a good starting point for statistical studies. In the *Herschel* Open Time Key Programme *Galactic Cold Cores*, we have mapped selected *Planck* clumps with the *Herschel* PACS and SPIRE instruments (100–500 $\mu$m). The higher spatial resolution of *Herschel* (Poglitsch *et al.* 2010; Griffin *et al.* 2010) makes it possible to study the cloud structure,

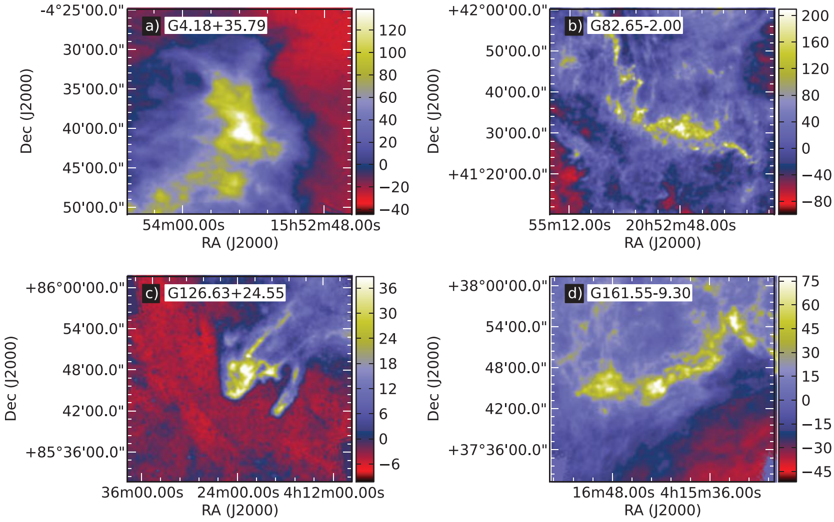


**Figure 1.** *Herschel* maps of four clouds with cold clumps. There are occasionally signs of dynamical interactions that are directly molding the clouds (see Juvela *et al.* 2012).

often resolving the individual cores. The extension to shorter wavelengths helps the study of dust properties and of the column density and temperature variations.

Our *Herschel* survey includes 117 fields with map sizes between 12 arcmin and one degree. The target selection was done based on *Planck* detections, ensuring the full coverage of clump masses and Galactic locations. The regions covered by the other programmes like Hi-GAL (Molinari *et al.* 2010), the Gould Belt Survey (André *et al.*2010) or HOBYS (Motte *et al.* 2010) were avoided. Our fields cover altogether over 300 individual *Planck* clumps. Their distance distribution extends from 100 pc to over 4 kpc and is similar to the distribution of all *Planck* clumps (Planck collaboration 2011a). Distances have been estimated for ∼80% of the fields using various methods (e.g., Marshall *et al.* 2009).

The first Planck results on cold cores were discussed in Planck collaboration (2011a) and Planck collaboration (2011b). Preliminary results of the *Herschel* survey have been presented in papers Juvela *et al.* (2010, 2011, 2012; see Fig.1). The final reduced *Herschel* maps of the 117 fields will be made public in 2013.

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https://doi.org/10.1017/S1743921314012241 Published online by Cambridge University Press