The JCMT Gould's Belt Legacy Survey: Summary for JCMT Proposers

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Abstract

The Gould's Belt Legacy Survey uses three JCMT survey instruments (SCUBA-2, HARP-B and POL-2) to survey nearby star-forming regions ($D < 500$ pc). The SCUBA-2 targets are well-known large molecular clouds, plus many small clouds and isolated cores, totalling an area of 700 square degrees in a shallow survey (of regions of $A_v > 1$) and an area of 107 square degrees in a deep survey (of regions of $A_v > 3$). The HARP-B and POL-2 observations each have two components: 1) the joint mapping of 10 roughly 300 square arcminute fields in various clouds and 2) the individual (follow-up) mapping of 1000 $2' \times 2'$ fields in ^{12}CO and 400 $2' \times 2'$ fields in ^{13}CO and C^{18}O with HARP-B and 100 single field targets with POL-2. We identify a conflict with our SCUBA-2 surveys if the targets overlap our declared map areas, require observations to the same depth, and are of sufficient cumulative area that the proposal seeks to address the stated science goals of this survey. For the targets identified for joint HARP-B/POL-2 mapping (a total of only 0.8 square degrees), a conflict constitutes any observation of these targets to comparable depth (and velocity resolution) in either HARP-B or POL-2 observations.

1 Contacts

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2 Summary of Observations

The survey is split into four components which each target different areas: the SCUBA-2 shallow survey; the SCUBA-2 deep survey; the HARP-B/POL-2 cloud regions survey; and the HARP-B/POL-2 cores survey.

The outer boundary of the SCUBA-2 *shallow survey* can be taken as the defining boundary of our survey. The other three components all target subregions within the area of the *shallow survey*.

2.1 SCUBA-2

SCUBA-2 SHALLOW SURVEY to a sensitivity of **10 mJy / beam** at 850μm, equivalent to 0.08 $M_\odot$/ beam at 500 pc (3σ) or 0.01 $M_\odot$/ beam at 150 pc, assuming $T_d = 20\ K$. Targets are:

- $A_v > 1$ regions of the large clouds Taurus/Auriga, Perseus, Orion, Corona Australis, Lupus I,II,V, Ophiuchus/Scorpius, Serpens, IC5146, Pipe Nebula, and Cepheus Flare, specified in `http://www.astro.cf.ac.uk/pub/David.Nutter/Scuba2/mapping_areas.html`.
- 120 sq. deg. of small clouds within 500 pc including L1333, Crossbones, the Spitzer c2d cores – `http://cfa-www.harvard.edu/sirtf-c2d-cfa/CORES-DB/` (Wu et al. astro-ph/0612365, Young et al. astro-ph/0610667); dense NH_3 cores from Jijina et al. 1999; and optically-selected cores and Bok globules from Lee & Myers (1999), Visser et al. (2002), Clemens & Barvainis (1988), and Bourke et al. (1995).
- 10 sq. deg. of blank field areas within the locus of Gould's Belt, not yet specified.

SCUBA-2 DEEP SURVEY to **3 mJy / beam** at 850 microns and simultaneously 12 mJy / beam at 450 microns (to be carried out in Grade 1 weather). The 850 μm sensitivity is equivalent to 0.08 $M_\odot$/ beam at 500 pc (3σ) or 0.01 $M_\odot$/ beam at 150 pc, assuming $T_d = 10\ K$ in the cold inner parts of clouds. Targets are:

- $A_v > 3$ high column density regions within the large clouds of the shallow survey.

2.2 HARP-B and POL-2

HARP-B / POL-2 CLOUD REGIONS All HARP-B and POL-2 targets will lie within the area defined by the *SCUBA-2 shallow survey* above. Many of the exact targets have yet to be specified as they require the SCUBA-2 observations; however, some obvious regions are known targets. Both HARP-B and POL-2 will target the same regions. The sensitivity for POL-2 observations will be 1 mJy/beam at 850 μm. The transitions, velocity resolution and sensitivity for HARP-B are as follows:

Line	Δv / km s^{-1}	T_R^* (RMS)/K
^{12}CO 3–2	1.0	1.0
^{13}CO 3–2	0.1	0.25
C^{18}O 3–2	0.1	0.3

We note that since C^{18}O and ^{13}CO are observable simultaneously, observations of either of these species to the same velocity resolution and depth cons titutes a conflict with this survey.

The targets are 10 extended cloud regions each of roughly 300 sq. arcmin. to be mapped in equal area by HARP-B (in all 3 CO isotopologues) and POL-2. The science to be achieved requires that we map diverse regions, which unfortunately in turn requires that we leave several unspecified until SCUBA-2 mapping is complete. Targets which can be specified at this time are:

1. Orion A filament ($30' \times 10'$)
2. rho Ophiuchi cluster ($20' \times 15'$)
3. Perseus NGC 1333 ($15' \times 30'$ centred on $03^{\rm h}$ $29^{\rm m}$ 00 $+31^\circ$ 20)
4. Perseus IC348 ($30' \times 10'$, centred on $03^{\rm h}$ $44^{\rm m}$ 15 $+32^\circ$ 02)
5. Orion B NGC 2024
6. – 10. TBD.

HARP-B / POL-2 CORES Roughly 1000 cores will be covered by HARP-B footprints in ^{12}CO, 400 in C^{18}O/^{13}CO, and 100 with the polarimeter. The sensitivities and spectral resolutions are the same as those specified for the cloud regions above. The targets will be follow-up to the SCUBA-2 survey, and their identification at this time is premature. Targets which can be specified for ^{12}CO mapping are the known submm cores in Perseus (Hatchell et al. 2005, 2006 in press) and Rho Oph (Motte et al. 1998).

As our HARP/POL survey is limited in what it can cover, we welcome other observers covering cores within our SCUBA-2 regions with these instruments. We would appreciate a notification where the same sensitivity/resolution criteria are met, firstly so that we can avoid duplication, and secondly so that once the data become publicly available we can process it consistently for inclusion in the legacy archive.

3 Summary of science goals

Protostellar Lifetimes and Accretion Rates. The census of prestellar cores and protostars from the continuum mapping will allow us to calculate the relative duration of these stages. Since half the envelope mass is accreted during the Class 0 stage and the rest during the Class I stage, the duration of each protostellar stage tells us about the protostellar accretion rate. Furthermore, the relative quantities of pre-stellar cores at varying degrees of central condensation (given by continuum radial profiles) will inform models that predict the onset of protostellar collapse (e.g., turbulent dissipation vs. magnetic regulation).

Origin of the IMF and Brown Dwarfs. With the census of nearby pre-stellar cores provided by the continuum mapping, we will be able to plot a very well-populated mass spectrum of these objects over a very wide range of masses. This will allow us to confirm or refute the claim that this mass function exactly mimics the IMF (Motte et al. 2001), particularly at the brown dwarf end. A statistically significant deviation would imply differing origins for brown dwarfs and higher-mass stars, e.g., brown dwarfs may form out of protostellar disks.

Structure of Cores to Clouds. With a distance limit of 0.5 kpc, the minimum linear resolution of the continuum mapping at 850 μm will be 0.03 pc. This scale is well matched for probing the structures of the detected pre-stellar and protostellar envelopes, such as radial density distributions and elongation. On slightly larger scales, the continuum mapping will have the sensitivity to probe the lower-density surroundings of these cores, allowing insights into core formation from its own structure. On even larger scales, the continuum mapping (especially that of the deep layer) will reveal the structure of extended filaments within clouds as never before. Coupled with the dynamical information obtained with HARP-B and the magnetic field geometry obtained with POL-2, the morphologies and structures of filaments revealed by the continuum mapping will provide clues both to their origins and the evolution of molecular clouds.

Classification and Mass Ejection. The presence of a high velocity molecular outflow will differentiate between pre-stellar and protostellar cores. Where outflows are detected, we will estimate outflow momentum flux (e.g., Bontemps et al., 1996) in this large homogeneous sample, allowing us to put on a firm statistical footing the proposed correlations with bolometric luminosity and envelope mass and investigate mass loss from protostellar envelopes.

Core Kinematics. We will use $C^{18}O$ to measure the thermal and non-thermal contributions to the line width, enabling a study of the support mechanisms. Where cores are clustered, we will compare the velocity dispersion between cores, a simple quantity to measure which can be compared both with star formation simulations and with young clusters of pre-main-sequence stars. Two independent measurements of the envelope mass, to compare with the dust mass, can be derived from $C^{18}O$: from the $C^{18}O$ integrated line strength and a virial mass estimate. We will use these observations to investigate CO depletion.

Clouds and Filaments. We will use the large maps of 10 filamentary or clustered star formation regions in ^{12}CO, $C^{18}O$ and ^{13}CO lines to analyse cloud structure and dynamics for comparison with gas dynamic and MHD turbulence simulations (eg. Padoan & Nordlund 2002; Bate et al. 2003). This sample will provide a crucial test of the relative importance of turbulence and magnetic fields in providing cloud support. Comparing to lower-J CO transitions, we will investigate the excitation of the clouds.

Tests of the Standard Model. According to the standard paradigm of low-mass star formation, collapse is guided by magnetic fields, producing flattened cores and disks. Outflows are then generated orthogonal to the disk, producing outflows aligned with the nascent field direction. With ~ 70 sources with outflow and magnetic field orientation, we will be able to establish statistically whether outflows are preferentially oriented with respect to the field direction. Using the SCUBA-2 data, we will also determine whether the field direction is related to the core morphology.

Models of Magnetic Field Geometry. Polarized dust emission yields only the 2D field geometry projected on the plane of the sky. Utilizing all three components from the survey (continuum, line and dust polarimetry), we will generate a set of analytic models of the three dimensional field geometry of all 100 cores as well as extended coherent structures (e.g., filaments). The polarisation dataset will determine if any quasi-static models (e.g., Mouschovias 1976; Tomisaka et al. 1988; Fiege & Pudritz 2000) can provide adequate fits to the data.

Magnetic Field Strength and Tests of the Chandrasekhar-Fermi Method. The fractional polarization from dust yields no direct estimate of the magnetic field strength since it is dependent on several additional unknowns (degree of grain alignment, grain shape and composition). The field strength will be derived from the commonly-used Chandrasekhar-Fermi method (Chandrasekhar & Fermi 1953).

Large-Scale Magnetic Fields and Turbulence. The relation between the core field geometry and that of the larger scale structure in clustered and filamentary regions will be observed and modeled. The gas dynamics from HARP-B $C^{18}O/^{13}CO$ observations will be used in concert with the polarization maps to test predictions of magnetized simulations of turbulence.

4 Further information

For general information on the Gould's Belt survey see the following websites or contact one of the survey coordinators (see front page).
`http://www.jach.hawaii.edu/JCMT/surveys/gb` – survey public website.
`http://www.astro.cf.ac.uk/pub/David.Nutter/Scuba2/mapping_areas.html` – details of SCUBA-2 regions

5 References

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