A SCUBA-2/Herschel Analysis of Prestellar Cores in Ophiuchus

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SUMMARY

We have used SCUBA-2, HARP $C^{18}O$ 3-2[1], Herschel[2] and IRAM N_2H^+ 1-0[3] observations of the Ophiuchus molecular cloud to identify and characterise the properties of the starless cores in the region. The SCUBA-2, HARP and Herschel data were taken as part of the JCMT[4] and Herschel[5] Gould Belt Surveys.

We determined masses and temperatures and performed a full virial analysis on our cores and found that **all our cores are virially bound, with gravitational energy and external pressure on average of similar importance** in confining the cores, but with a wide variation from region to region, with cores in the region influenced by B stars (Oph A) being substantially gravitationally bound, and cores in the most quiescent region (Oph C) being pressure confined. We observe dissipation of turbulence in all of our cores, and find that this dissipation is more efficient in regions which do not contain outflow-driving protostars.

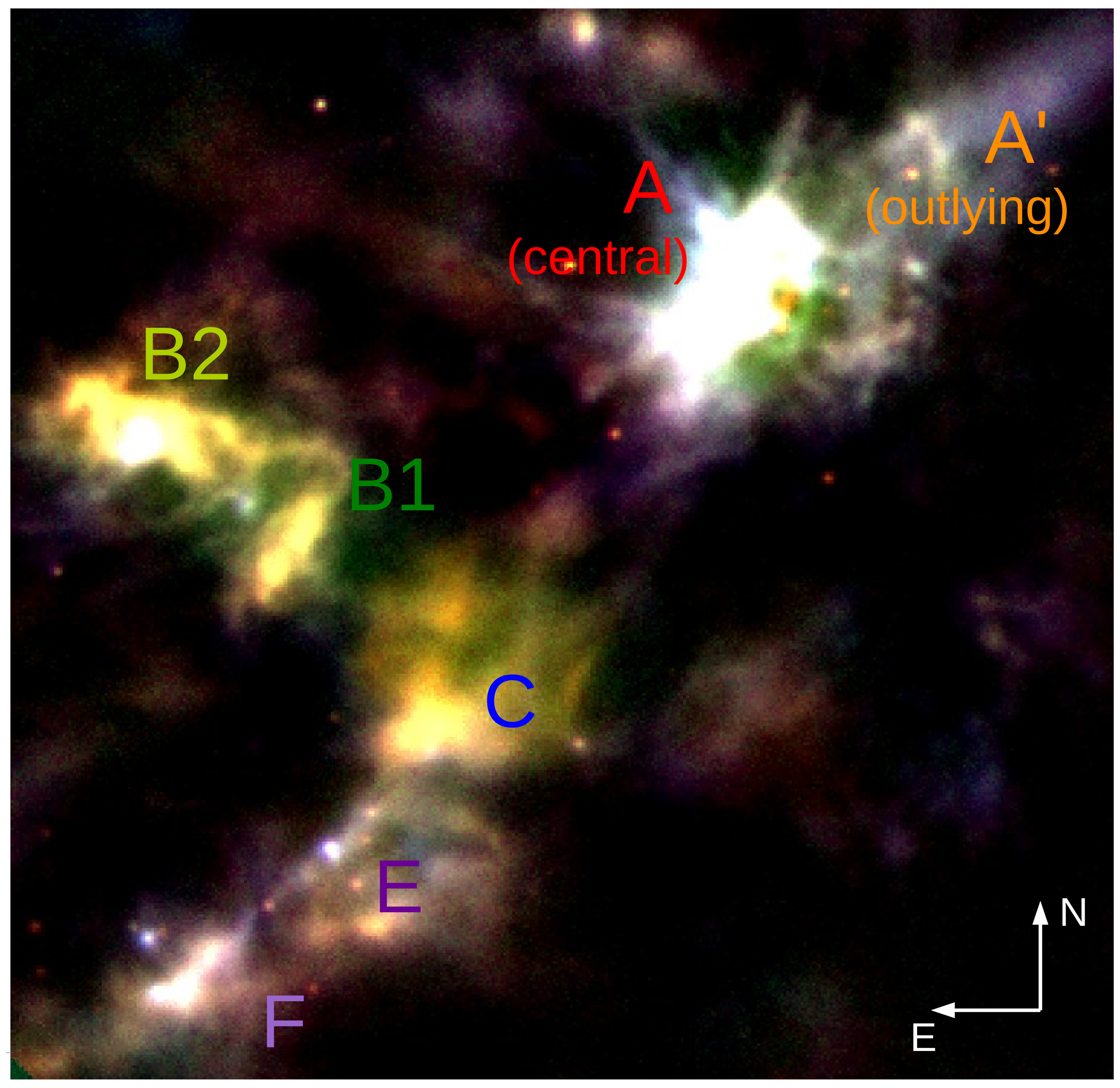

Figure 1: RGB image of L1688, with sub-regions labelled. Red: SCUBA-2 850µm, Green: SCUBA-2 450µm, Blue: spatially-filtered SPIRE 250µm.

COMBINING SCUBA-2 AND HERSCHEL DATA

We generated a set of convolution kernels from the SCUBA-2, SPIRE and PACS beam maps, following the method of Aniano et al. (2011)[6]. Using these kernels substantially decreases the discrepancies previously noted[7] between SCUBA-2 and Herschel fluxes. We also spatially filtered the Herschel maps to remove structure on scales greater than 600'', to which SCUBA-2 is not sensitive.

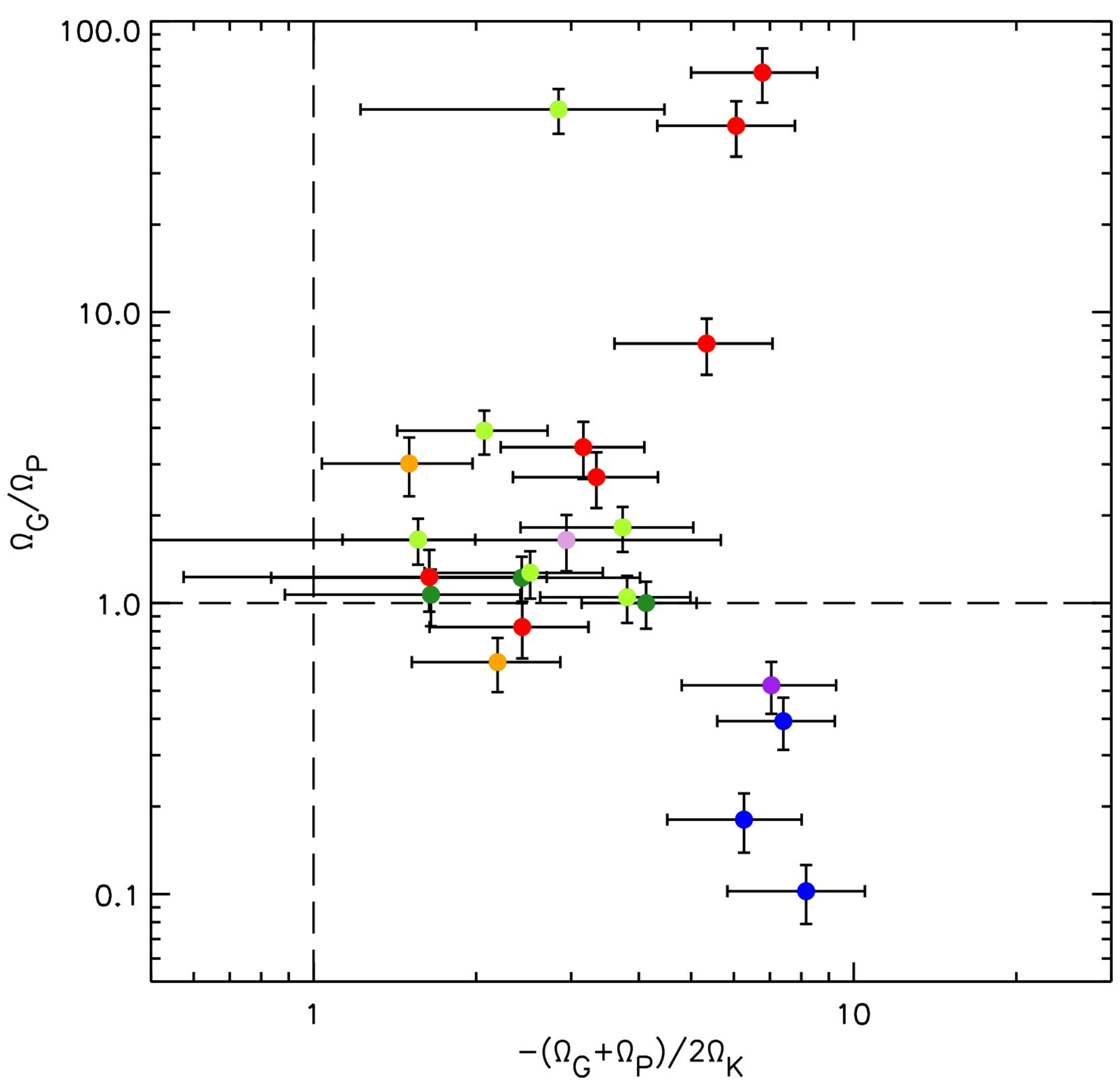

Figure 2: Virial stability of our cores, compared to the ratio of gravitational energy and external pressure in the virial equation. The vertical dashed line indicates the line of virial stability, with the right-hand side of the plot being bound and the left-hand side being unbound. The horizontal dashed line marks equipartition between external pressure energy and gravitational potential energy; cores above the line are gravitationally bound, while cores below the line are pressure confined.

DATA ANALYSIS

Seventy sources were identified in the SCUBA-2 850µm map of L1688 using the curvature-based CuTEx algorithm[8] in its detection mode. The sources were then fitted by a multiple-Gaussian fitting routine. Each source was fitted with a greybody SED using the 160µm, 250µm, 450µm and 850µm bands, with a spectral index of 2.0. Mass estimates were derived from the fitted temperatures and 850µm flux densities. The sources were classified as starless cores or protostars based on morphology, temperature, PACS 70µm flux, and previous identifications. The mean HARP $C^{18}O$ and IRAM N_2H^+ velocity dispersions were measured for each core for which data were available; the internal energies of the cores were calculated from the N_2H^+ velocity dispersion, while the external pressure on the N_2H^+-traced material was determined from the $C^{18}O$ velocity dispersion. The virial stability of the cores, and the relative contributions of gravity and external pressure to core confinement, were estimated (Figure 2).

REGIONAL VARIATIONS

All of our cores are virially bound. Cores in the centre of Oph A are typically strongly gravitationally bound. Cores in Oph C are pressure confined. The rest of the cores are in approximate equipartition between gravitational and pressure energy. We suggest that the influence of nearby B stars HD 147889 and S1 might be sweeping up material in Oph A, causing higher densities. Oph C appears less evolved than the surrounding regions; we speculate that it might be at a slightly different distance. Cores in Oph C, E and F dissipate turbulence more efficiently than those in Oph A, A' and B (Figure 3), which we hypothesise may be due to the lack of outflows in Oph C, E and F.

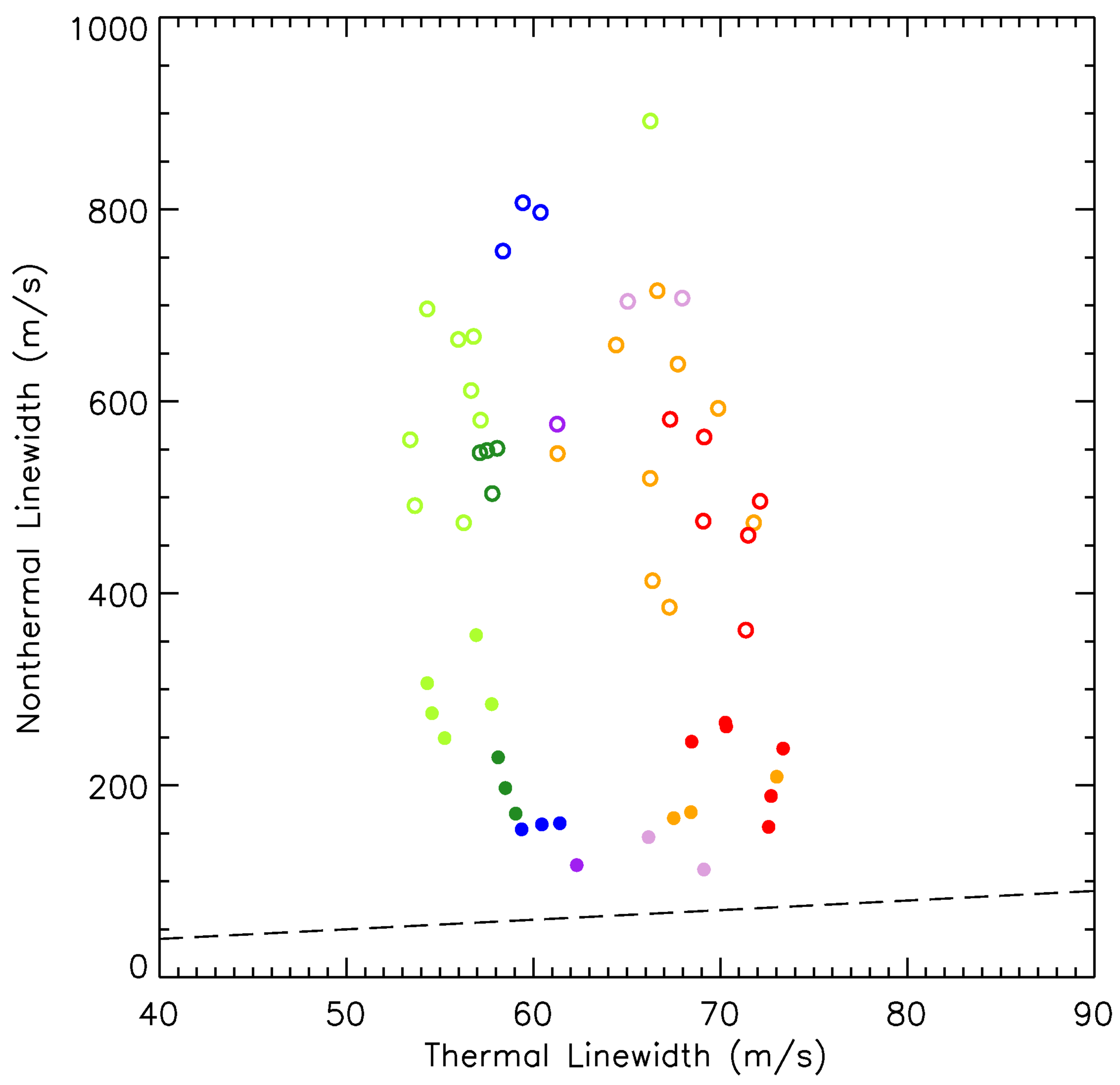

Figure 3: Comparison of thermal and non-thermal linewidths for $C^{18}O$ (open circles) and N_2H^+ (closed circles). The dashed line shows the 1:1 relation.

REFERENCES

[1] White et al., MNRAS, 2014 (accepted)
[2] Ladjalate et al., 2014 (in prep.)
[3] André et al., A&A 472 519, 2007
[4] Ward-Thompson et al., PASP 119 855, 2007
[5] André et al., A&A 518 102, 2010
[6] Aniano et al., PASP 123 1218, 2011
[7] Sadavoy et al., ApJ 767 126, 2013
[8] Molinari et al., A&A 530 A133, 2011

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JCMT Gould Belt Legacy Survey

Herschel Gould Belt Survey