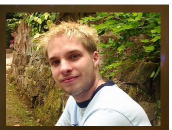
Using Spinning Dust Emission To Constrain The Abundance Of Small Dust Grains In Dense Cores



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Cold Cores

Within many molecular clouds in our Galaxy there are cold, dense regions known as cold cores. Given the low temperatures (≈10 - 15K) and high densities (≈10^5H/cm^3), these environments are dark at mid-IR wavelengths and emit strongly at wavelengths >160µm. The lack of mid-IR emission can be attributed to one of two reasons:

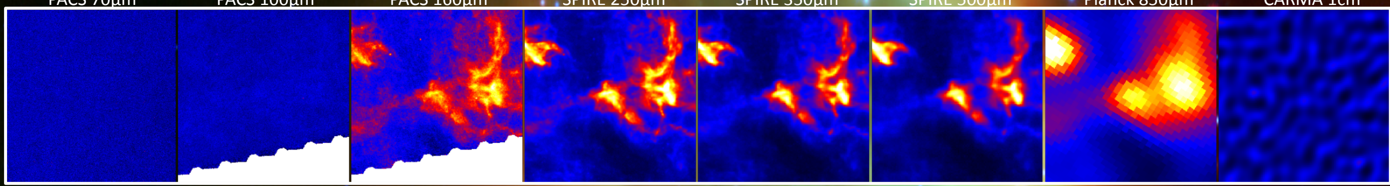
i) a deficit of the small dust grains that emit stochastically at mid-IR wavelengths

ii) small dust grains are present, but due to the high densities, stellar photons cannot penetrate deep enough into the clumps to excite them.

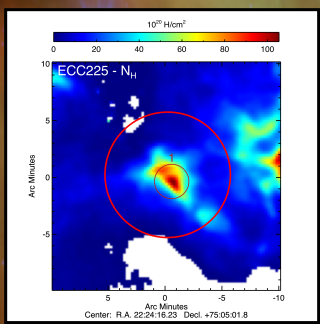
Using mid-IR observations alone it is impossible to distinguish between these two scenarios, but by using spinning dust emission it is possible to break this degeneracy.

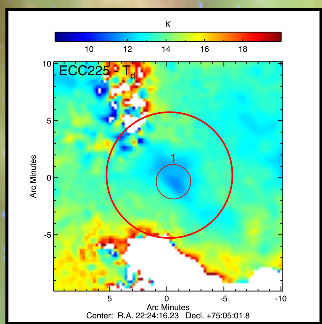
This Work

The goal of this work is to use spinning dust observations to determine how the dust grains are evolving in these dense environments. Recent modelling by Ysard et al. (2011) show that if small dust grains are present in these environments, they will produce spinning dust. Therefore, if spinning dust were detected, it would prove that small dust grains are present and that the lack of mid-IR emission is due to a lack of stellar photons. Conversely, a lack of spinning dust would indicate a deficit of small dust grains, and since small dust grains require harsh radiation fields to be destroyed, a lack of small dust grains is likely a result of dust grain coagulation. Below we illustrate our method of using spinning dust observations to constrain dust grain evolution in a sample of 15 cold clumps selected from the Planck Early Cold Cores catalogue (Planck Collaboration, 2011).



Fit the Herschel 160, 250, 350, and 500µm data on a pixel-by-pixel basis to produce maps of N_H and T_d

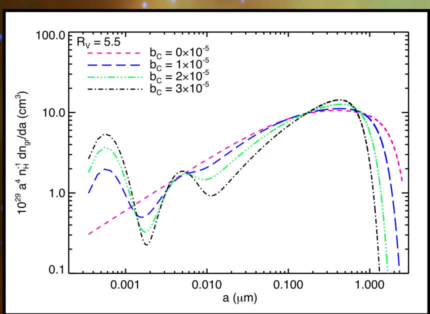


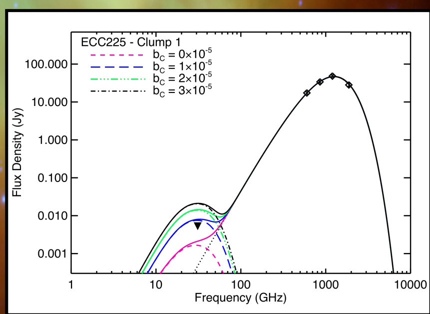


Use N_H and distance to estimate n_H for each sub clump → n_H

Use T_d to estimate G_0 for each sub clump → G_0

Dust grain size distributions (Weingartner & Draine, 2001) implemented within SPDUST for a range of values of the abundance of small carbonaceous dust grains (b_C).





SED for clump ECC225. The spinning dust curves are produced using SPDUST for each dust grain size distribution. The 1cm (31GHz) data point is the 5σ upper limit estimated from the CARMA data. Also plotted (open diamonds) are the Herschel data at 160, 250, 350, and 500µm.

Constraining The Small Grain Abundance

For each of the 15 cold clumps in our sample, we use Herschel data to derive maps of N_H and T_d. These maps are inspected to identify sub clumps, and for each sub clump we estimate n_H and G_0. These properties are combined with the spinning dust model, SPDUST (Silsbee et al., 2011), allowing us to compute the predicted level of spinning dust emission. This analysis is performed for a range of values of the abundance of the small carbonaceous dust grains, b_C. These predictions are then compared to our CARMA 1cm observations, enabling us to constrain the small dust grain abundance. In the SED above, we show the result of this analysis for one of our clumps, ECC225, where we are able to constrain the abundance of the small grains, $b_C < 1\times10^{-5}$.

Conclusions

We demonstrate our method of using spinning dust observations to constrain the abundance of small dust grains in dense cores. Understanding the evolutionary properties of dust grains in these dense environments is crucial to improving our knowledge of the early stages of star formation. This is the first time that spinning dust has been used to constrain the physical properties of interstellar dust grains.

References

Planck Collaboration, 2011, A&A, 536, A23

Silsbee et al., 2011, MNRAS, 411, 2750

Weingartner & Draine, 2001, ApJ, 548, 296

Ysard et al., 2011, A&A, 535, A89

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