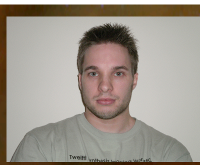
Tibbs et al. 2011, MNRAS, 418, 1889



Spitzer characterization of dust in an anomalous emission region: the Perseus cloud

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Anomalous microwave emission is known to exist in the Perseus cloud. One of the most promising candidates to explain this excess of emission is electric dipole radiation from rapidly rotating very small dust grains, commonly referred to as spinning dust. Photometric data obtained with the Spitzer Space Telescope have been reprocessed and used in conjunction with the dust emission model DUSTEM to characterize the properties of the dust within the cloud. This analysis has allowed us to constrain spatial variations in the strength of the interstellar radiation field (χ_{ISRF}), the mass abundances of the PAHs and VSGs relative to the BGs (Y_{PAH} and Y_{VSG}), the column density of hydrogen (N_H) and the equilibrium dust temperature (T_{dust}). The parameter maps of Y_{PAH}, Y_{VSG} and χ_{ISRF} are the first of their kind to be produced for the Perseus cloud, and we used these maps to investigate the physical conditions in which anomalous emission is observed. We find that in regions of anomalous emission the strength of the ISRF, and consequently the equilibrium temperature of the dust, is enhanced while there is no significant variation in the abundances of the PAHs and the VSGs or the column density of hydrogen. We interpret these results as an indication that the enhancement in χ_{ISRF} might be affecting the properties of the small stochastically heated dust grains resulting in an increase in the spinning dust emission observed at 33 GHz. This is the first time that such an investigation has been performed, and we believe that this type of analysis creates a new perspective in the field of anomalous emission studies, and represents a powerful new tool for constraining spinning dust models.

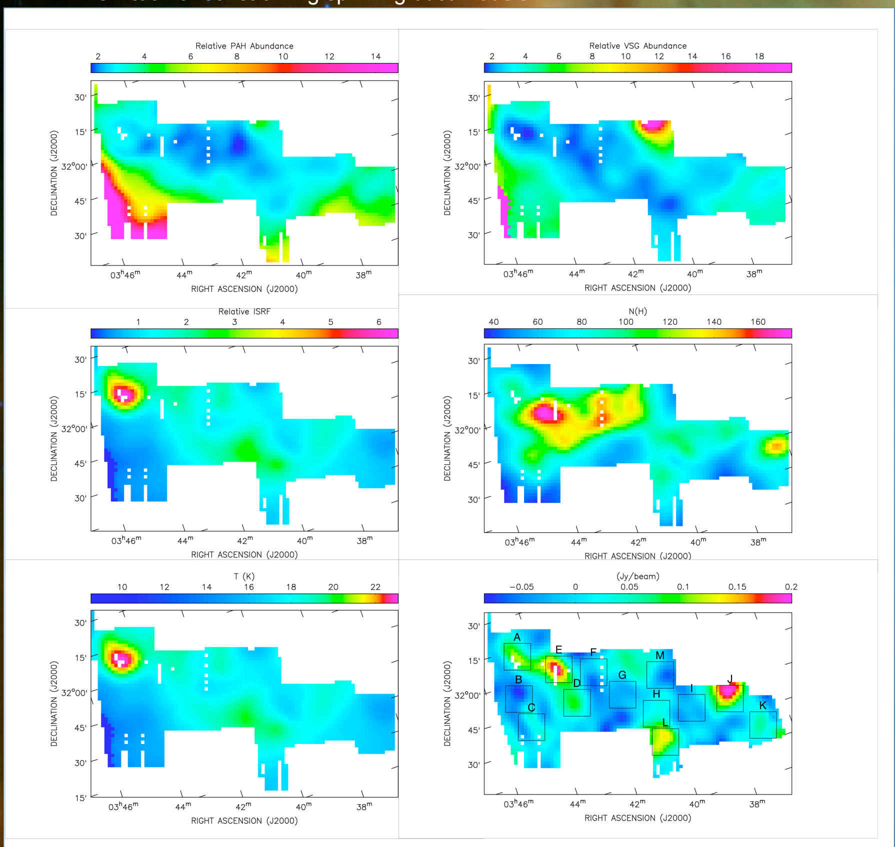

Figure 1. Maps of the Perseus cloud: Y_{PAH} map (Top Left); Y_{VSG} map (Top Right); χ_{ISRF} map (Middle Left); N_H map (Middle Right); T_{dust} map (Bottom Left); and the VSA 33 GHz map (Bottom Right). The Y_{PAH}, Y_{VSG} and χ_{ISRF} parameter maps are the first to be produced for the Perseus cloud. Y_{PAH} and Y_{VSG} are given relative to the value for the diffuse high galactic latitude medium (see Compiègne et al., 2011), while χ_{ISRF} is dimensionless. The N_H map was computed from the 2MASS/NICER extinction map and is in units of 10^{20} H cm^{-2} . The VSA map is provided to allow a visual comparison, and is overlaid with the thirteen regions in which the analysis was performed. All maps are displayed at 7 arcmin angular resolution.

Modelling the IR Dust Emission

To constrain the dust properties in the Perseus cloud we wrote an SED fitting routine that combines the computed dust emissivities from DUSTEM (Compiègne et al., 2011) with the instrumental bandpass filters, and allows us to estimate the flux that would be observed by an instrument at a given wavelength. Using this fitting routine with Spitzer data at 8, 24, 70 and 160 µm, we would like to constrain the mass abundances of the PAHs and VSGs relative to the BGs (Y_{PAH} and Y_{VSG}), the strength of the interstellar radiation field (ISRF) relative to the Mathis et al. (1983) solar neighbourhood value (χ_{ISRF}) and the column density of hydrogen (N_H). However, due to a lack of data at wavelengths longer than 160 µm, we do not measure the peak emission of the thermal equilibrium dust, which prevents us from recovering a reasonable estimate of the temperature and thus the strength of the ISRF. Consequently, there is a degeneracy between the strength of the ISRF and the column density of emitting material. To circumvent this problem, we made use of the COMPLETE extinction map (Ridge et al., 2006). Using $N_H/A_V = 1.87 \times 10^{21}$ H cm^{-2} mag^{-1} (Bohlin et al., 1978) we converted this map into a map of the column density, hence breaking the degeneracy described above. The angular resolution of the extinction map is 5 arcmin, which sets a lower limit to the angular resolution at which we can conduct our analysis. Since the VSA 33 GHz map has a 7 arcmin angular resolution, we degraded all maps to this resolution. Having estimated N_H, we kept this parameter fixed in the model, and we fitted the 8, 24, 70 and 160 µm data points for Y_{PAH}, Y_{VSG} and χ_{ISRF}. Running DUSTEM on a pixel-by-pixel basis resulted in a set of parameter maps – see Fig. 1.

Characterizing the Anomalous Microwave Emission

To identify potential correlations between the anomalous emission and the dust properties in the Perseus cloud 13 regions were selected in which to perform an analysis (see Fig. 1). The mean value of each of the parameters within each region was computed, and by splitting the regions according to their location relative to the anomalous emission, a weighted mean was computed for each parameter (see Table 1). These results indicate that there is a significant increase in χ_{ISRF}, and hence T_{dust}, in regions of anomalous emission.

Parameter	AME	No AME	Significance
Y_{PAH}	2.60 ± 0.18	2.44 ± 0.21	0.6σ
Y_{VSG}	2.29 ± 0.23	2.75 ± 0.31	1.2σ
χ_{ISRF}	1.74 ± 0.15	0.87 ± 0.09	4.9σ
N_H	94.3 ± 9.0	93.8 ± 8.3	0.0σ
T_{dust}	20.2 ± 0.5	17.7 ± 0.7	3.1σ

Table 1. Results of performing a weighted mean analysis on the parameters in all thirteen regions. These results show that for regions with anomalous emission (AME) there is a significant increase in the strength of the ISRF and the temperature of the dust.

References

Bohlin et al. 1978, ApJ, 224, 132; Compiègne et al. 2011, A&A, 525, 103; Ridge et al, 2006, AJ, 131, 2921

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