The Dust Content of Evolved HII regions: Spitzer and Herschel Characterization

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Paladini R.[1], Veneziani M.[1], Umana G.[2], Noriega-Crespo A.[1], Anderson L. D.[3], Piacentini F.[4], Paradis D.[5], Tibbs C. T.[1], Bernard J.-P.[5], Natoli P.[6]

([1] IPAC/Caltech, [2] I NAF – Osservatorio di Catania, , [3] West Virginia University, [4] Dipartimento di Fisica, Universita' di Roma La Sapienza, [5] Universite' de Toulouse, UPS-OMP, IRAP, [6] Universita' di Roma Tor Vergata)

Abstract: We have analyzed a uniform sample of 16 HII regions located in a 2 deg X 2 deg field observed as part of the Herschel Hi-Gal survey.
The field, centered at l = 30 deg, is characterized by the presence of several HII regions, many of which are evolved. The evolutionary stage of these HII regions has been determined using ancillary radio data, which allow us to guarantee uniformity of the sample.

By combining Hi-Gal PACS (70μm and 160μm) and SPIRE (250μm, 350μm and 500μm) measurements with MIPS 24μm data, we build the Spectral Energy Distributions (SEDs) of the sources and show that a 2-component grey-body model is a good representation of the data. In particular, wavelengths > 70μm appear to trace a cold dust component, for which we estimate an equilibrium temperature of the Big Grains (BGs) in the range 20 - 30 K, while for λ < 70μm, the data indicate the presence of a warm dust component at temperatures of the order of 50 - 90 K.

The analysis also reveals that dust is clearly present within HII regions and that the ionized gas is spatially correlated with the 24μm emission. In addition, the data appear to corroborate the hypothesis that the mechanism responsible for the (partial) depletion of dust in HII regions is radiation-pressure-driven drift, as recently proposed in Draine (2011).

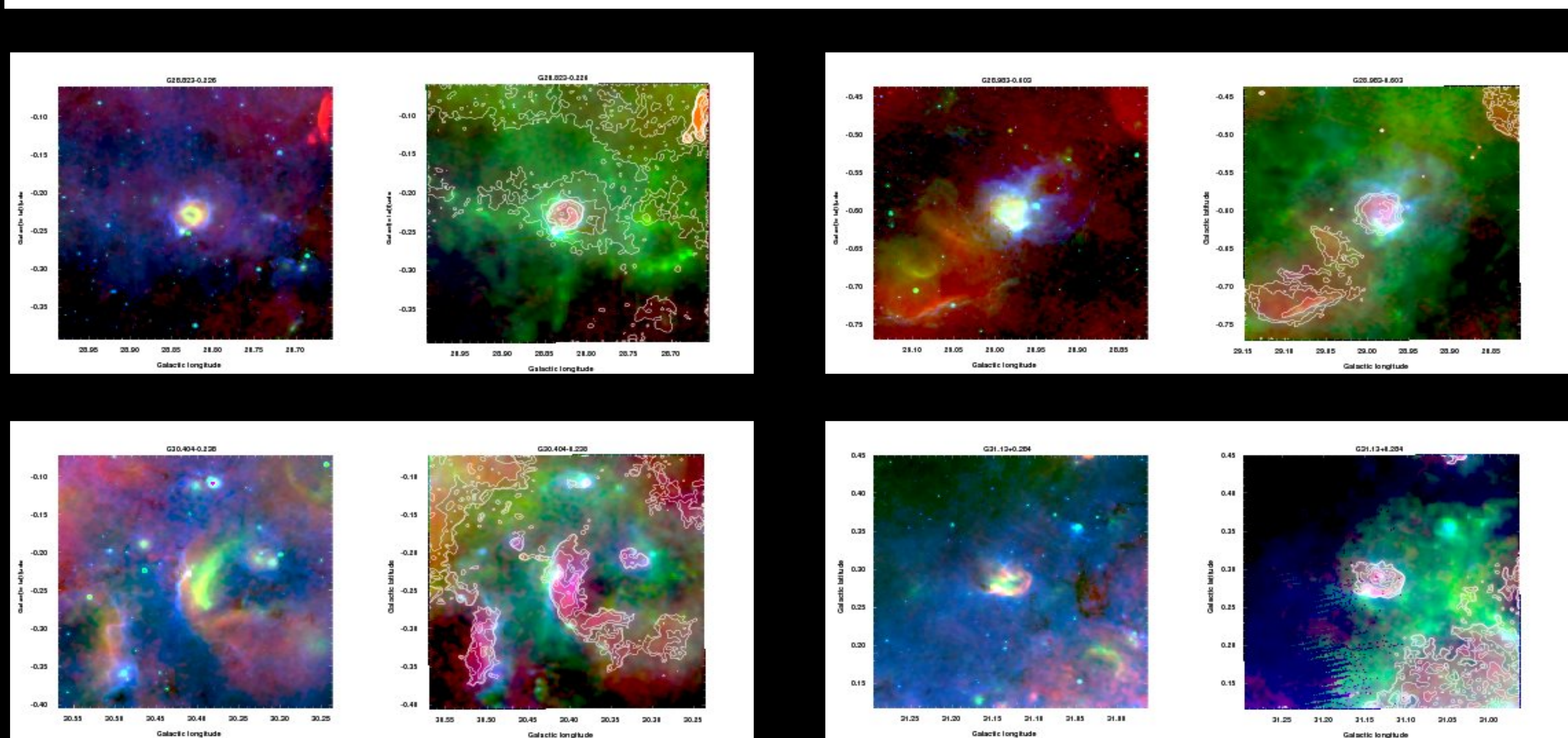

Fig 1.: Examples of 3-color images of evolved HII regions. Left panel: MAGPIS 20-cm (red), MIPS 24μm (green), IRAC 8μm (blue). Right panel: MAGPIS 20-cm (red and contours), SPIRE 250μm (green), PACS 70μm (blue).

Analysis 1: We use the MAGPIS 20-cm data (6") to identify the boundary of the gas-ionized dominated region within each source + IRAC 8μm, MIPS 24μm, PACS (70μm and 160μm)) and SPIRE (250μm, 350μm, 500μm) data to trace all populations of grains known to date (PAHs, VSGs, BGs);

• We create 3-color images (Fig. 1) as well as longitude/latitude profiles (Fig.2) to investigate both the spatial distribution of gas with respect to dust, and the spatial distribution of different populations of grains (as traced by different wavelengths) relative to each other (Fig. 3);

Analysis 2: guided by the MAGPIS 20-cm contours, we compute the flux at all wavelengths (8μm to 500μm) and build SEDs (Fig. 4).

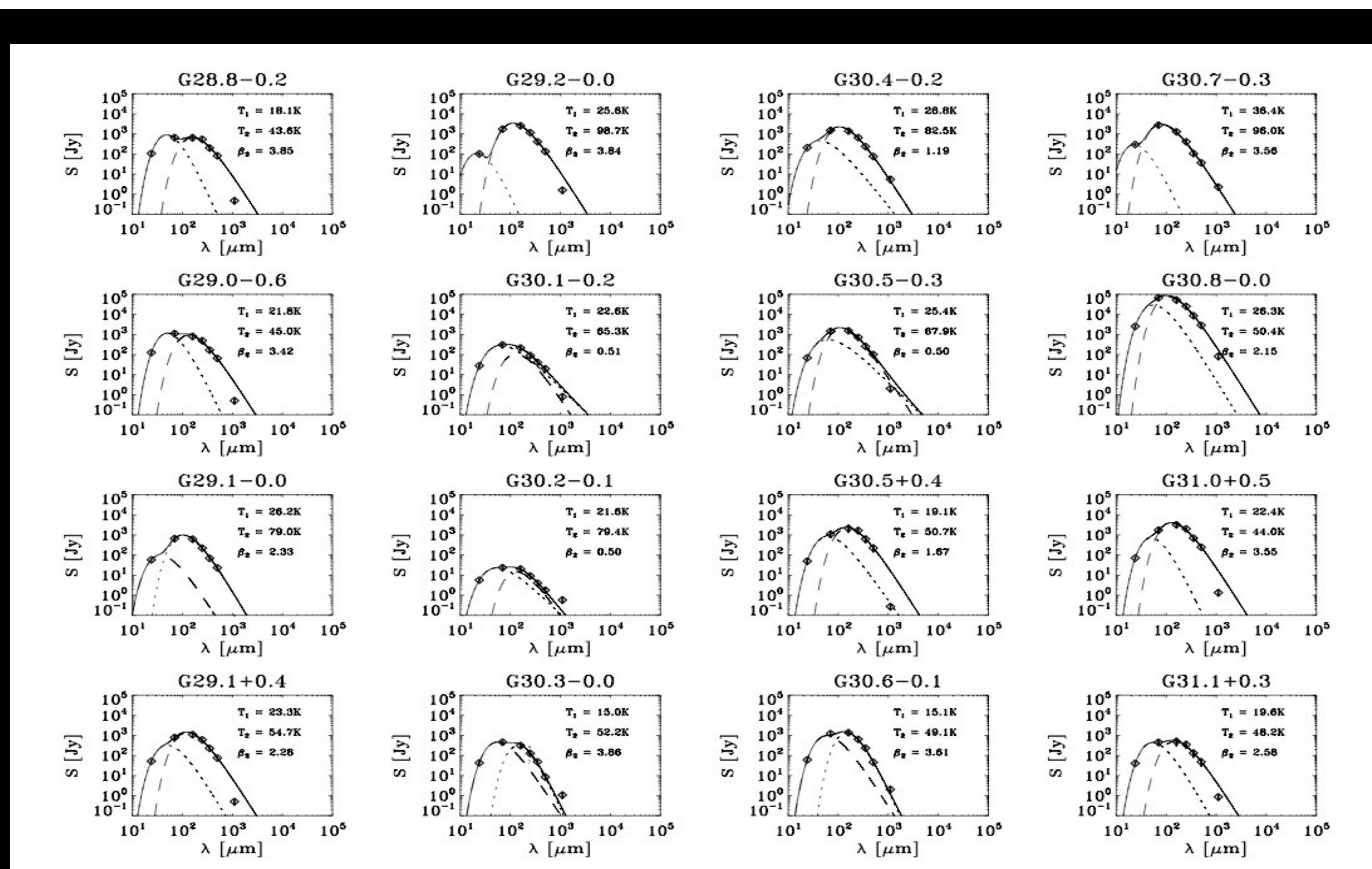

Fig. 4: SEDs for the 16 HII regions in our sample. Triangles denote photometric measurements in the IRAC 8μm, MIPS 24μm, PACS 70μm and 160μm, SPIRE 250μm, 350μm, 500μm, and Bolocam 1.1mm. The solid line shows the best-fit model, with the dashed-line illustrating the warm and cold components, respectively.

Can Dust Survive in HII Regions ?

• Dust grains may not be able to survive the extreme environmental conditions (intense UV photon flux and radiation pressure, stellar winds and high temperatures) characterizing the interior of HII regions;

• in particular, 3 mechanisms are thought to be at work (Inoue 2002; Draine 2011):

1. radiation pressure (causes grains to be swept out + sputtering)
2. stellar winds (same + sputtering)
3. dust sublimation (but not very efficient)

• According to Draine (2011), radiation-pressure-driven drift is the most effective mechanism. BGs drift at higher speed. Small grains drift as well but more slowly.

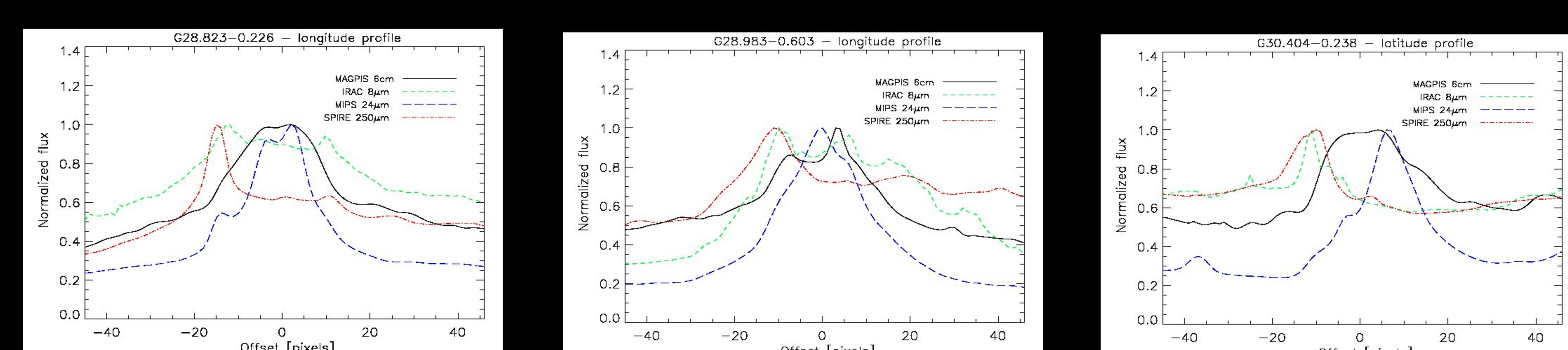

Fig 2.: Examples of longitude and latitude profiles obtained by slicing MAGPIS 20-cm, IRAC 8μm, MIPS 24μm, SPIRE 250μm postage stamp images. All images are convolved to SPIRE 250μm resolution (18").

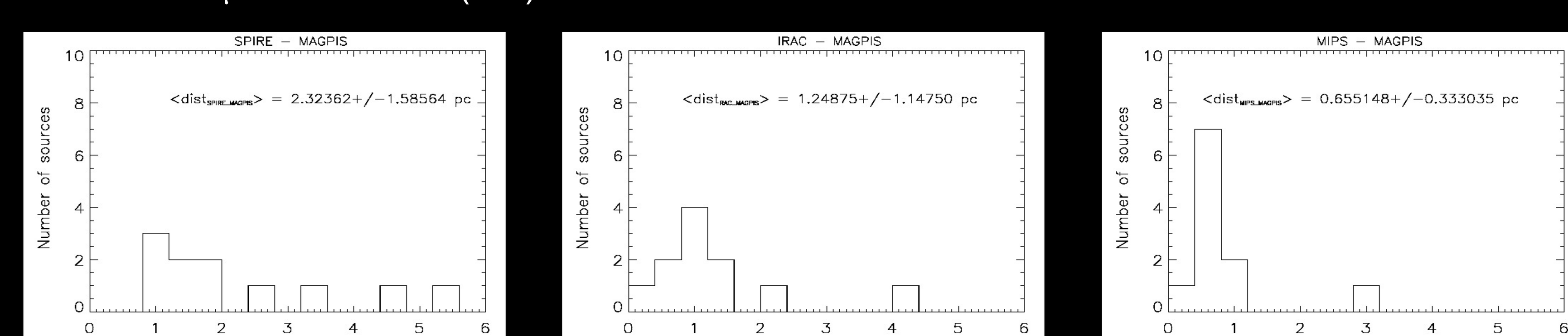

Fig. 3: Linear separation distributions (in pc) between the peak of emission of SPIRE 250μm and MAGPIS 20-cm (left), IRAC 8μm and MAGPIS 20-cm (middle), and MIPS 24μm and MAGPIS 20-cm (right).

Results 1: The linear separation between the peaks of emission at 20-cm and 250μm is twice the linear separation between the peaks at 20-cm and 8μm. This is consistent with a scenario (as predicted by Draine 2011) in which BGs (250μm) and PAH (8μm) drift outward under the effect of radiation pressure (with BGs drifting at higher speed than PAHs) ;

Results 2: the linear separation between the peaks of emission at 20-cm and 24μm is the smallest. MIPS 24μm cannot trace VSGs, as these, with a size intermediate between PAHs and BGs, should drift faster than PAHs but more slowly than BGs. Hence, we interpret this emission as also due to BGs, but warmer (and possibly younger) than the BGs traced by SPIRE wavelengths;

Results 3: the photometric measurements retrieve, after background subtraction, positive residuals at all wavelengths (and for all sources), indicating the clear presence of dust blended with the ionized gas;

Results 4: the best-fit to the SEDs is a two-component grey-body model, with a warm component (T_D ~ 50 – 90 K) and a cold component (T_D ~ 20 - 30 K) .