Characterising the submillimiter excess in dwarf galaxies
Presentation of the Herschel Dwarf Galaxies Survey

A.Remy[1]. (aurelie.remy@cea.fr), S. C. Madden, , F. Galliano, M. Galametz, S. Hony + the Herschel SAG2 consortium
[1] Laboratoire AIM, CEA Saclay, 91190 Gif-sur-Yvette, France

Dwarf galaxies are of great importance in understanding the formation and evolution of galaxies. The spectral energy distribution (SED) of a galaxy is an essential tool to understand the underlying astrophysical processes integrated over the lifetime of the galaxy. The Herschel Space Observatory is revolutionizing our FIR/submillimeter view of galaxies. Herschel is confirming the submillimeter excess that has been noted previously in low metallicity dwarfs.

We present here the Dwarf Galaxies Survey sample, observed with PACS and SPIRE, through various color-color diagrams. We will then focus on three galaxies presenting different interesting behaviour in the FIR as revealed by Herschel.

Dwarf Galaxies Survey Colors

The *Herschel* GT Key Program – the Dwarf Galaxy Survey (PI: S.C.Madden), dedicated to 48 dwarfs, we aim to study the dust and gas properties in the ISM of low-metallicity objects. The metallicities of the galaxies range from 1/50 solar to solar metallicity.

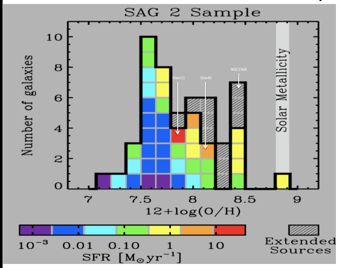


Fig.0 : Metallicity distribution of the DGS sample. The SFR are also indicated by a color code. Note Haro11, IIZw40, NGC1569

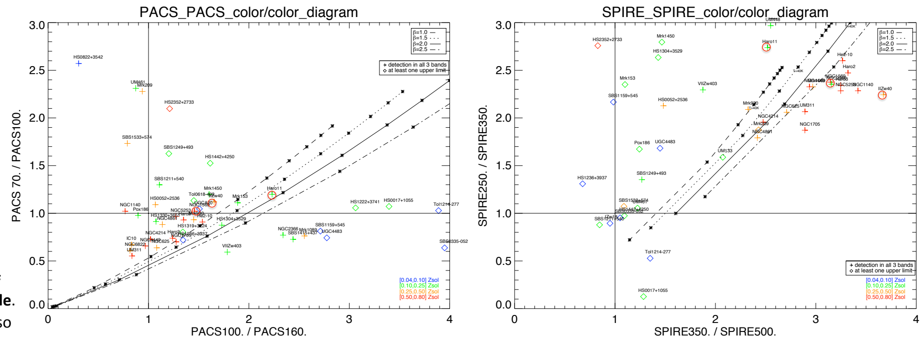


Fig.1: Color-color diagrams. *Left:* PACS color-color diagram. The diamonds are galaxies with at least one upper limit in the three PACS fluxes. The colors delineate the different metallicity bins for the targets. The three lines give the theoretical PACS fluxes ratios for a simulated grey body for β = 1.0, 1.5, 2.0, 2.5 and T from 10 to 100K with 10K bins marked as black dots, increasing in T from left to right. The 3 zoom-in galaxies are marked with a red circle. *Right*: Same but with SPIRE wavelengths.

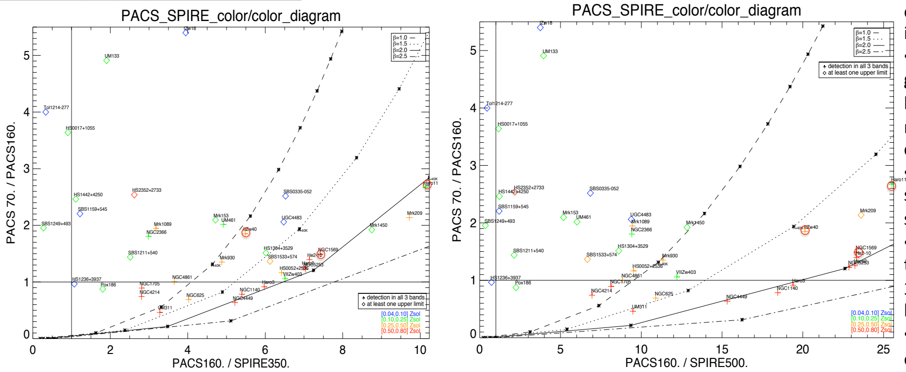


Fig.2: Mixed color-color diagrams. *Left:* PACS70/PACS160 vs PACS160/SPIRE350. *Right:* PACS70/PACS160 vs PACS160/SPIRE500. See Fig.1 for a more detailed description.

- Most of them fall on a β < 2 domain. Some fall on even lower β domain : 1.0 < β < 1.5 (contrarily as what is often used)
- Extreme cases : About 1/5th of the sample (10 galaxies) present a peak at very short λ (< 70µm): hottest galaxies of the sample(~50K). The temperature range of the sample goes from ~50K to ~20K for the coldest ones peaking at λ > 160 µm.
- General trend on Fig.2 : compact group on panel left spreading on panel right revealing submm excess starting at ~350µm (ie Haro11)
- The commonly adopted model with β = 2 for a temperature of 30-40K gives a 350/500 ratio of 3.1-3.4. "Obvious" submm excess can be detected for lower values of 350/500 : Haro11, VIIZw403, HS0052
- BUT : IIZw40 presents a 350/500 ratio of 3.7 AND an excess (Fig.3) starting after 500 µm : excess hard to see if it starts after 500 µm

Zoom on particular cases

These 3 galaxies have been chosen because of their behaviour in the FIR domain and also because they span a range in metallicity.

Haro11 - is one of the most distant galaxies of the sample (D~90Mpc). This LIRG presents all the characteristics of an extreme starburst (SFR~25Msun.yr-1) Its particularity is that it shows very little neutral hydrogen and molecular gas. About the FIR behaviour:

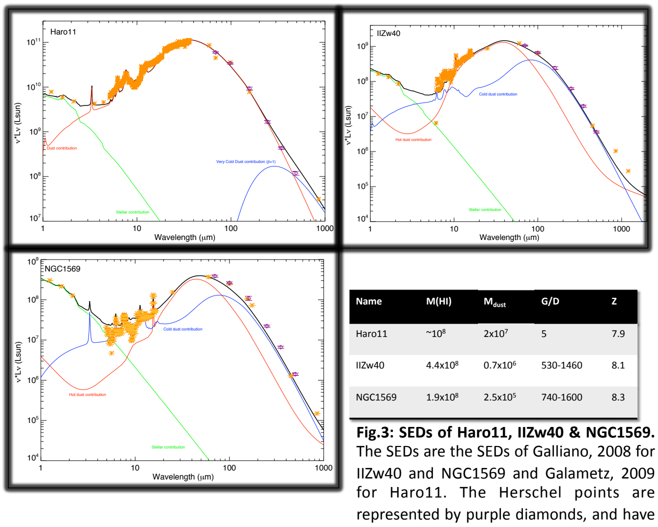
- Excess compared to fiducial model.
- Additional Very Cold Dust (VCD) component with β=1 and T~10K can explain the excess (Galametz, 2009).
- Starts clearly at 500µm : highlights the necessity to have SPIRE constraints.

IIZw40 - is a Blue Compact Dwarf Galaxy at D~10Mpc. Remnant of two merging galaxies, it is also a very young starbusrt. HI is very abundant whereas the low CO intensity implies low molecular content. (Galliano, 2005). About the FIR behaviour :

- Very steep decreasing from 160 to 500µm (coherent with Fig.1).
- Excess seems to start after 500µm so not visible on the color diagrams. Need mm data.
- Additional VCD component has already been used to explain the excess (Galliano, 2005).

NGC1569 - is a nearby galaxy (D~2.2Mpc) containing two SSCs wich burned most of their gas reservoir in a recent burst of star formation. It is a little bit colder than the 2 others as it can be seen on the various diagrams. About the FIR behaviour :

- The model here seems to be underestimating the whole FIR emission but the 500µm point seems to reveal a little excess, as seen on Fig.2 right.
- The 850µm point confirms a small excess.



Name	M(HI)	M_{dust}	G/D	Z
Haro11	~10^8	2x10^7	5	7.9
IIZw40	4.4x10^8	0.7x10^6	530-1460	8.1
NGC1569	1.9x10^8	2.5x10^5	740-1600	8.3

Fig.3: SEDs of Haro11, IIZw40 & NGC1569. The SEDs are the SEDs of Galliano, 2008 for IIZw40 and NGC1569 and Galametz, 2009 for Haro11. The Herschel points are represented by purple diamonds, and have just been overlayed on the plot. The orange stars are the other observational constraints used in the fit (Spitzer, LABOCA, SCUBA, IRAS).