Seyfert and Star Formation Activity in the Far IR: Results from the SAFIR project

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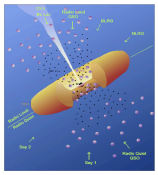
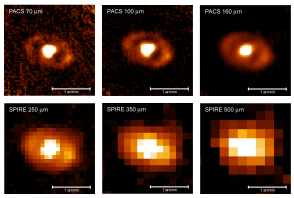


Summary *(see http://arxiv.org/abs/1210.7489)*

- Small (15.1h) guaranteed time (GT) proposal implemented at the Herschel Space Observatory
- To perform imaging photometry of a reduced sample of nearby Seyfert galaxies (18 objects). The sample has been chosen based in the availability of multi-wavelength data (specially MIR).
- 6-band imaging: 70, 100, 160µm (PACS) and 250, 350, 500µm (SPIRE)
- Aimed at studying:
  - The physical nature of the nuclear IR emission by means of multi-component SED fitting. The emission is well characterised by the superposition of a warm component (torus), a cold component (dust heated by star formation) and a very cold component (dust heated by the interstellar radiation field).
  - The star formation properties of AGN hosts, as traced by cold dust.

NGC 3081 *(Ramos-Almeida et al., MNRAS 2011, 417, L46)*

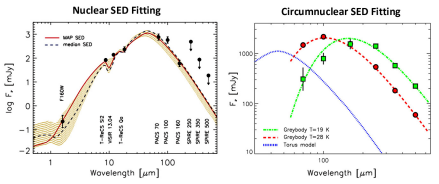
•Early-type barred spiral, hosting a Seyfert 2 nucleus with star formation in nested rings.



•A clumpy torus has been modeled for the AGN. FIR data inclusion results in a notable increase of the torus outer radius and a flattening of the radial distribution of clouds. Remaining fitting parameters are in agreement with those obtained without FIR range.

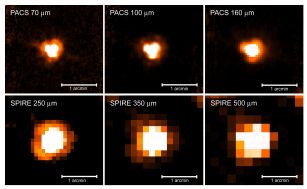
•On larger scales (1.7 kpc ≤ r ≤ 5.4 kpc), the FIR emission can be reproduced by cold dust at T=28±1 K (greybody with β=2), heated by young stars within the galaxy disc (likely located at the nuclear ring)

•The FIR emission from the outer part of the galaxy is compatible with dust heated by the interstellar radiation field (T=19±3 K)



Mrk 938 *(Esquej et al., MNRAS 2012, 423, 185)*

•Morphologically peculiar galaxy proposed to be the remnant of a gas-rich merging of two unequal mass galaxies. It contains a Seyfert 2 AGN and it is classified as LIRG.

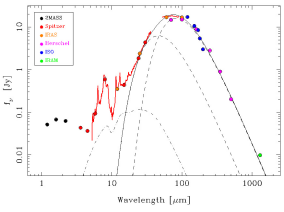


•A multi-wavelength study was performed for this object combining X-ray, NIR, MIR and PACS/SPIRE FIR data to characterise the origin and nature of its strong emission in the IR range.

•The IR spectrum is dominated by obscured star formation activity located in a compact region with r ≤2kpc.

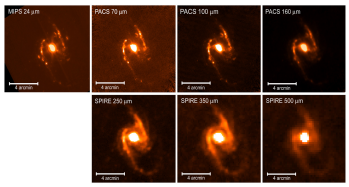
• The AGN contribution to the total IR luminosity is ≈2% (supporting the proposed scenario that intense dusty SBs are responsible for the high IR luminosities in most local LIRGs)

•The FIR spectrum can be fitted by two MBB components, with β=2 and T1=63K and T2=35K.

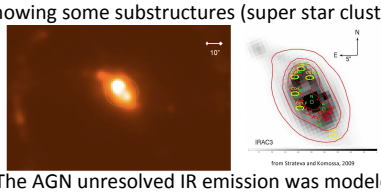


NGC 1365*(Alonso-Herrero et al., MNRAS 2012, 425, 311)*

•Supergiant barred spiral galaxy (SB(s)b).It contains a Seyfert 1.5 AGN, hosts a powerful nuclear starburst ring with an approx. diameter of 2 kpc and is nearby a LIRG object(18.6 Mpc).



•The strong star formation activity in the ring is resolved by the Herschel/PACS imaging data showing some substructures (super star clusters).



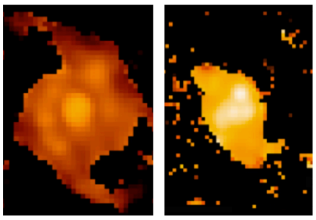
•The AGN unresolved IR emission was modeled with a clumpy torus model showing that the contribution of the AGN, being dominant at 24 µm, is only ~1-2% within the central 30 arcsec at 70 µm. The estimated torus size is ~ 5 pc.

•Intense SF is taking place, as traced by 24 and 70 µm BB and [Ne II] & PAH features

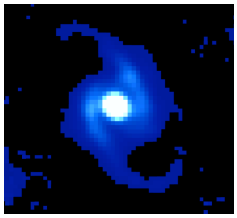
•Comparison of the IR-derived SFR with that obtained from H_α observations indicates that ~85% of the on-going star formation within the inner Linbland ressonance (ILR)region is taking place in dust–obscured regions.

Dust properties of resolved AGN host galaxies *(Sánchez-Portal et al., AcPol submitted)*

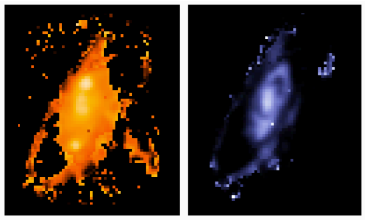
- A study of the dust properties of spatially well- resolved AGN hosts has been started. The objects are NGC 1365, NGC 4258, NGC 1566 and NGC 5728.
- These have an apparent size large enough to allow a detailed analysis of the spatial dust properties, notably temperature and mass that can be directly compared with the star formation characteristics.
- Producing maps of the dust mass, temperature, and SFR. The spatial resolution corresponds to that of the largest beam (SPIRE 500 µm). Pixel size of 14".
- Assuming an optically thin emission, the flux density can be expressed as $f_\nu \propto \nu^\beta B(\nu, T_{dust})$ where β is the dust emissivity. Up to three components (warm, cold, very cold) are being considered.
- Several examples of the on-going work are shown below:



Temperature maps of NGC 1365 (left) and NGC 1566 (right). Average temperatures range from ≈17– 18 K in the inter-arm regions to T ≈23–24 K in the bright spots within the spiral arms. The highest average dust temperatures are observed in the central region of NGC 1365 with T ≈26 K.
NGC 1566 is a bright (LC II-III), nearby (11.83 Mpc) SAB(s)bc spiral galaxy harboring a Seyfert type 1.5 nucleus.



SFR map of NGC 1365, obtained from the grey body IR luminosity integrated between 8 and 1000 µm.



SFR map of NGC 1365, obtained from the grey body IR luminosity integrated between 8 and 1000 µm.

- Maps created with a single temperature component with a fixed emissivity β = 2
- The temperature maps generated closely follow the topology of the star formation regions, with the highest temperatures corresponding to areas of high SF activity
- SFR maps of NGC 1365 obtained by integrating the SED and applying Kennicutt 1998 relation
- Excellent agreement with the structures revealed by the dust temperature map
- The most intense star formation is taking place in the circum-nuclear region (within the ILR).
- Outstanding SFR is also taking place in the arms.

The spatial distribution of dust mass can be obtained from the temperature maps, using the expression:

$$M_{dust} = \frac{D_L^2 f_\nu}{\kappa_\nu B_\nu (T_{dust})}$$

(adapted from Hildebrand 1983), assuming κ(250)=4.99 $cm^2 g^{-1}$(Li&Draine 2001)

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