# HerMES: The far-infrared properties of type-2 quasi-stellar objects

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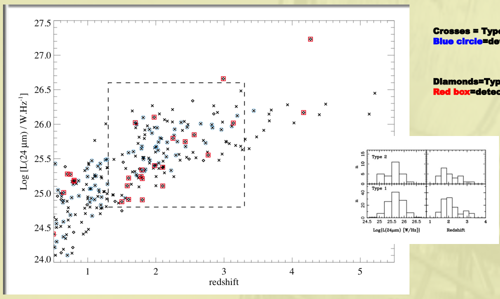
## Abstract

We present 250 μm observations of type-2 quasi-stellar objects (QSOs) observed in the Spitzer First Look (FLS) and Lockman SWIRE fields as part of the Herschel Multi-tiered Extragalactic Survey (HerMES). Samples of type-1 and type-2 QSOs are selected matched in 24 μm luminosity (a proxy for AGN power) and redshift (1<z<3 where the accretion luminosity density peaks). We find that the type-2 objects have higher far-infrared flux densities and a significantly higher detection rate than the type-1 objects. Computed mean values for the star-formation rate and dust mass of the type-2s are <SFR>=747±136 M☉/yr and <Dust Mass>=(1.2±0.2)×10^8 M☉ respectively. These results are inconsistent with the basic Unified Scheme for AGN. Rather they argue that significant obscuration is provided by material in the host galaxies of the type-2s which might be related to the formation of the galaxy spheroids in these objects.


## Samples




Crosses = Type 1
Blue circle=detected

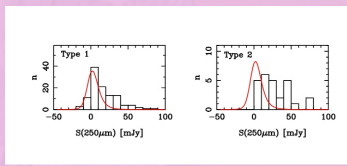
Diamonds=Type 2
Red box=detected

- Samples matched in redshift (1.3<z<3.3) and 24 μm luminosity (24.8<Log[L(24)(W/Hz)]<26.6) (see insert).
- Type-1 QSOs taken from the SDSS (Abazajian et al. 2009) and Hectospec surveys (Papovich et al. 2006).
- Type-2 QSOs taken from Martinez-Sansigre et al. (2005) [19 objects], Polletta et al. (2006) [7 objects] and Lacy et al. (2007) [1 object].

## Detection rate

- Using a 3-σ (5-σ) detection criterion we detect 40 (21) out of 112 type-1 QSOs and 18 (14) out of 26 type-2 QSOs.
- A simple binomial test shows that these detection rates are inconsistent at the 99.96% (99.995%) level with the type-2 objects having a higher detection rate.

## Flux density distributions




Histograms of the distribution of 250 μm flux densities for the QSOs. The red lines show the distribution of flux densities in the entire FLS field normalised by a factor equal to the number of QSOs in the sample divided by the number of pixels in the FLS image.

- Each QSO distribution displays an obvious tail of positive , bright flux densities.
- While the type-1 distribution matches the average pixel distribution at low flux densities, the type-2 distribution is skewed towards higher values.
- A two-sample Kolmogorov-Smirnov test shows that the two flux density distributions are different at the >99% level.
- Mean flux densities are 16.7±1.8 mJy (type 1) and 30.1±8.8 mJy (type 2).

## Physical properties

- SED modelling shows that the far-infrared emission is from star-formation NOT reprocessed AGN emission (e.g. see poster by Hatziminaoglou et al.).
- We calculate the mean SFR for the type-2 QSOs by scaling their 250 μm flux densities with that of Mrk 231 placed at the redshift of the QSO. We find <SFR>=747±136 M☉/yr (range is 300 - 600 M☉/yr).
- The mean dust mass was calculated in the standard manner, again assuming that Mrk 231 is a good local analogue. We find <Dust mass>=(1.2±0.2)×10^8 M☉ (range is 2×10^7 – 5×10^8 M☉)

## Interpretation

- The bulk of the type-2 sample is taken from the work of Martinez-Sansigre et al. who used a radio pre-selection criteria. We checked whether this radio pre-selection might be biasing our results using the VLBI results of Klöckner et al. (2009). We find no trend between the fraction of recovered radio flux and the far-infrared determined SFR. This finding suggests that the radio flux is not due to star-formation on kpc scales and therefore no bias exists.
- Therefore the excess far-infrared emission in the type-2 objects can be linked to an excess of dust and hence star-formation in their host galaxies. The calculated dust masses would be sufficient to obscure the nucleus if placed within a radius of a few kpc.
- It is thus plausible that the type-2 QSOs are observed during an epoch of enhanced star-formation activity linked to the growth phase of the galaxy spheroid.

## References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2. Klöckner H. et al. 2009, MNRAS, 398, 176
3. Lacy M. et al. 2007, AJ, 133, 186
4. Martinez-Sansigre A. et al. 2005, Nature, 436, 666
5. Papovich C. et al. 2006, AJ, 132, 231
6. Polletta M. et al. 2006, ApJ, 642, 673


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