HerMES, the Herschel Multi-tiered Extragalactic Survey: Candidate High-Redshift Galaxies discovered with SPIRE

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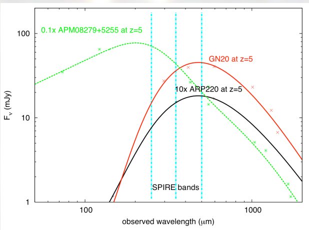
Motivation

Only a handful of FIR-bright, optically-faint "submillimeter galaxies" have been found at z > 4 (e.g., Coppin et al. 2010). Large-area SPIRE surveys will detect many more such objects – if they are numerous, and if they can be effectively selected from the maps – giving unique information about the rate at which hyperluminous galaxies appear in the universe prior to their peak at z ≈ 2.5.

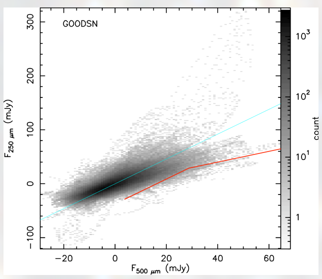


Left: Selection of SPIRE galaxies is motivated by templates of known submillimeter galaxies. When placed at z = 5, star-forming ULIRG/HLIRG templates have a spectral peak near the SPIRE 500 μm channel. We show as examples a galaxy equal to ten Arp220's, and the z = 4 submillimeter-selected galaxy GN20 (Pope et al. 2005; Daddi et al. 2009). "500 μm peakers" are relatively rare, but dozens can be identified in the Science Demonstration Phase HerMES maps. In the SPIRE bands alone, AGN-dominated templates (like APM08279+5255) at high redshift are more difficult to distinguish from lower-redshift star-forming galaxies and are missed in our analysis.

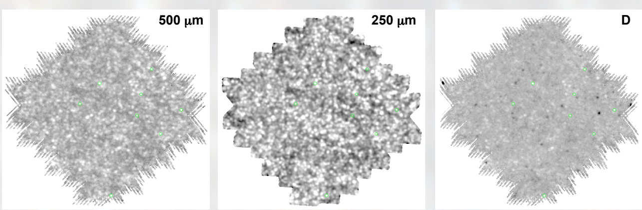
SPIRE Map Processing and Source Selection

We have adopted an image-based selection process for this analysis. We start by subtracting the 250 μm map from the 500 μm map with a relative scaling which subtracts "average" galaxies.

Right: Flux vs. flux for GOODSN field, represented as a 2D histogram of all the map pixels. The cyan line shows the average galaxy color derived by minimizing the variance in the scaled difference map D. The red curve shows the cut used to select objects for our red SPIRE galaxy sample.



$$D = 0.92\ M_{500\mu m} - 0.40\ M_{250\mu m}$$



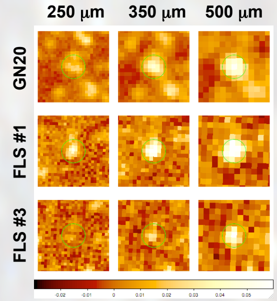
Above: 500 μm, 250 μm, and difference maps for GOODSN field. For ease of performing the difference, we binned each map to the same 4" pixel scale using the SMAP pipeline, then interpolated and smoothed to the same resolution. Sources which survive all flux density cuts are shown with green circles.

Source identification is performed on the difference map for sources above a threshold in D. The list is culled to include only sources with $F_{500\mu m} > F_{350\mu m} > F_{250\mu m}$.

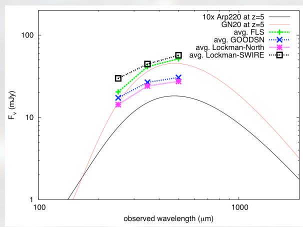
Basic Characteristics of the Red SPIRE Galaxy Sample

Field	Survey Area (sq. deg.)	Criteria	Number
FLS	6.4	$0.92F_{500\mu m} - 0.40F_{250\mu m} > 30$ mJy	20
		above, and $F_{500\mu m} > F_{250\mu m}$	16
		above, and $F_{500\mu m} > F_{350\mu m} > F_{250\mu m}$	**7**
GOODS-N	0.38	$0.92F_{500\mu m} - 0.40F_{250\mu m} > 15$ mJy	25
		above, and $F_{500\mu m} > F_{250\mu m}$	19
		above, and $F_{500\mu m} > F_{350\mu m} > F_{250\mu m}$	**8**
Lockman-North	0.48	$0.92F_{500\mu m} - 0.40F_{250\mu m} > 15$ mJy	33
		above, and $F_{500\mu m} > F_{250\mu m}$	22
		above, and $F_{500\mu m} > F_{350\mu m} > F_{250\mu m}$	**11**
Lockman-SWIRE	14.5	$0.92F_{500\mu m} - 0.40F_{250\mu m} > 36$ mJy	33
		above, and $F_{500\mu m} > F_{250\mu m}$	32
		above, and $F_{500\mu m} > F_{350\mu m} > F_{250\mu m}$	**18**

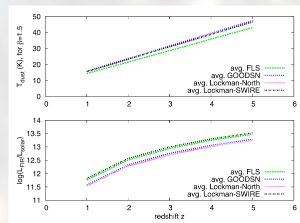
Above: Survey fields and source counts. Thresholds for source identification within the difference map are based on field depth.



Right: Three example sources in the SPIRE sample – the prototype GN20, a source which has the same color but is a brighter, and a source which is fainter and redder.



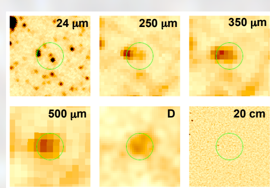
Above: The average spectrum of the sources selected in each field is plotted (points), superposed on the z = 5 templates (curves).



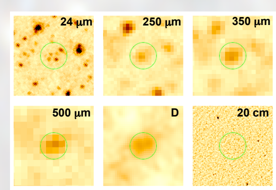
Above: The dust temperature and source luminosity are unknown until the redshift can be determined. Are these sources z = 1.5 ULIRGs with T_{dust} = 20 K, or z = 4 HLIRGs with T_{dust} = 35 K? Are some lense amplified, as expected for many of the brighter high-redshift objects (Negrello et al. 2007)?

Counterparts and Follow-Up

Counterpart identification from existing ancillary data is ongoing but appears to be difficult in general.



Above: The 24 μm counterpart of this source is likely revealed by the deblending effect of the differencing method. However, the source is undetected in the radio.



Above: At SPIRE resolution, this source is coincident with several 24 μm sources and is undetected in the deep radio image (Morrison et al. 2010).

One of the important outcomes of this analysis is a target list for follow-up with other telescopes. The use of ground-based (sub)millimeter telescopes is a key next step in getting accurate source positions and in measuring the turnover in the rest-frame FIR spectrum, and we have initiated such observations and proposals.

Acknowledgments / References

SPIRE has been developed by a consortium of institutes led by Cardiff Univ. (UK) and including Univ. Lethbridge (Canada); NAOC (China); CEA, LAM (France); IFSI, Univ. Padua (Italy); IAC (Spain); Stockholm Observatory (Sweden); Imperial College London, RAL, UCL-MSSL, UKATC, Univ. Sussex (UK); Caltech, JPL, NHSC, Univ. Colorado (USA). This development has been supported by national funding agencies: CSA (Canada); NAOC (China); CEA, CNES, CNRS (France); ASI (Italy); MCINN (Spain); SNSB (Sweden); STFC (UK); and NASA (USA).

References: Coppin et al., 2010, arXiv:1004.4001; Daddi et al., 2009, ApJ, 694:1517; Morrison et al., 2010, ApJS, 188, 178; Negrello et al., 2007, MNRAS 377:1557; Pope et al., 2005, MNRAS, 358:149