



Open Research Online

The Open University's repository of research publications and other research outputs

A 15 m selected sample of hHigh-z starbursts and AGNs

Conference or Workshop Item

How to cite:

Hernán-Caballero, A.; Pérez-Fournon, I.; Rowan-Robinson, M.; Rigopoulou, D.; Afonso-Luis, A.; Hatziminaoglou, E.; González-Solares, E.; Montenegro-Montes, F. M.; Vila-Vilaro, B.; Farrah, D.; Lari, C.; Vaccari, M.; Babbedge, T.; Oliver, S.; Clements, D.; Serjeant, S.; Pozzi, F.; La Franca, F.; Gruppioni, C.; Valtchanov, I.; Lonsdale, C. and the SWIRE team (2008). A 15 m selected sample of hHigh-z starbursts and AGNs. In: The 2nd Spitzer Conference: Infrared Diagnostics of Galaxy Evolution, 14-16 Nov 2005, Pasadena, CA. USA.

For guidance on citations see [FAQs](#).

© 2008 Ranga-Ram Chary, Harry I. Teplitz, Kartik Sheth, eds.

Version: Version of Record

Link(s) to article on publisher's website:

http://www.aspbooks.org/a/volumes/article_details/?paper_id=28120

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data [policy](#) on reuse of materials please consult the policies page.

oro.open.ac.uk

A 15 μm Selected Sample of High- z Starbursts and AGNs

A. Hernán-Caballero,¹ I. Pérez-Fournon,¹ M. Rowan-Robinson,² D. Rigopoulou,³ A. Afonso-Luis,¹ E. Hatziminaoglou,¹ E. González-Solares,⁴ F. M. Montenegro-Montes,⁵ B. Vila-Vilaro,⁶ D. Farrah,⁷ C. Lari,⁵ M. Vaccari,² T. Babbedge,² S. Oliver,⁸ D. Clements,² S. Serjeant,⁹ F. Pozzi,¹⁰ F. La Franca,¹¹ C. Gruppioni,¹⁰ I. Valtchanov,² C. Lonsdale⁷ and the SWIRE team

¹*Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain*

²*Astrophysics Group, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2BZ, UK*

³*Department of Astrophysics, Oxford University, Keble Road, Oxford OX1 3RH, UK*

⁴*Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA*

⁵*Istituto di Radioastronomia, INAF, via Gobetti 101, I-40129 Bologna, Italy*

⁶*National Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan*

⁷*Department of Astronomy, Cornell University, Ithaca, NY 14853*

⁸*Astronomy Center, University of Sussex, Brighton BN1 9QH, UK*

⁹*Centre for Astrophysics & Planetary Science, School of Physical Sciences, University of Kent, Canterbury, Kent CT2 7NR, UK*

¹⁰*INAF, Osservatorio Astronomico di Bologna, via Ranzani 1, 40127 Bologna, Italy*

¹¹*Dipartimento di Fisica, Università Roma Tre, via della Vasca Navale 84, 00146 Roma, Italy*

Abstract. We report results from our *Spitzer* GO-1 program on IRS spectroscopy of a large sample of Luminous Infrared Galaxies and quasars selected from the European Large Area ISO Survey (ELAIS). The selected ELAIS sources have a wide multi-wavelength coverage, including ISOCAM, ISOPHOT, IRAC and MIPS (from SWIRE), and optical photometry. Here we present the sample selection and results from the IRS spectroscopy.

1. Sample Selection and IRS Observations

The sources were selected from the European Large Area ISO Survey (ELAIS) final band-merged catalog of Rowan-Robinson et al. (2004). The sample consists of 70 sources with 15 μm fluxes larger than ~ 1 mJy and spectroscopic or estimated photometric redshifts $z > 1$. Although no color cuts were applied, the objects are brighter than $r \sim 24$, the limit of the Isaac Newton Telescope Wide Field Survey CCD photometry used in the optical identification of ELAIS sources (González-Solares et al. 2005). The 15 μm observations and catalog are

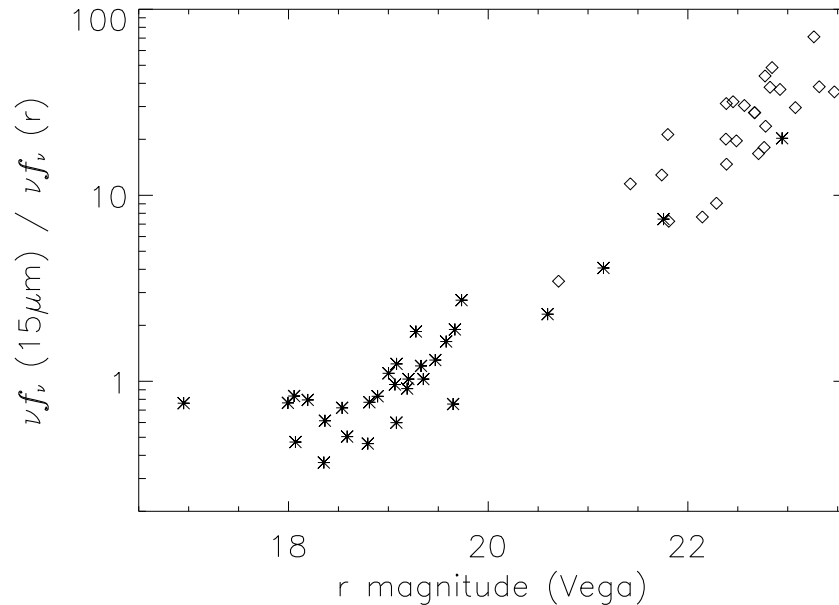


Figure 1. Ratio $\nu f_\nu(15\mu\text{m}) / \nu f_\nu(r)$ for the ELAIS-IRS sources versus r -band magnitude. Diamonds: star-forming galaxies and obscured AGN; stars: unobscured AGN.

presented in Vaccari et al. (2005).

Low-resolution IRS spectroscopy was carried out using all four IRS modules, covering thus the wavelength range between 5 and 40 μm . Typical total exposure time per object was of about one hour. Figure 1 shows the ratio of νf_ν at 15 μm over r -band as a function of the r -band magnitude. ELAIS-IRS targets with bright magnitudes have blue optical to 15 μm colors typical of type-1 AGN (Afonso-Luis et al. 2004; González-Solares et al. 2005; Hatziminaoglou et al. 2005). Objects with fainter optical IDs are identified as obscured AGN and star-forming galaxies.

2. Results from the IRS Spectroscopy

The IRS spectra were extracted from the SSC pipeline processed data using SPICE, and individual spectra of each object were coadded. A selection of the IRS spectra is shown in figure 2. The IRS spectra show a wide variety of spectral shapes and clear features (PAHs in emission and silicate absorption at 9.7 μm) can be seen in a number of objects. The IRS spectra can be classified into three main categories: (a) smooth featureless continuum, usually associated with type-1 AGN, (b) PAH features in emission and silicate absorption, and (c) silicate absorption.

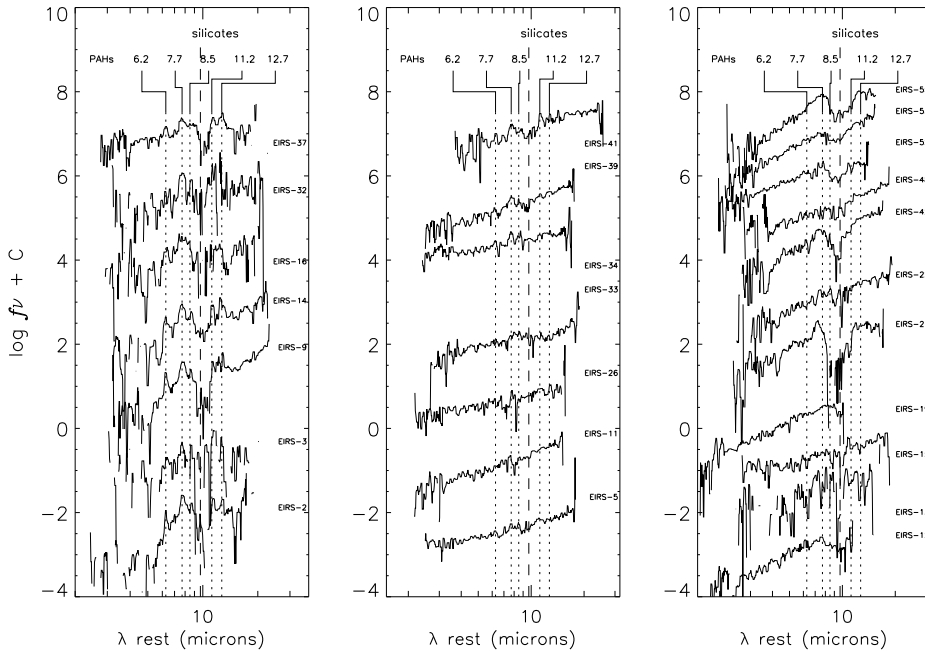


Figure 2. A selection of ELAIS-IRS spectra showing different types of mid-IR SEDs, including strong PAH, star-forming dominated SEDs (left), power-law continua with or without PAH features (center) and silicate absorption (right).

Redshifts can be measured for a number of objects from the IRS spectroscopy, and they agree with the optical spectroscopic redshifts, whenever available. They are also consistent in most cases with the photometric redshifts obtained from template fitting to the optical and IRAC photometry from SWIRE (Lonsdale et al. 2003, 2004). Objects in our sample with PAH features and starlight-dominated optical SEDs are interpreted as star-forming galaxies. Their redshifts are in the range $0.6 < z < 1.2$ and the far-IR (8-1000 μm) luminosities are in the range $\sim 10^{11} - 10^{12} L_{\odot}$.

Some galaxies are found at higher redshifts, up to $z \sim 2$. They only show silicate in absorption and no bright PAH features. Their luminosities are in the ULIRG range. Their SEDs and IRS spectra suggest they are obscured AGN.

3. Comparison with Other IRS Samples of High- z Galaxies

Our sample, selected at 15 μm from the ELAIS survey, differs in redshift range and luminosity from those in other major IRS surveys (fig. 3). The sample selection of Yan et al. (2005) was based in color cuts using the Spitzer 24 and 8 μm bands and one optical band (R), while Houck et al. (2005) selected objects with very red 24 μm to R band colors. Our ELAIS-IRS sample selection aims to cover all possible types of $z \gtrsim 1$ sources selected at 15 μm , regardless of their

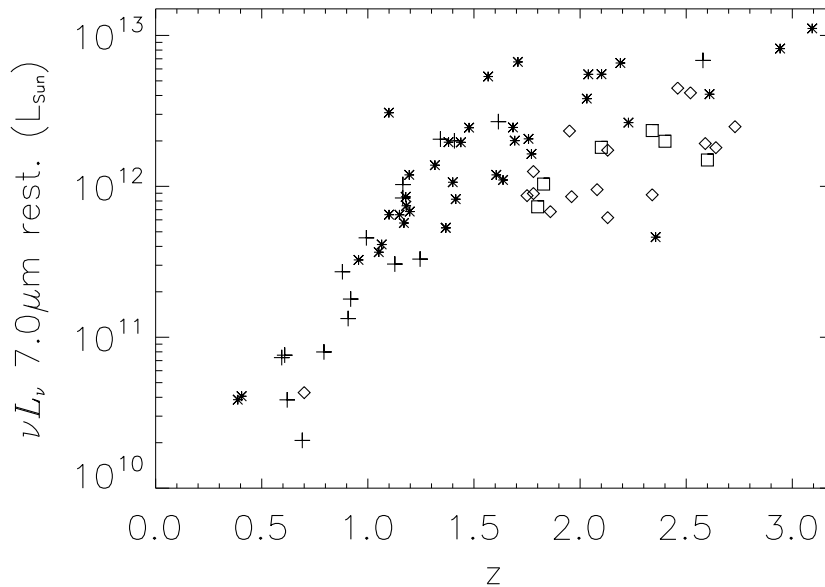


Figure 3. Restframe $7\ \mu\text{m}$ luminosity (νL_ν) versus redshift for the ELAIS-IRS sample. Objects with optical spectroscopic redshifts (mostly AGN) are shown as stars, whereas those with z estimated from their IRS spectra are plotted as plus signs. For comparison, samples from Yan et al. (2005) and Houck et al. (2005) are represented as squares and diamonds, respectively.

mid-IR colors. The results show that a large fraction of the star-forming galaxies in the sample is at $z \sim 1$, as expected from the photometric redshifts estimates, and is consistent with bright PAH features (7.7 and $8.5\ \mu\text{m}$) redshifted into the ISOCAM LW3 band ($15\ \mu\text{m}$). At low redshift ($z < 1$) our sample includes luminous infrared star-forming galaxies and two AGN at intermediate redshifts ($1.0 < z < 1.8$) we find AGN, both obscured and unobscured, and star-forming galaxies, all with restframe $7\ \mu\text{m}$ luminosities comparable to those in the Yan et al. (2005) and Houck et al. (2005) samples. At $z \gtrsim 1.8$ we find AGNs, typically more luminous than the comparison IRS samples.

The ELAIS-IRS sample constitutes one of the best samples of luminous and ultraluminous IR sources with IRS spectroscopy in the redshift range ($0.5 < z < 1.8$). A number of spectroscopic follow-up programs are underway. The ELAIS-IRS sample and detailed results are presented in Hernán-Caballero et al. (2006).

Acknowledgments. This work is based on observations made with the *Spitzer Space Telescope*, which is operated by the Jet Propulsion Laboratory, Caltech under NASA contract 1407.

References

- Afonso-Luis, A. et al. 2004, MNRAS, 354, 961
González-Solares, E. et al. 2005, MNRAS, 358, 333
Hatziminaoglou, E. et al. 2005, AJ, 129, 1198
Hernán-Caballero, A. et al. 2006, in preparation
Houck, J. R. et al. 2005, ApJ, 622, 105
Lonsdale, C. J. et al. 2003, PASP, 115, 897
Lonsdale, C. J. et al. 2004, ApJS, 154, 54
Rowan-Robinson, M. et al. 2004, MNRAS, 351, 1290
Vaccari, M. et al. 2005, MNRAS, 358, 397
Yan, L. et al. 2005, ApJ, 628, 604