Diagnostics of Dusty vs Non-Dusty Early-Type Galaxies

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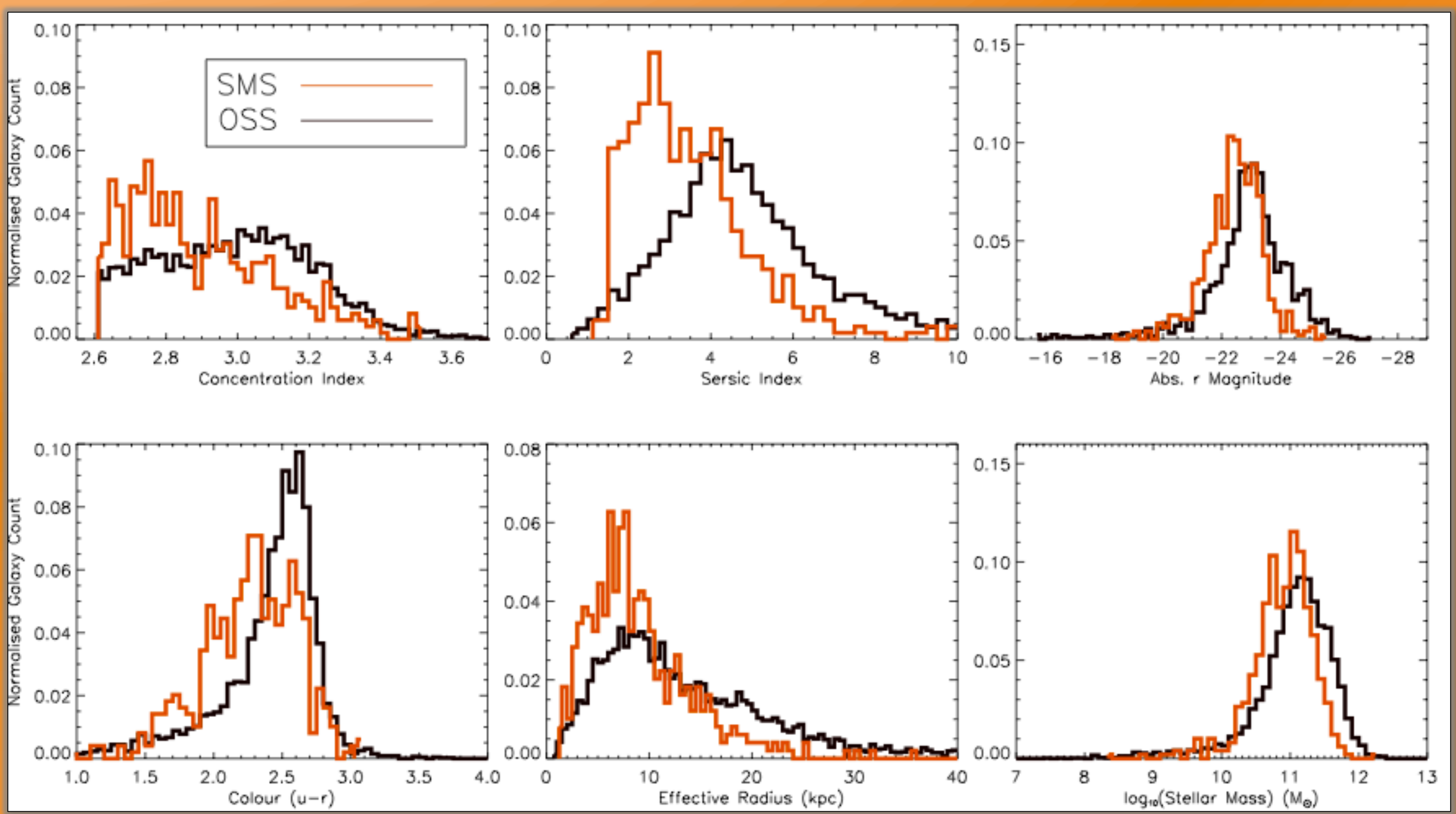
Motivation

The availability of multi-wavelength data for large samples of galaxies over large areas of sky is making it possible to trace the physical processes that lead to stellar emission, dust absorption and emission in Early-type Galaxies (ETGs; Ellipticals/Lenticulars). By tracing the cold dust masses and other properties belonging to most dusty ETGs, we can begin to understand the origins of this dust: internal (from stellar mass loss) or external (accretion during merging events).

Host ETG Properties

We look at distributions of host galaxy parameters (shown in Fig. 2) and test them using the KS-test to see whether the samples are drawn from the same parent distribution. Both of the samples have had galaxies with AGN activity removed (based on the Kauffmann et al. (2003) prescription of the BPT diagram). Results from these statistical tests are shown in Table 1. Most of the properties are shown to have significantly different distributions on a 1% level. Two exceptions are UV luminosities and surface densities, which are similar on a 2% level (shown in Fig. 2).



Greybody Fitting

We fit modified Planck functions to the sub-mm detected galaxies containing at least 3σ detections in all 3 SPIRE wavebands. These preliminary fits are used to gauge the range of dust mass and temperature that can be fit with these data. When left free, the rest-frame dust temperatures range from 9-30K for ETGs at $z \leq 0.1$ and, shown for specific mass in Fig. 3, this causes dust mass variations from 10^6 – $10^8 M_\odot$. ETGs in our sample at higher redshift have small effective radii and possible background contamination, resulting in overly large dust masses. Our mean dust mass for ETGs at $z \leq 0.1$ is $7.1 \times 10^7 M_\odot$, which agrees with recent work done by Rowlands et al (2012) on H-ATLAS Science Demonstration Phase ETGs.

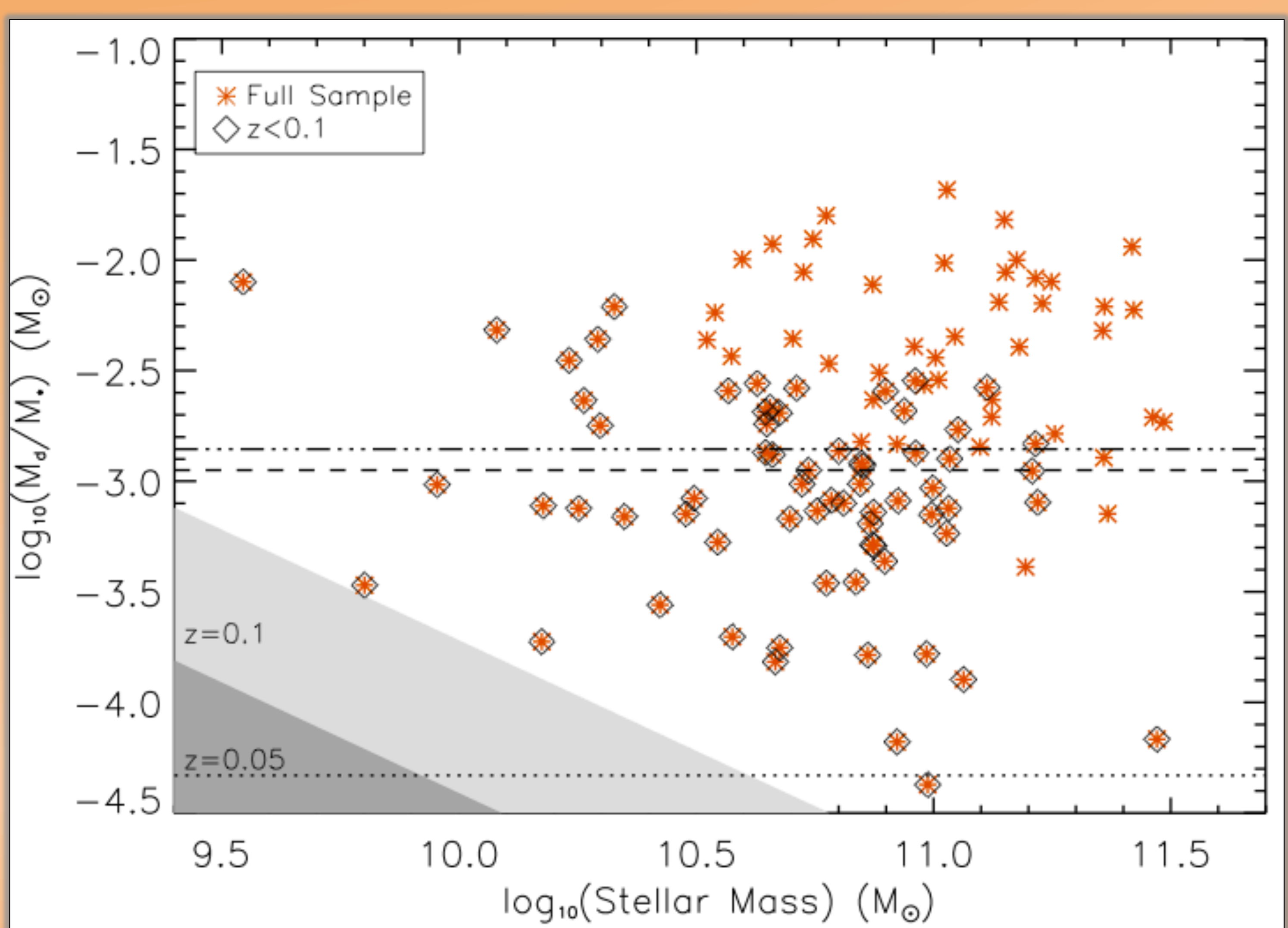


Fig. 3 – Specific Dust Mass plotted as a function of stellar mass (orange points) for all ETGs with 3σ detections, highlighting those at $z \leq 0.1$ with black diamonds. We show the mean specific dust mass for ETGs up to redshift z=0.1 (dot-dash line) and the mean specific dust mass for the ETGs in the H-ATLAS SDP field by Rowlands et al. (2012) (dashed line). We also show the Smith et al (2012) mean specific mass for a sample of ETGs in the Herschel Reference Survey (dotted line). The shaded regions are included to indicate the ability to detect dust emission at different redshifts.

Sub-mm Detected ETG Sample

We present a sample of 508 ETGs with H-ATLAS SPIRE detections, with counterparts in the GAMA multi-wavelength database. These are selected using an optical morphological proxy, concentration index ≥2.6, and refined by visual classification of the optical images. As a control sample, we use the same proxy to select GAMA ETGs which are undetected by H-ATLAS. Choice of such a proxy is based on reliability and completeness of ETG selection compared to other possible proxies (see Fig. 1).

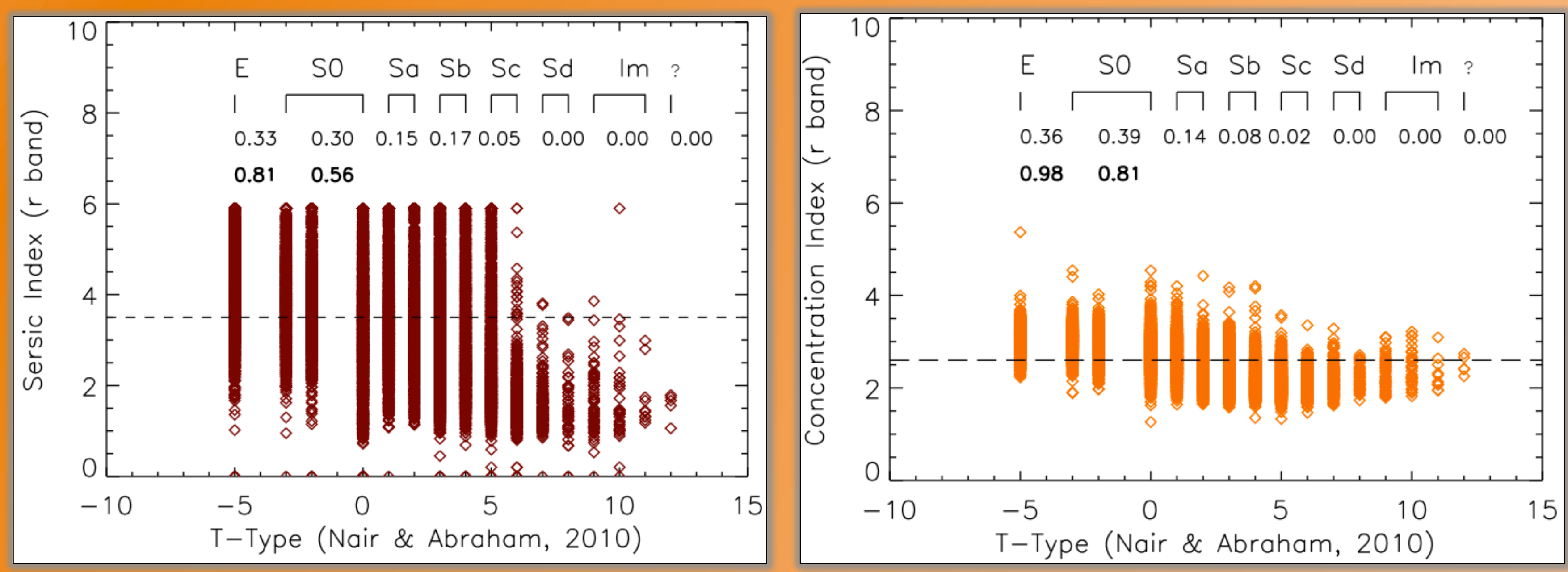


Fig. 1 – Visual classifications of an optical control sample (Nair & Abraham, 2010) against possible optical proxies. Concentration index is shown to be a more reliable and complete proxy than Sersic index, based on the proportions shown in these plots.

Fig. 2 – Normalised distributions of Sub-mm (SMS) and Optical (OSS) Samples in (left-to-right) Concentration index, Sersic index, Absolute r-band magnitude, (u-r) colour, intrinsic effective radius and stellar mass spaces. Distribution shapes are vastly different in most cases, with the sub-mm detected ETGs containing typically lower values.

Parameter	KS-stat (D)	KS-prob	Sample Size		Mean Value	
			Submm	*Optical*	*Submm*	*Optical*
Concentration index (r band)	0.227726	8.93×10^{-21}	494	4754	2.89	2.99
Sersic index (r band)	0.360503	0.0	494	4754	3.53	5.42
Absolute Magnitude (r band)	0.142607	2.01×10^{-8}	494	4754	-22.41	-22.63
Colour (u-r band)	0.273414	7.93×10^{-30}	494	4754	2.26	2.41
Effective Radius (r band)	0.281310	1.50×10^{-31}	494	4754	9.38	16.86
Stellar mass	0.218411	3.46×10^{-19}	494	4754	10.89	11.04
Absolute Magnitude (NUV band)	0.201328	2.45×10^{-12}	385	2506	-17.32	-16.95
Absolute Magnitude (FUV band)	0.212566	1.05×10^{-13}	385	2506	-16.81	-16.45
Surface Density	0.160768	1.02×10^{-8}	418	2845	2.53	4.44

Table 1: KS statistics for Dusty vs Non-Dusty ETGs

The 2-tailed Kolmogorov-Smirnov test results for the distribution of host galaxy parameters in our ETGs. In both samples, ETGs with a discernible AGN presence have been removed. We show the relevant tested parameters in Column 1, with the KS-statistic D and associated probability for null hypothesis in Columns 2 & 3. The relevant sample sizes are given in Columns 4 & 5, and the mean values of the respective distributions are given in the final two columns.

Future Work and Conclusions

Based on diagnostics shown here, we can identify both optically and sub-mm detected ETGs as massive objects in a similar range of environments. The dusty ETGs show bluer optical colours and smaller radii than the non-dusty ETGs. As low redshift, the sub-mm detected galaxies show average dust masses of $(7.1 \pm 0.1) \times 10^7 M_\odot$ for a range of T_{dust}=9-30K. These masses are in agreement with other results from H-ATLAS, but are a factor of 10 higher than those in the recent Herschel Reference Survey.

Future work involves combining SPIRE data with WISE MIR data for these dusty ETGs. These data will be fit with a series of template models accounting for radiative heating and stochastic heating, to identify which mechanism is dominant in these galaxies. The results of this type of SED fitting will give us good indication of the origin of cold dust in our ETGs.

References

Kauffmann G. et al., 2003, MNRAS, 346, 1055
Nair P. B., Abraham R. G., 2010, ApJS, 186, 427
Rowlands K. et al., 2012, MNRAS, 419, 2545
Smith M.W.L. et al, 2012, ApJ, 748, 123