Dusty early-type galaxies and passive spirals

Kate Rowlands[1]

With: L. Dunne, S. Maddox, N. Bourne, H. L. Gomez, S. Kaviraj, S.P. Bamford, S. Brough, S. Charlot, E. da Cunha, S.A. Eales, A. M. Hopkins, R.C. Nichol, A.E. Sansom, R. Sharp, D.J.B. Smith, P. Temi, P. van der Werf + H-ATLAS and GAMA.

[1] The University of Nottingham

Email - ppxkr@nottingham.ac.uk

Introduction

Early-type galaxies (ETGs) are thought to be devoid of dust and star-formation, having formed most of their stars at high redshift. We present the detection of the very dustiest ETGs in a large area blind submillimetre survey with Herschel (H-ATLAS – Eales et al. 2010), where the lack of pre-selection in other bands makes it the first unbiased survey for cold dust in ETGs. We compare to a control sample of optically selected ETGs to investigate how the two populations are different. We also highlight the properties of an interesting population of passive spirals detected by Herschel.

Sample selection

H-ATLAS sample -

- 250μm 5σ detection.
- Reliable optical counterpart (Smith et al. 2011).
- Spectroscopic redshift + GAMA optical photometry (Hill et al . 2011)
- Visual morphological classification

} 1088 galaxies


44 Early-type (E/S0)


496 Late-type


23 Mergers

525 Unknown

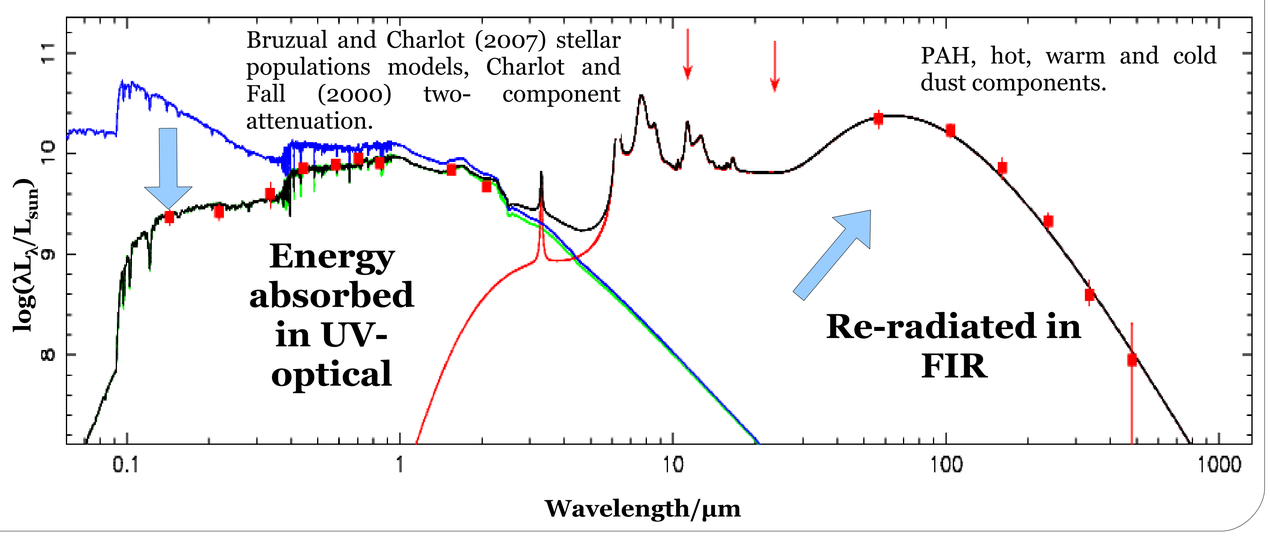
Control sample -

- Same r-band magnitude and redshift distribution as H-ATLAS sample – gets rid of selection effects.
- Not detected at 250μm.
- Morphologically classified.

} 1052 galaxies

SED fitting

- Energy balance model - da Cunha et al. (2008).
- Bayesian approach - statistical constraints on physical parameters:
  - Compare observed galaxy SED to large library of models which encompass all parameter combinations.
  - Build marginalised likelihood distribution of physical parameters - compute χ^2 goodness of fit for each model – generate probability density function (PDF).



Properties of H-ATLAS early-types

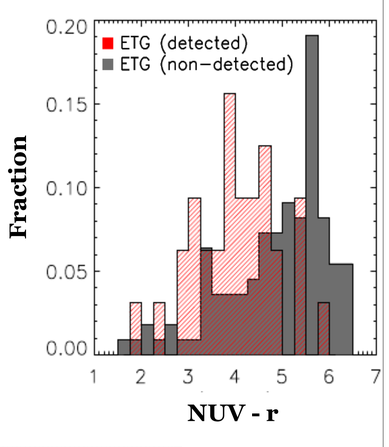
- $\langle M_{dust} \rangle = 5.5 \times 10^7\ M_{sun}$
- $\langle SFR \rangle = 0.7\ M_{sun}/yr$.
- <stellar population age> = 2.8 Gyr.
- ~ 76 percent have not had a burst of star-formation in the last 10^9 years – majority of sample have residual star-formation left over from last major star-formation episode.
- Range of UV-optical colours, many ETGs exist in transition region between blue cloud and red sequence.

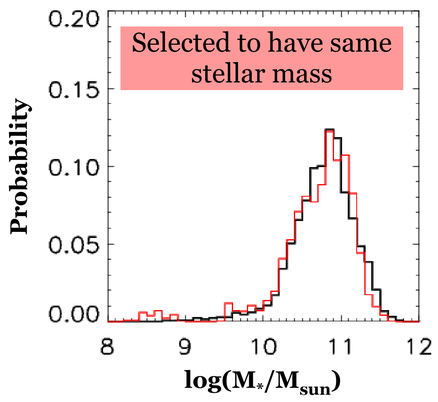
Are H-ATLAS ETGs different to control ETGs?

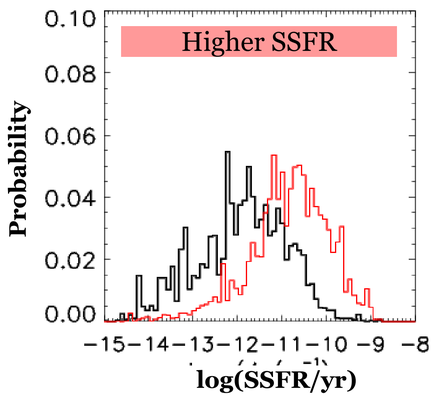
- ***H-ATLAS ETGs are >10x dustier than control ETGs.*** Dust mass of 233 control ETGs inferred from stacking:

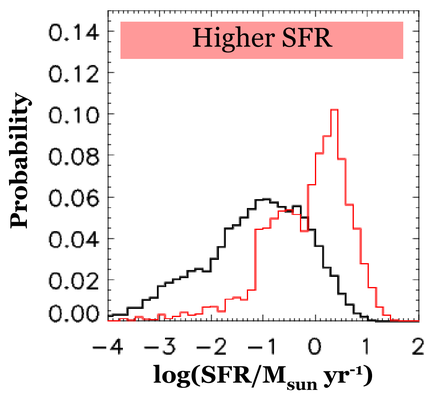
  $(0.8\text{-}4.0) \times 10^6\ M_{sun}$.

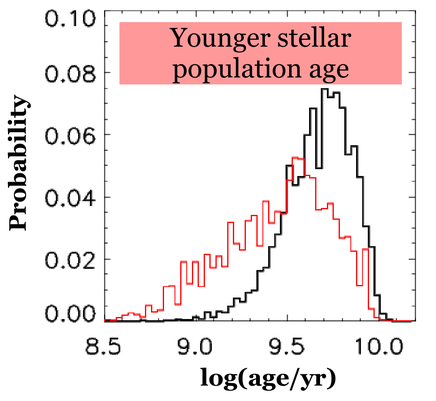
- $\langle SFR \rangle = 0.07\ M_{sun}/yr$.
- Control ETGs are 1.0 magnitudes redder – contain less dust so colour dominated by stellar populations.
- Stellar populations of control ETGs are 1.8 Gyr older.
- H-ATLAS and control ETGs inhabit similar density environments (but beware sample size and density range).











Origin of dust in ETGs

➔ Internal sources (mass loss from stars).

➔ External sources (mergers and accretion).

- Chemical evolution modelling (Gomez et al. in prep) - ***AGB stars cannot produce enough dust to account for that observed in H-ATLAS ETGs.*** Need either:
  - External dust source – accrete $1 \times 10^7\ M_{sun}$ of dust within last ~1 Gyr.
  - Grain growth in the ISM.
  - Dust destruction timescale longer – ETGs deficient in X-ray gas?
    - dust grains shielded from radiation?

Passive spirals

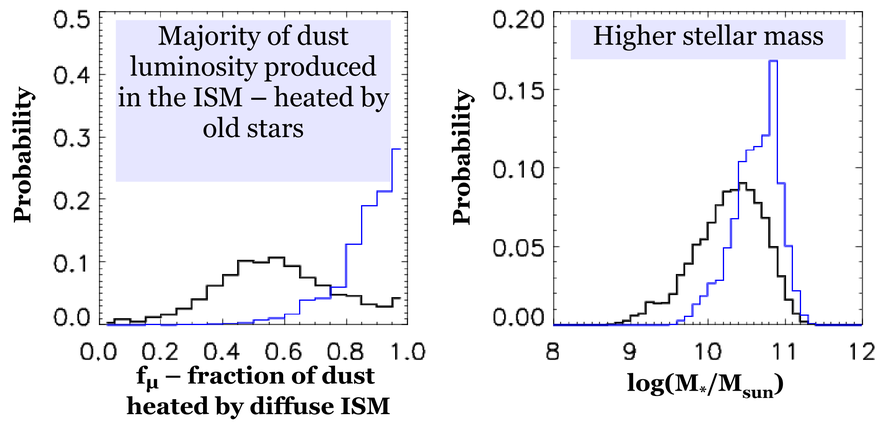
➔Dust extinction?

or

➔ Old stellar population?

(e.g. Wolf et al. 2005, 2009; Masters et al. 2010).

- 19 passive spirals - have low specific star-formation rate (SSFR)$<10^{-11}\ yr^{-1}$. Comparing to average PDFs of H-ATLAS spirals with SSFR$>10^{-11}\ yr^{-1}$, we find passive spirals have:



- Green/red NUV-r colours are due to old stellar population and not increased dust reddening.
- Appear to reside in the same environments (but beware small sample size).

Conclusions

- ETGs detected by Herschel are >10x dustier than in optically selected ETGs of a similar stellar mass.
- Majority of H-ATLAS ETGs have residual low-level star-formation left over from the last burst a few Gyrs ago, and their optical colours suggest they exist in the transition region between the blue cloud and the red sequence.
- Control ETGs have older stellar populations than H-ATLAS ETGs, which is consistent with the red UV-optical colours of the control ETGs.
- ETGs detected in H-ATLAS contain more dust than can be accounted for by production in AGB stars. Most of the dust must be formed in the ISM, or an external source of dust from mergers is needed. It is also possible that in H-ATLAS and control ETGs the dust destruction timescale is longer.

References:

- Bruzual G., Charlot S., 2003, MNRAS, 344, 1000
- Bruzual G., Charlot S., 2007, in prep
- Charlot S., Fall S. M., 2000, ApJ, 539, 718
- da Cunha E., Charlot S., Elbaz D., 2008, MNRAS, 388, 1595
- Eales S., et al., 2010, PASP, 122, 499
- Gomez et al. in prep
- Hill D. T., et al., 2011, MNRAS, 412, 765
- Masters K. L., et al., 2010b, MNRAS, 405, 783
- Smith D. J. B., et al., 2011a, MNRAS, in press
- Wolf C., et al., 2005, A&A, 443, 435
- Wolf C., et al., 2009, MNRAS, 393, 1302