Exploring the Evolution of Dust Temperature using Spectral Energy Distribution Fitting in a Large Photometric Survey

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1) Introduction

- Understanding its dust content is crucial to inferring accurate information about a galaxy. Dust properties (e.g. temperature) can change with time, affecting the evolution and properties of galaxies.
- Currently there is little consensus on the dust temperature evolution with redshift ($T_d - z$), with plateauing (e.g. Liang et al. 2019) to exponential-like (e.g. Viero et al. 2022) derived relations.
- Most previous work is based on infrared (IR) data only, ignoring the stellar component which acts as the heating source and the spectrum of which can influence dust parameters.
- We investigate the $T_d - z$ relation using full spectral energy distribution (SED) fitting from the ultraviolet (UV) to the IR.

2) Results and Contamination Issues

Stacked COSMOS2020 (Weaver et al. 2021) star-forming galaxy subsamples are fit using BAGPIPES (Carnall et al. 2018), finding a linear trend in the $T_d - z$ relation out to $z \approx 5$ (Figure 1, see section 4 for higher-z galaxies). However, UV emission is detected beyond the Lyman limit, meaning contamination is present in the sample, biasing results. To get a clean, robust ("*gold*") sample, we remove any galaxy where:

- A probability of chance alignment, the chance emission originates from another object, was > 0.1
- Derived photometric redshifts from BAGPIPES fits and the COSMOS2020 catalogue disagree by > 0.3

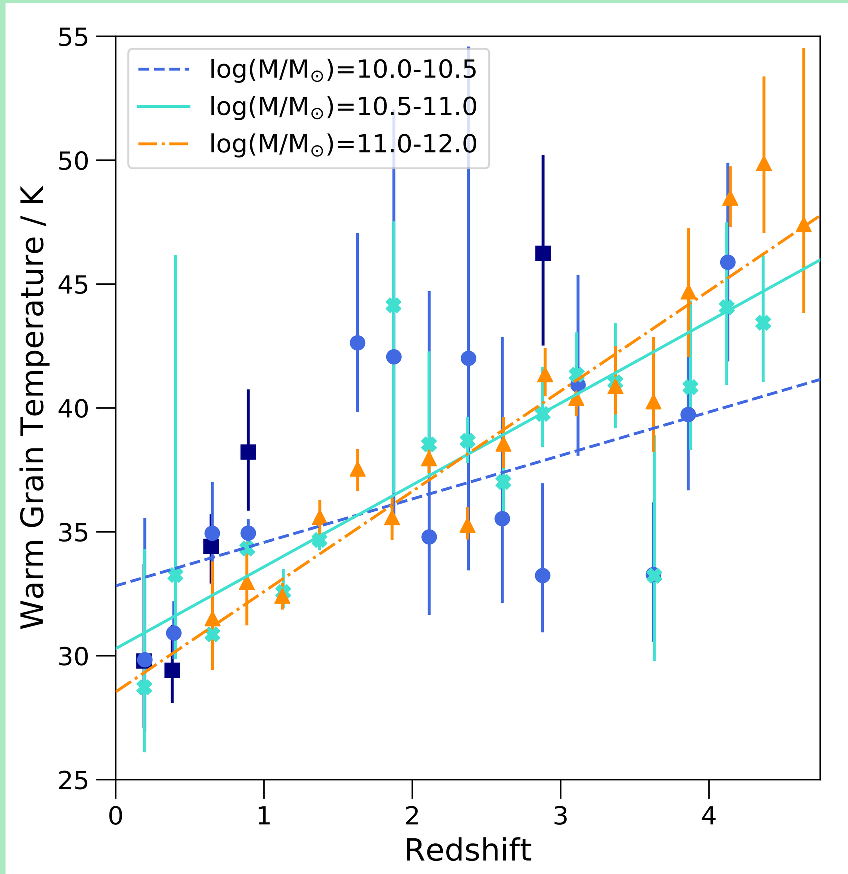

Figure 1. Derived T_d for each stacked subsample. Mass bins of log(M/M$_\odot$) = 9.5-10.0, 10.0-10.5, 10.5-11.0 and 11.0-12.0 are shown as dark blue squares, medium blue circles, light blue crosses and orange triangles, respectively.

3) *Gold* Sample Results and Literature Comparison

Our *gold* sample supports a linear trend in the $T_d - z$ relation (Figure 2), but is systematically offset to the full sample, deriving lower temperatures by $4.0^{+5.0}_{-1.9}$ K when comparing subsamples (Figure 3). Good agreement is found with most literature, but a discrepancy exists with Viero et al. (2022) who analysed the same sample without robust contamination or stellar emission consideration (Figure 4).

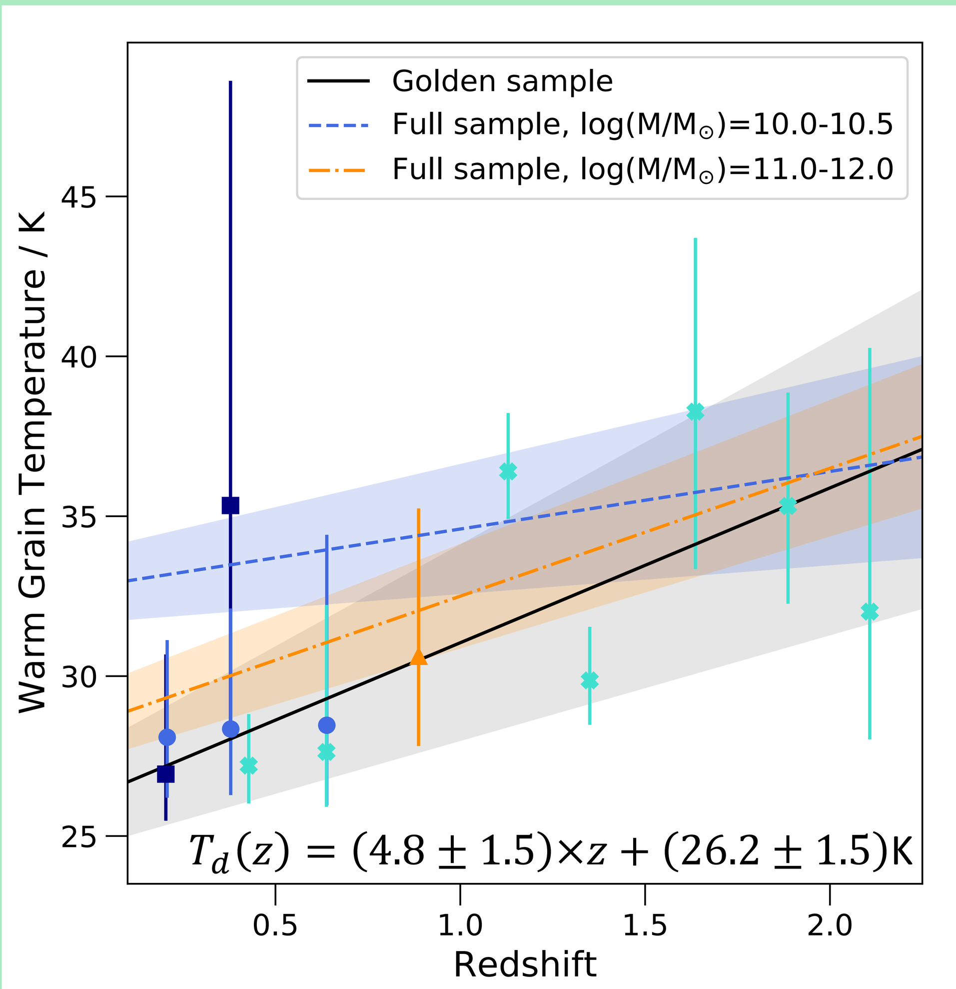

Figure 2. Same as Figure 1 for the *gold* sample. The best-fit to the sample is shown in black and quoted.

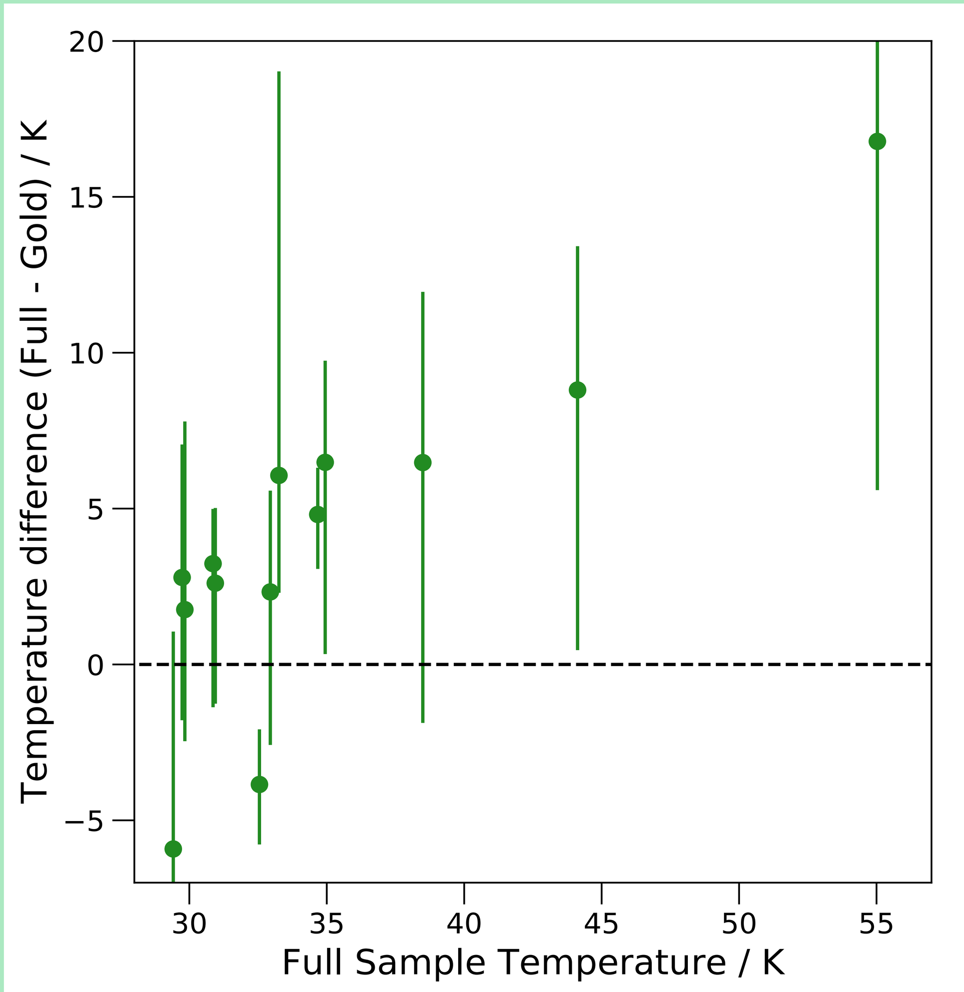

Figure 3. Difference in derived temperatures for subsamples in both the full and *gold* samples.

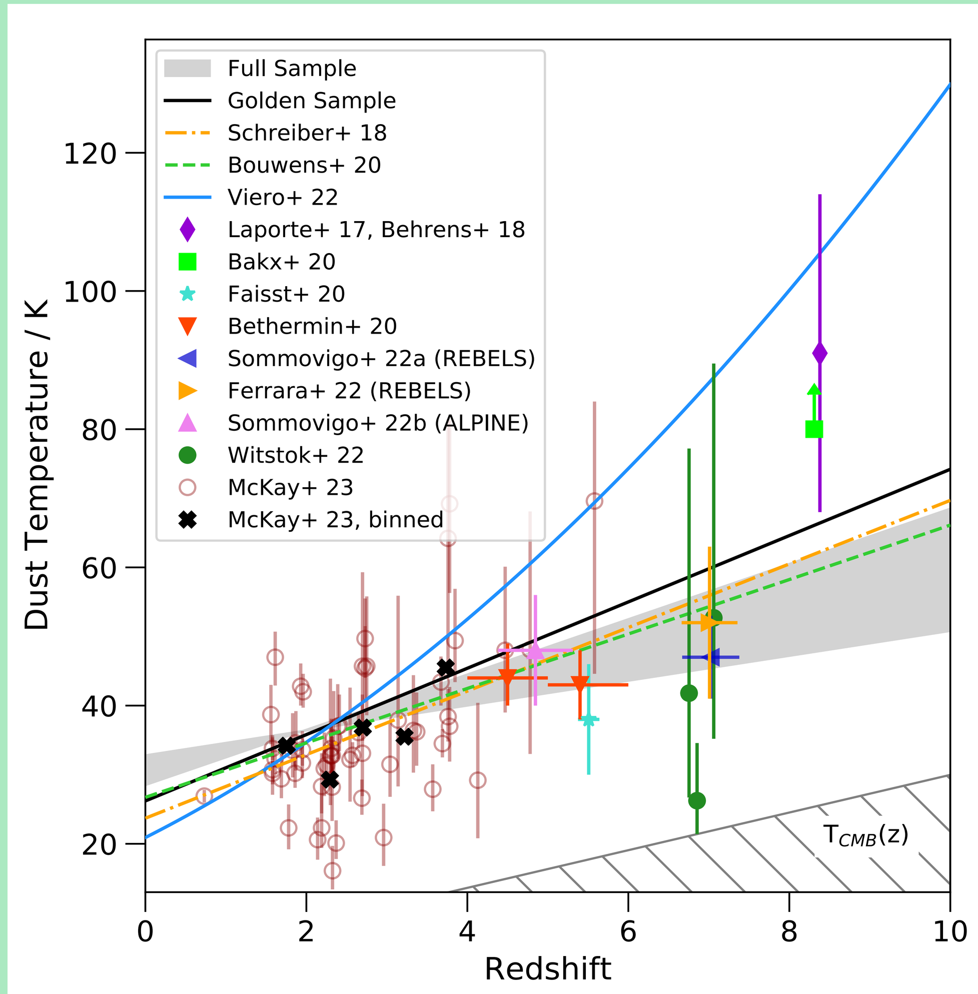

Figure 4. Our derived relations in context of previous work. Shaded region is the limits from the full sample (Figure 1) and black line is our *gold* sample (Figure 2).

4) UV-IR disconnect

In 15 of 20 subsamples at $z > 4.5$, the best-fitting model constrains the stellar component while under-predicting the IR flux (Figure 5). This is likely due to a spatial separation in peak UV and IR emission from galaxies which breaks the fundamental energy-balance formalism.

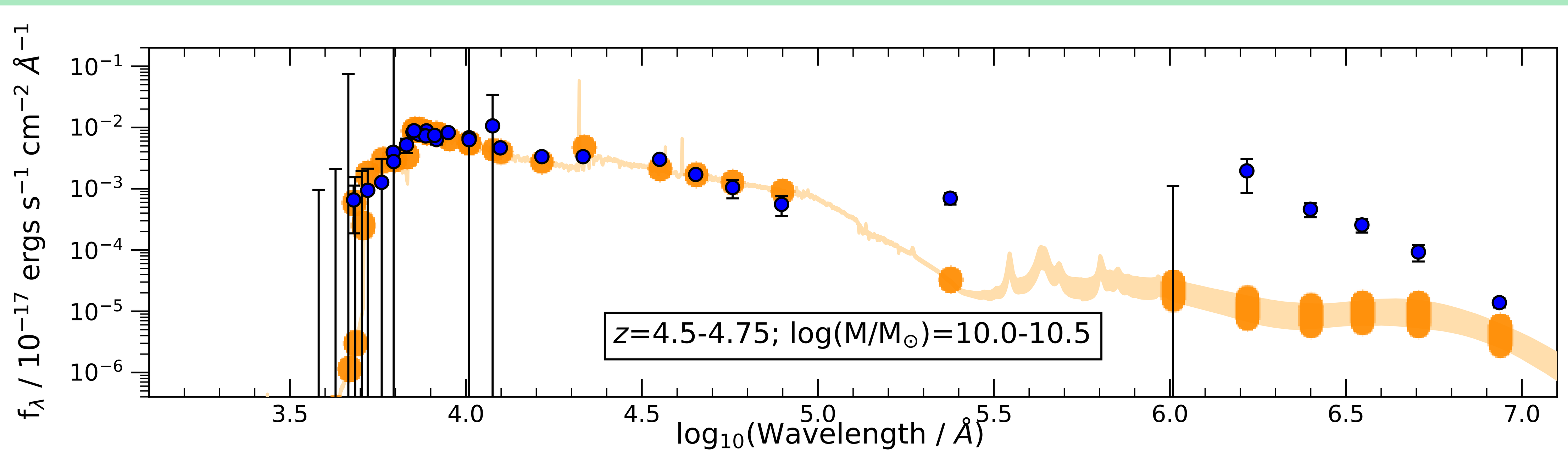

Figure 5. Best-fit model from BAGPIPES in orange against observational data in blue. The subsample bin is labelled.

5) Conclusions

- We find a linear $T_d - z$ relation, which agrees with majority of literature but differs crucially to Viero et al. (2022).
- Contamination biases relation to higher dust temperatures, thus providing an upper limit if not accounted for.
- In $z > 4.5$ subsamples, energy-balance formalism underpredicts the IR flux, implying presence of contamination, highly-extincted stellar population, or a non-stellar dust-heating component.

References

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