Systematics in the determination of dust mass from far-infrared SEDs: the role of temperature-dependent opacity

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One of the most powerful tools in the study of the interstellar medium is the spectral energy distribution (SED) of thermal dust emission, which is mainly observed at far-infrared and submillimeter wavelengths (~100–1000 μm). Using a dust emission model such as a modified blackbody, this SED can be fit to reveal the dust temperature, as well as its column density, which can be converted to a gas column density via a conversion factor. The dust SED is therefore a tracer of the structure and local conditions of the interstellar medium, and plays a key role in topics such as star formation and galactic chemical evolution.

One caveat regarding SED fitting is that its results depend strongly on the adopted value for dust opacity. This is especially important in view of recent experimental findings which suggest that our previously adopted values for far-infrared dust opacity, extrapolated from shorter wavelengths, may be systematically biased. These experimental results suggest that dust opacity is higher than previously thought and, crucially, dependent on temperature: as temperature increases, the opacity of dust analogues tends to increase and its dependence on wavelength becomes shallower. It is therefore essential to understand how this new understanding on dust opacity changes our interpretation of dust emission SEDs.

We are working on quantifying the effect of temperature-dependent dust opacity in SED fits results. This effect has been identified as a possible source of bias in fit results for some time, but has not yet been studied quantitatively. We use optical data on several candidate dust materials, collected by multiple laboratories, to model dust opacity as a function of wavelength and temperature. We then produce a grid of synthetic galaxy SEDs for various temperature distributions and redshifts. By fitting these synthetic observations with a fixed-opacity model we can then recover the bias in the fit results. We find that the dust masses recovered by the fit can be underestimated or overestimated depending on the target's temperature and redshift, as well as the choice of photometric bands.

Finally, we exploring the relevance of our findings for the determination of dust abundances in the early Universe, where dust mass estimates pose a challenge to dust formation models (the so-called "dust budget crisis").