Bayesian modelling of dust emission in galaxies

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A large fraction of the energy in a galaxy can be emitted in the infrared (IR) and is due to the reprocessing of the stellar light by dust grains from the interstellar medium. Understanding this emission is crucial to get a better handle on the dust content of a galaxy (and thus its enrichment in metals), on the dust size distribution (which is linked to the formation and destruction processes of dust grains), on the dust temperature, and ultimately link these parameters to galaxy evolution.

The spectral energy distribution (SED) of galaxies in the IR has now been sampled by several missions like IRAS, Spitzer, WISE, Herschel, Planck. Furthermore, the spatial resolution of these observations enables us to study these SEDs in many resolved regions within nearby galaxies. Modelling point by point these SEDs in nearby galaxies, one can create maps of the different parameters of interest (dust temperature, spectral index, PAH mass fraction, ...).

However, free parameters from dust models are known to be degenerate. For example, even the simplest power-law-modified blackbody model is plagged by a strong degeneracy between the dust temperature and the spectral index. Taking such degeneracies into account is crucial to be able to understand relationships between the results of the modelling (column density versus temperature, temperature versus spectral index,...). Recent efforts to do so have been carried on by using a Bayesian hierarchical method on a simple power-law-modified blackbody model [1].

The goal of this thesis is to apply the Bayesian hierarchical method on a more complete dust model (DUSTEM [2]) and to use it fit the point-by-point SEDs of two of the most nearby galaxies: the Small and the Large Magellanic Clouds. The DUSTEM dust model has been successfully used in detailed analysis of regions in our Galaxy, as well as in nearby galaxies. The Magellanic Clouds are an ideal location to study dust as 1) they have been observed by all recent infrared missions, 2) they are sufficiently close that we are able to resolve individual regions and thus follow dust through different environments, and 3) they are at a low metallicity (1/2 and 1/5 solar) and hence are interesting environments to study how dust differs in such conditions compared to higher metallicity environments like our Galaxy.

The thesis will be supervised by Bernd Vollmer and Caroline Bot (Observatoire de Strasbourg) and Karl Gordon (STScI, Baltimore). The thesis is funded through grants to the STScI (Space Telescope Science Institute, Baltimore, MD, USA) and as a consequence, the student will spent a large fraction of the time in the United States at STScI. Possible extensions of the thesis include the study of other nearby galaxies (M31, M33). The thesis could also be expanded by using another dust model (Draine et al.) and comparing one or both to the "simple" modified black-body fitting. The study of dust in nearby galaxies provides a rich area to probe the details of dust physics and its importance in galaxy evolution. Our understanding of the lifecycle of dust in galaxies is evolving rapidly due, in a large part, to the large amount of new IR data (Spitzer, Herschel, Planck). The study proposed here will directly impact our understanding of the lifecycle of dust through answering questions about the spatial distribution of the dust components (PAH mass fraction, dust emissivity variations, sub-mm excess) and how it compares to potential formation (AGB stars, SNRs, ISM itself) and destruction sites (star formation, SNRs).

[1] B. C. Kelly, R. Shetty, A. M. Stutz, J. Kauffmann, A. A. Goodman, R. Launhardt, *Dust Spectral Energy Dustributions in the Era of Herschel and Planck: A Hierarchical Bayesian-Fitting Technique,* ApJ, 752, 2012
[2] M. Compiègne, L., Verstraete, A. Jones, J.-P. Bernard, Boulanger F., N. Flagey, J. Le Bourlot, D. Paradis, N. Ysard, *The global dust SED: tracing the nature and evolution of dust with DustEM,* A&A, 525, 2011