Modeling the Mid-infrared Spectra of Interstellar Grains (PAHs) with hierarchical Bayesian inference

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The knowledge of interstellar dust grain properties is crucial to understanding numerous physical processes in galaxies. Mid-infrared (MIR) spectra contain most of the solid-state resonance features of interstellar grains, including the unidentified infrared bands (UIB) ranging from 3.3 to 17 microns. They arise from a statistical mixing of polycyclic aromatic hydrocarbons (PAH) of different sizes and structures.

The spectral features of galaxies in the MIR have been widely observed by the *Spitzer* (IRS; 5.2 – 38 microns) and the AKARI (IRC; 2.5 – 5 microns) satellites. Carefully combining the spectra from both instruments and inter-calibrating the different modules have allowed us to analyze all the MIR features jointly. To that purpose, we have developed a new spectral decomposition software applying the hierarchical Bayesian (HB) inference to model heterogeneous samples of nearby galaxies and galactic regions simultaneously. The HB approach addresses the numerous degeneracies of the model and extracts the maximum information from the data, accounting for various sources of uncertainties, without overinterpreting the observations. In particular, we have performed a case study of M82 to analyze the available archived data consistently and interpret the spatial variations of MIR features with the physical conditions of interstellar PAHs (ionization, size distribution, dehydrogenation, etc.). This work is pertinent for the upcoming observations of the JWST, which has a spectroscopic capability (NIRSpec: 0.6 – 5 microns; MIRI: 5 – 27 microns) covering the entire spectral range of the UIBs, along with unprecedented angular resolution and sensitivity.