Blind signal separation in mid-IR spectroscopic astronomical data

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The James Webb Space Telescope (JWST) will deliver an unprecedented quantity of high-quality spectral data over the 0.6-28 μm range. Specific tools are required to provide efficient analysis of such large data sets.

In this study, we aim at illustrating the potential of unsupervised learning methods to get insights into the chemical evolution of the populations that carry the aromatic infrared bands (AIBs), more specifically polycyclic aromatic hydrocarbons (PAHs) species and very small carbonaceous grains (VSGs). We consider ISO-SWS spectra which mimic best the spectral information that will be achieved by JWST.

After extracting the AIB contribution from the observed spectra, we applied a non-negative matrix factorization (NMF) algorithm [1]. We used the output of a new geometric blind signal separation method, MASS [2], to initialize the NMF algorithm and retrieve a pseudo unique solution, i.e. a set of four elementary spectra. We demonstrate that this set is consistent with that obtained with a Monte Carlo method but much faster.

The main characteristics of the four spectra are those of populations dominated by cationic PAHs, neutral PAHs and evaporating VSGs [3] and large ionized PAHs [4], as previously identified [5]. Our dataset also covers the 3 μm range for the first time. We find that the improved spectral resolution reveals additional chemical information compared to previous studies. However, the interpretation is now limited by the lack of spatial information. Further progress is expected with the upcoming JWST.

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