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ANALYSIS OF THE EMISSION OF VERY SMALL DUST PARTICLES FROM SPITZER-IRS OBSERVATIONS, USING BLIND SIGNAL SEPARATION METHODS

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Abstract. The nature of the very small dust particles which carry the mid infrared interstellar emission is still uncertain. The combination of spectral and spatial studies of photodissociation regions (PDRs) is one way to have access to the nature of these particles, by probing their processing under UV radiation. Several PDRs were observed as part of the SPECPDR program, using the Spitzer-IRS spectrograph in the spectral mapping mode. In order to extract as much information as possible from the data, we applied signal processing algorithms known as"Blind Signal Separation" methods to the spectral cubes of four PDRs. For each one of them, we were able to extract two to three spectra with similar properties from a PDR to another. The extracted spectra were attributed to populations of polycyclic aromatic hydrocarbons (PAHs) and a population of very small grains (VSGs). Using the spatial information from the reconstructed distribution maps of these populations, and the spectral information in the extracted spectra, we infer the chemical properties of these particles, and their evolution inside the PDR.

1 Observations and Blind Signal Separation analysis

The mid-infrared (5-35 μm) emission of interstellar dust is commonly attributed to polycyclic aromatic hydorcarbons (PAHs), emitting the well known aromatic infrared bands (AIBs), and very small grains (VSGs), producing the underlying continuum. The exact nature and properties of both PAHs and VSGs is still very uncertain. We have observed their emission in several photodissociation regions using the infrared spectrograph IRS onboard the Spitzer Space Telescope, providing four 5-35 μm spectral cubes. Each observed spectrum in a given spectral cube is the result of the combined emission of several populations of dust. Our goal here is to provide the spectra of each type of population in order to understand how they are linked one to another and how they are affected by the local physical conditions. In order to recover the original spectrum of each dust population we have used a Blind Signal Separation (BSS) analysis and more particularly the Non-Negative Matrix facorisation by Lee & Seung (2001). The spectra of a given cube are placed in a 2D matrix X. This matrix is then approximated by the product W×H, where H contains the original spectra corresponding to each dust population and W is the weight matrix. This approximation of X is reached using the iteration algortithm described in Lee & Seung (2001).

2 Results and interpretation

We were able to extract two or three spectra (case of NGC 7023NW) corresponding to different populations of dust particles (Fig. 1) in the four PDRs. The first spectrum called arbitraly *Signal 1* is dominated by a rising

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continuum together with broad bands at 7.8 and 11.3 μm. The combination of band and continuum emission is consistent with carbonaceous VSGs as proposed by Désert et al. (1986) and Cesarsky et al. (2000). The spectrum called *Signal 2* exhibits AIBs but no continuum and is likely due to free neutral PAHs (Rapacioli et al. 2005). Finally, we attribute *Signal 3* to ionised PAHs ($PAHs^+$) because of the lower 11.3/7.7 μm band intensity ratio. We have constructed the correlation maps of each extracted spectrum to the observations in order to estimate the contribution of each population of dust in the observations (Fig. 1). These maps show that the relative contribution of free PAHs is greater in regions of higher UV field, where the VSG signal drops, implying that there is an evolution from VSGs to PAHs and eventually $PAHs^+$ under the effect of UV field. This suggests that VSGs are progenitors of PAHs in PDRs and thus strenghtens the hypothesis that they are carbonaceous in nature (Désert et al. 1986 and Cesarsky et al. 2000), possibly PAH clusters (Rapacioli et al. 2006). Further studies (Berné et al. 2006) show that big grains at thermal equilibrium cannot account for the continuum emission observed in the cool PDRs studied in this contribution. This implies that the VSGs identified here dominate the emission in the IRAS 25 μm band.

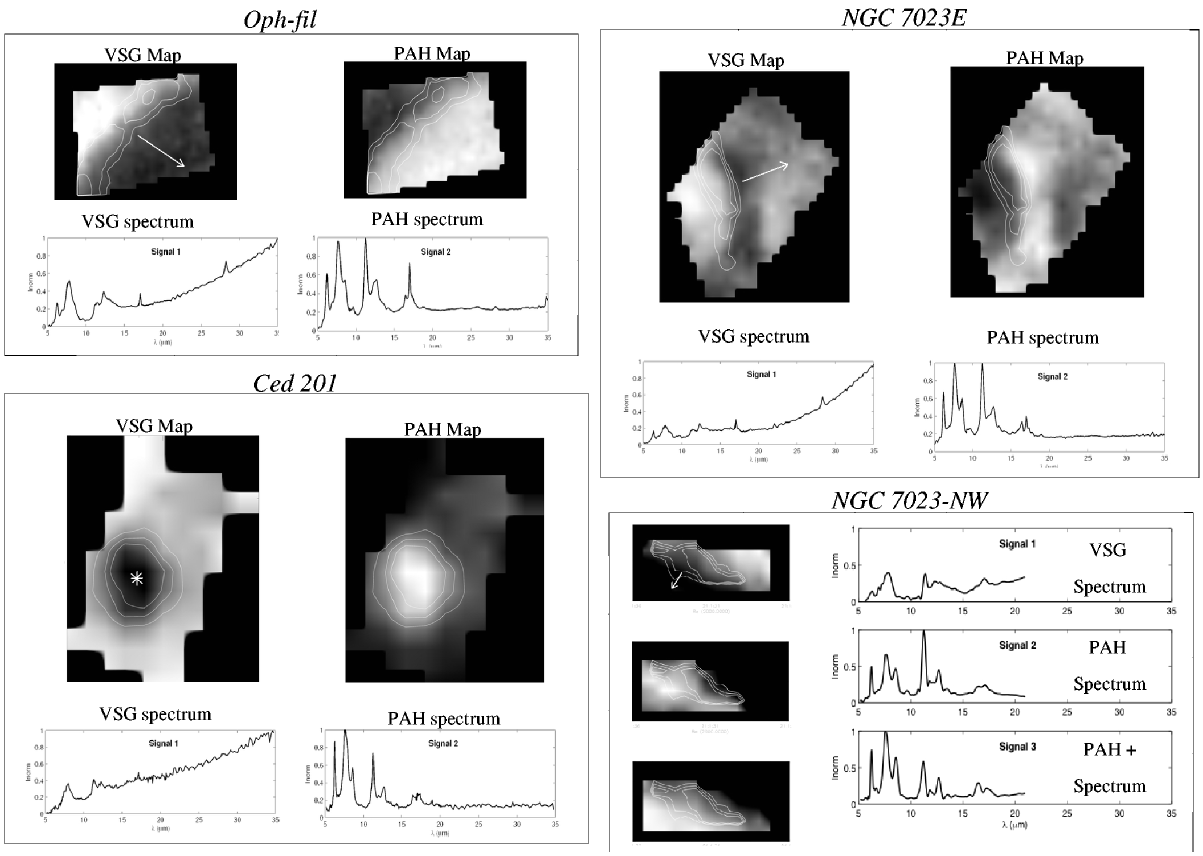

Fig. 1. Extracted spectra in the four observed PDRs. The associated distribution maps are shown next to the relevant spectrum (white is maximum), in countours is the 5-35 μm integrated emission. The * symbol indicates the position of the illuminating star when inside the field of view, otherwise the direction of the star is shown with an arrow.

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