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DUST PROCESSING IN PHOTODISSOCIATION REGIONS MID-IR EMISSION MODELLING OF NGC2023N

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Abstract. This study is done in the context of dust evolution and its interaction with the gaseous phase throughout the interstellar medium evolution cycle. We focus on the mid-IR spectral variations of the dust emission across photodissociation regions, observed with both ISO and Spitzer satellites. We use a dust emission model coupled with a radiative transfer model in order to study the excitation effects on these spectral variations. We show that in NGC2023N, radiative transfer effects cannot account for the observed spectral variations. Thus, we interpret these variations in term of changes of the relative abundance between polycyclic aromatic hydrocarbons (PAHs, mid-IR bands carriers) and very small grains (VSGs, mid-IR continuum carriers). We conclude that the PAH/VSG abundance ratio is about 5 times lower in the dense deep part than in the diffuse illuminated part of the PDR where dust properties seem to be the same as in the diffuse high galactic latitude medium. Consequently, we conclude that dust must evolve from "dense properties" to "diffuse properties" at the small spatial scale of the dense illuminated ridge.

1 Introduction

Dust plays a key role for the physics and the chemistry of photodissociation regions (PDRs) which are important IR emitters in galaxies. ISO observations revealed a systematic diminution of the ratio between aromatic infrared bands (AIBs, attributed to polycyclic aromatic hydrocarbons, PAHs) and mid-IR continuum (attributed to very small grains, VSGs) in PDRs (e.g. Abergel et al., 2002). Rapacioli et al. (2005) and Berné et al. (2007) have interpreted these variations in term of chemical properties evolution of carbonaceous emitters (PAHs $\Leftrightarrow$ VSGs evolution) using the single value decomposition method and the blind signal separation method. A limitation of these methods is that it does not take into account possible variation due to radiative transfer effects. We present a study of dust mid-IR emission in NGC2023 North (hereafter NGC2023N) using a dust model coupled to a radiative transfer model. We interpret the AIB / continuum variations observed with Spitzer/IRS and ISOCAM in term of PAH/VSG relative abundance evolution. More details are given in Compiègne et al. (2008).

2 Observed and modelled spectral variations

NGC2023N is excited by a B1.5V star (HD37903) embedded in the L1630 molecular cloud. This PDR exhibits a strong mid-IR spectral variation as shown by Abergel et al. (2002). Fig.1 shows this variation that occurs at the dense illuminated ridge traced by $H_2\, \nu = 1-0\, S(1)\, 2.12\mu$m emission. The AIB (7-9$\mu$m)/continuum (22-24$\mu$m) ratio goes from a value of 1.9 in the diffuse illuminated part to a value of 0.4 in the deep dense part of the PDR. The left panel of Fig.2 shows both the modelled and observed spectrum of the diffuse illuminated part. The modelled spectrum is obtained using the dust model described in Compiègne et al. (2008). The used exciting radiation field corresponds to a B1.5V star located at 0.3 pc and extinguished with $A_V \sim 1.25$ (for details, see Compiègne et al., 2008). Cirrus dust properties allow us to reproduce the spectrum of the diffuse illuminated part of NGC2023N. The right panel of Fig.2 shows the modelled evolution of the AIB (7-9μm)/continuum (22-24μm) ratio as a function of optical depth in the PDR (for details, see Compiègne et al., 2008) for $n_H = 10^4$ and $10^5\, cm^{-3}$ (Field et al., 1998). The required extinction of $A_V \sim 12$ to account for the value of 0.4 of the ratio at the deep dense location with only excitation effects is not in accordance with the raise of the 22-24μm observed intensity from $\sim$70 MJy sr^{-1} to $\sim$100 MJy sr^{-1} between the diffuse illuminated part and this location.

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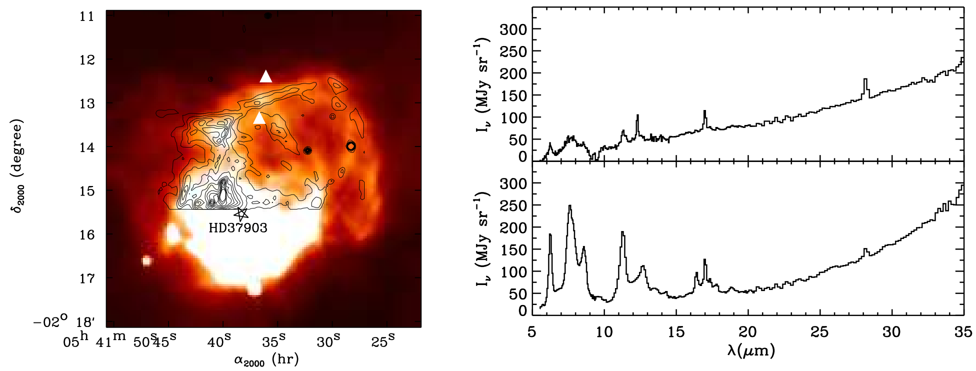

Fig. 1. NGC2023 as seen by ISOCAM/LW2 (5-8.5μm). Contours show the $H_2\,\nu = 1-0\,S(1)\,2.12\mu m$ emission observed with SOFI. **Spectra:** ISOCAM/CVF and IRS spectra of the diffuse illuminated part (southern triangle on the map) and of the deep dense part (northern triangle on the map) of the PDR.

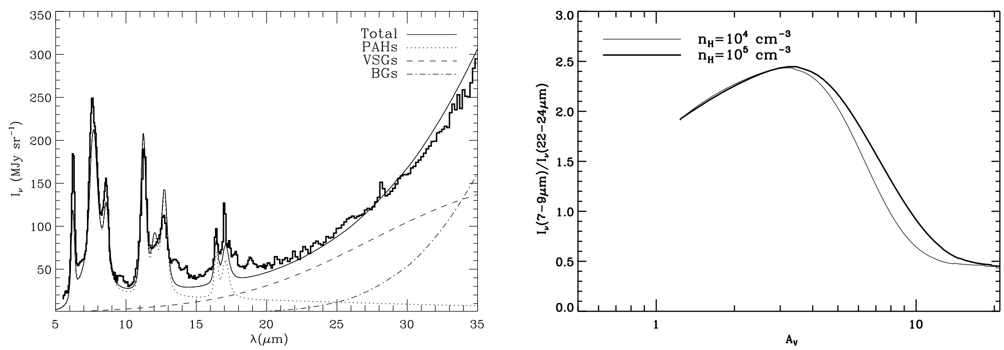

Fig. 2. Left: Spectrum of the diffuse illuminated part observed (thick line) and modelled (thin line). Used dust properties are those of Cirrus. **Right:** Modelling of the AIBs/continuum ratio evolution across the PDR for two different densities.

3 Conclusion

The modelling of the mid-IR emission in NGC2023N shows that radiation transfer effects can not explain the observed spectral variations. We conclude that PAH/VSG relative abundance is ~5 times lower in the deep dense part of the PDR than in the diffuse illuminated part where dust properties seem to be the same as in Cirrus. Thus, dust must evolve from “dense” to “diffuse” properties at the small spatial scale of the PDR. The strong evolution of the PAH relative abundance between the dense and diffuse medium in PDRs has importance for the physics and the chemistry of these regions, for the interpretation of extragalactic sources spectra or also concerning the use of AIBs as a tracer of the star formation activity.

References

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