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Very Small Particles and Chemistry in Photodissociation Regions : from ISO to Spitzer

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Abstract.
Since the IRAS mission, it is well known that there exists a population of very small particles which are transiently heated by the absorption of single UV photons and emit in the mid-IR range. Polycyclic aromatic hydrocarbons (PAHs) were proposed to account for the well-known Aromatic IR Bands (AIBs) between 3.3 and 12.7 μm. Another component, called very small grains (VSGs; Désert *et al.* (1990)), was introduced as the carrier of the emission in the 25 μm IRAS band. The very small particles (PAHs and VSGs) are now considered to play a major role in the physics and chemistry of the interstellar medium. They dominate the heating of interstellar gas through photoelectric effect. They are also suspected to play a major role in the formation of H_2, in particular in Photo-Dissociation Regions (PDRs) where UV photons heat the dust making inefficient the physisorption and diffusion of H atoms at the surface of grains, the processes which are usually invoked to form H_2 (Habart *et al.* (2004)). In PDRs, the UV field varies as a function of depth within the cloud, and this gives a unique opportunity to study how the dust populations and the molecular content evolve with the excitation and physical conditions.

Spectro-imagery in the mid-IR (5-16 μm) was possible with the camera CAM on board the Infrared Space Observatory (ISO). A striking result from these observations is the presence of continuum emission in PDRs far from exciting sources (Abergel *et al.* (2002)). This reveals the presence of VSGs transiently heated by single UV photons. The continuum relative to the bands is highly variable, showing that VSGs are a dust component different from PAHs. Further analysis of the data (Rapacioli *et al.* (2005)) allowed to extract three spectra : two carrying only band emission (attributed to PAH cations and neutrals) and one with continuum emission (attributed to VSGs). The authors found a drop in the VSG emission at the cloud edge which is correlated with the increase in the PAH emission. They proposed that VSGs could be aggregates of PAHs which photoevaporate at the surface of clouds.

This work can now continue thanks to the unique spectro-imagery capabilities of the Spitzer Space Telescope. With the spectrometer IRS, spectro-imagery studies are possible in the 5-35 μm range, giving the possibility to better characterize the VSG emission and therefore the chemical identity of this dust population. Second, the spectrometer IRS allows to access to the full set of rotational lines of H_2: 0-0 S(0), S(1), S(2) and S(3) at 28.2, 17.0, 12.3 and 9.7 μm. The interpretation of the line intensities with a PDR model allows to derive precise information

on the formation mechanism of H_2, in particular the formation rate and the ortho-to-para ratio (Le Bourlot (2000)). Finally, the spectro-imagery data obtained with IRS will be soon combined to MIPS-SED observations between 55 and 95 μm in order to follow the spatial evolution of the abundance and size distribution of the different dust populations including large grains.

The Spitzer data will be presented. Our sources were selected in order to span a broad range of physical conditions (radiation field, geometry and density). Interpretation is in progress using PDR, radiative transfer and dust models developped by our team. The obtained data is clearly a benchmark for models describing the nature and evolution of all dust populations as well as for the excitation and formation of H_2. Complementary work includes ground-based observations, blind source separation analysis and laboratory/theoretical work.

Keywords. Infrared: ISM; ISM: dust, reflection nebulae; molecular processes

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