PHOTOLUMINESCENCE OF AN INTERSTELLAR DUST LABORATORY ANALOG.

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Introduction: One of the goals of the interstellar medium (ISM) research is to attribute the observed spectral features to carriers and thus identify ISM compounds for a thorough understanding of the cycle of matter in galaxies. One of the ISM spectral features, the extended red emission (ERE), is a large featureless emission band in the red part of the spectrum (600-820 nm) observed in many interstellar environments. This spectral feature is probably due to photoluminescence (PL) of ISM carriers following the absorption of UV-visible photons, but their true nature is still under debate. Several candidates have been proposed over the past decades. In order to identify which interstellar material is responsible for this observed large emission band, each constraint imposed by the ERE must be compared to the properties of the candidates.

Amorphous hydrogenated carbons (a-C:H or HAC) are carbonaceous material of astrophysical interest since they have proved to be analogs of one of the highly significant interstellar dust components [1-4] through IR absorption bands (C-H stretching at 3.4 µm and C-H bending at 6.85 and 7.25 µm) ubiquitously observed in the diffuse interstellar medium (DISM) of galaxies. a-C:H photoluminesce in the visible spectral range and are ERE carrier candidates. It is thus important to characterize the PL behavior of this ISM component contributing to the interstellar dust emission and compare the a-C:H PL to the ERE observed properties. In particular, the absolute PL efficiency, which is for the ERE carrier candidates one of the strongest constraints set by the observations, has to be accurately investigated for a-C:H materials in the sample.

Experimental methods: Interstellar a-C:H analogs were produced using a plasma-enhanced chemical vapor deposition (PECVD) system, with different hydrocarbons as precursor gas. We obtain samples as form of films of few micrometers deposited on a substrate. After characterization by IR and UV-visible transmission, we measure the PL of our samples, with a luminescence spectrometer for selected monochromatic excitation in the UV-visible wavelengths greater than 250 nm.

The intrinsic PL quantum yield (ratio of emitted to absorbed photons numbers) is calculated from the external PL measurements by taking into account the optical interferences due to the interfaces of the a-C:H film and the distribution of luminescent centers.

Results and Discussion: We produced and analyzed different a-C:H samples, photoluminescent in the visible when illuminated by UV photons. The position wavelength of the PL maximum varies from about 450 nm to 670 nm. We studied the influence of the excitation wavelength that gives rise to the PL: by varying this excitation between 250 and 450 nm, no strong modification of the PL peak position and quantum yield has been observed. As already shown in previous a-C:H PL studies (e.g. [5]), we observe that the a-C:H PL yield decreases with the optical gap of the samples. Our work constrains the *intrinsic absolute* PL yields ranging from few hundredths of percent to few percents. The astrophysical ERE observations provide lower limits for the carrier quantum yield, varying with ISM environments. These yields correlate and increase with the density of the local radiation field. The quantum yields that we deduce are compatible with most of the quantum yield limits set by ERE observations. However, they do not correspond to the highest quantum yield of 10% set by the scarce and difficult observations of the weakly emitting DISM.

Conclusion: The evaluation of the astrophysical ERE efficiency from observations of different ISM environments, and in particular the diffuse low density medium, is not a trivial task. Setting the strongest ERE constraint, the efficiency determination needs to be improved. Additional observations of the ERE in the DISM and proper evaluations of the UV-visible photons absorbed by the ISM carriers are mandatory. We provide in our study the first measurements of absolute PL yield as a function of excitation wavelength for a-C:H interstellar dust laboratory analogs. To a greater extent, by modeling the astronomical spectrum, the geometry and size of interstellar grains, together with our wavelength dependent yield, will provide insights into the astrophysical a-C:Hs, already identified by IR spectroscopy, and establish their contribution to the visible interstellar medium.

References:

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