# VUV characterization of soot particles and hydrogenated carbons of astrophysical interest

L. Gavilan[1,2], T.K.C. Le[3], I. Alata[3], A. Giuliani[4], T. Pino[3], E. Dartois[1]

[1]Institut d'Astrophysique Spatiale, Orsay, 91405, France
[2]Laboratoire Atmosphères, Milieux, Observations Spatiales, Guyancourt, 78280, France
[3]Institut de Sciences Moléculaires d'Orsay, 91405, France
[4]DISCO beam line, SOLEIL synchrotron, St. Aubin, 91190, France

Keywords: soot, hydrogenated carbon, VUV, astrochemistry
Presenting author email: lisseth.gavilan@latmos.ipsl.fr

Astronomical observations of dust beyond the Lyman limit are scarce and so are the laboratory spectra of dust analogs in this range. At the IAS and ISMO laboratories (Paris Sud University, France), we produce carbon analogs to interstellar carbon dust dust, namely, amorphous hydrogenated carbons (a-C:H) and soot nanoparticles. Soot particles have been produced using *Nanograins,* a combustion setup that provide samples dominated by a polyaromatic carbon skeleton. This setup includes a flat burner flame using premixed hydrocarbon (ethylene) and oxygen. Such a laminar flame is a one-dimensional chemical reactor offering a broad range of combustion conditions and sampling of by-products. The a-C:H were produced using an R.F. plasma reactor at low pressures, and their structure is dominated by aromatics linked in an aliphatic skeleton.

The central goal of this study is to obtain absolute spectral properties of carbon dust analogs in both the VUV/Vis regions and the infrared ranges, complementing earlier studies of hydrocarbon solids, particularly in the VUV range, where optical measurements are scarce. A full spectral characterization of these materials will clarify their potential contributions as carriers of observed spectral features in the infrared and in the UV, such as the FUV rise and also the 217.5 nm bump of interstellar extinction curves [Fitzpatrick & Massa 2007].

UV measurements of our carbon analogs were performed with three instruments. At the IAS we use a UV-Vis spectrometer ($\lambda$ = 210 nm - 710 nm) with a sub-nm resolution. It consists of a deuterium lamp, whose light is conducted by optical fibers and illuminates the sample. The transmitted signal is then collected and carried by optical fibers towards a grating spectrometer (Maya PRO UV, Ocean Optics). For measurements in the vacuum ultraviolet, we use the APEX branch of the DISCO beamline at the SOLEIL synchrotron. The APEX chamber allows measurements between $\lambda$ = 50 nm - 260 nm in windowless mode (Giuliani et al. 2009), with a beam size at the sample of ~ 2 mm. From now on, we will interchange between the terms VUV and FUV to refer to this wavelength range. Finally, a spectrophotometer (Specord, Analytikjena) allowed measurements on MgF2 windows at $\lambda$ = 190 - 1000 nm. These transmission spectra allow the derivation of optical constants from these carbonaceous materials, necessary to simulate observed astronomical extinction curves. We also measured these films in the infrared, allowing us to characterize the quality and suitability of our samples as interstellar dust analogs.

By combining UV to IR measurements, we scaled the UV contribution to the 3.4 μm band to compare the observed UV extinction to our laboratory a-C:H measurements. We derived the VUV-Vis optical constants for a laboratory a-C:H and soot from several sets of transmission measurements at different thicknesses. We used these optical constants to calculate extinction curves which show that a-C:Hs contribute to the steep FUV rise, while soots are suitable carriers of the UV bump [Gavilan et al. 2016]

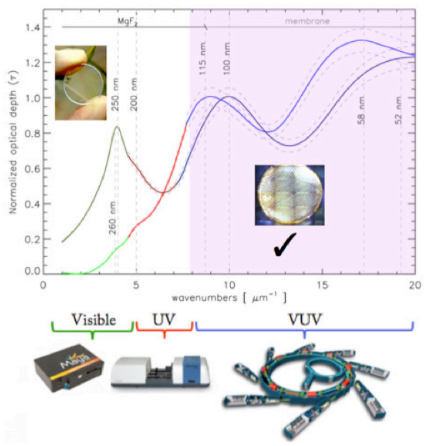


Figure 1. VUV-UV (50 nm – 1μm) spectra of soot nanoparticle film and hydrogenated carbon film measured at SOLEIL (VUV) and at the IAS (UV-Vis)

This work was supported by a postdoctoral research allocation by the Centre National d'Etudes Spatiales.

Giuliani, A. et al. (2009) DISCO: a low-energy multipurpose beamline at synchrotron SOLEIL. J. Scynchrotron Radiation, 16, 835
Gavilan, L. et al. (2016) VUV spectroscopy of carbon dust analogs: contribution to interstellar extinction. Astronomy & Astrophysics, 586, A106
Fitzpatrick, E. L. & Massa D. (2007) An analysis of the shapes of interstellar extinction curves. The Astrophysical Journal, 663, 320