The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus
Proceedings IAU Symposium No. 303, 2013
L. O. Sjouwerman, C. C. Lang & J. Ott

doi:10.1017/S1743921314000581

An overview of the PAHTAT toolbox

P. Pilleri[1], C. Joblin[2,3], O. Berné[2,3], J. Montillaud[4] and Y. Okada[5]

[1]Los Alamos National Laboratory,
P. O. Box 1663, Los Alamos (NM) 87545, USA
email: ppilleri@lanl.gov

[2]Université de Toulouse, UPS, IRAP,
9 avenue du colonel Roche, 31062 Toulouse cedex 4, France
email: [christine.joblin|olivier.berne]@irap.omp.eu

[3]CNRS, UMR 5187,
31028 Toulouse, France

[4]Institut Utinam, CNRS UMR 6213, OSU THETA, Université de Franche-Comté,
41bis avenue de l'Observatoire, 25000 Besançon,France
email: julien@obs-besancon.fr

[5]I. Physikalisches Institut der Universität zu Köln
Zülpicher Straße 77, 50937 Köln, Germany
email: okada@ph1.uni-koeln.de

Abstract. In this contribution, we briefly describe how an observed mid-infrared (5.5-14 μm) spectrum can be used to trace key physical conditions along a given line of sight, such as the UV radiation field, the ionization parameter and the dust column density. These parameters are often difficult to determine independently from PDR models. The PAHTAT toolbox offers the opportunity to analyze mid-IR spectra using a limited number of parameters, that are associated with the physical properties of the dust and gas being observed.

Keywords. ISM: lines and bands — ISM: dust, extinction — infrared: ISM

1. PAH Toulouse Astronomical Templates

Carbon is an important component of dust in Photo-Dissociation Regions (PDRs), mainly tied up in Polycyclic Aromatic Hydrocarbons (PAHs) and associated very small grains as well as in amorphous carbon grains. The mid-infrared (5-14 μm) spectrum of most galactic objects is characterized by emission in the Aromatic Infrared Bands (AIBs), a few gas lines and a relatively linear continuum emission.

The mid-IR spectrum of several galactic PDRs was analyzed by Rapacioli *et al.* (2005) and Berné *et al.* (2007). The authors propose three populations as the carriers of the AIBs: neutral PAHs, cationic PAHs, and evaporating Very Small Grains (eVSGs). They show that UV radiation can easily photo-dissociate eVSGs into PAHs. This process has important consequences for the chemistry and physics of PDRs (Pilleri *et al.*, 2012). PAHs and eVSGs are the most efficient species for the heating of the gas by photo-electric effect and their evolution can significantly impact the thermal balance of PDRs (Okada *et al.* 2013).

We have developed a toolbox called PAHTAT (PAH Toulouse Astronomical Templates), which allows one to fit any observed spectrum that shows AIB emission. The fit can be used to derive the physical properties of the emitting regions. PAHTAT uses a minimal set of parameters associated to physical quantities: a linear combination of the PAH and eVSG band template spectra, H_2 and ionized gas lines, and a linear continuum due to

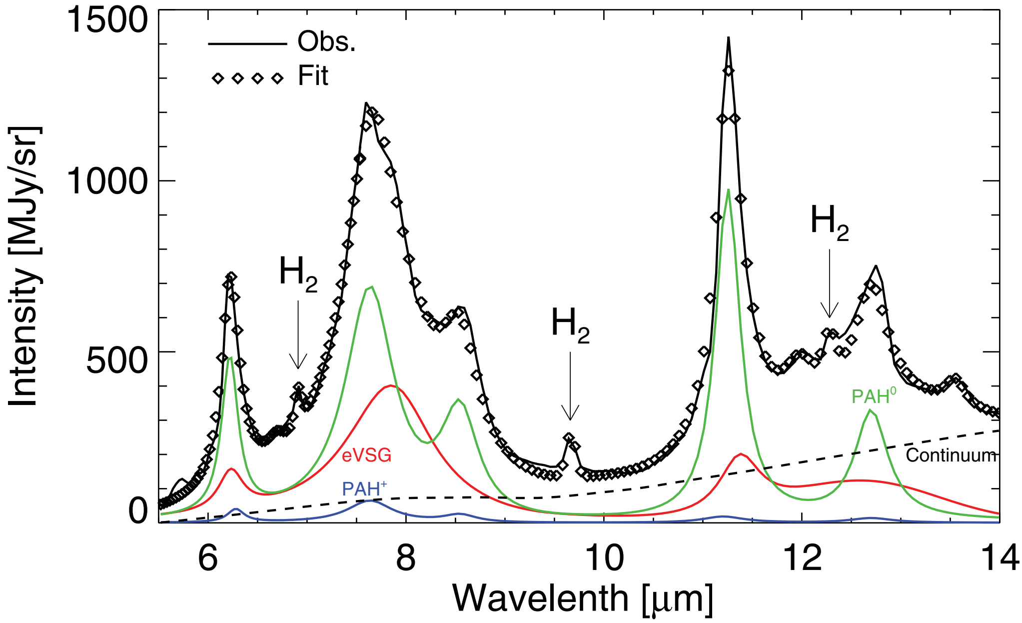

Figure 1. The fit of a *Spitzer*-IRS mid-IR spectrum of the reflection nebula NGC 7023 NW using the PAHTAT IDL toolbox. [A color version is available online.]

larger grains. We also take into account the effect of extinction due to dust along the line of sight. The PAHTAT IDL wrapper is publicly available to the community and can be downloaded at `http://userpages.irap.omp.eu/∼cjoblin/PAHTAT/Site/PAHTAT.html`

2. Tracing the physical conditions in star forming regions

We have shown that the intensity of the local UV field (expressed in units of the Habing field, $G_0 = 1.6 \times 10^{-3}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$) is linked to the fraction of carbon locked in eVSGs (f_{eVSG}) with a log-linear correlation (Pilleri *et al.*, 2012). eVSGs are less abundant in PDRs with high UV fields, reflecting their photo-destruction and the production of PAHs. PAHTAT can be used to determine f_{eVSG}, and thus the local radiation field, directly from a mid-IR spectrum. The relation was found to hold in the range $100 < G_0 < 5\times10^4$.

The fraction of PAH^+ relative to the total PAH abundance is directly proportional to the ionization parameter of the gas, $\gamma = G_0\sqrt{T}/n_e$, where T is the kinetic temperature of the gas and n_e is the electron density (Okada *et al.* 2013). By computing the relative weight of ionized and neutral PAHs, PAHTAT can be used to quantify this parameter. Finally, PAHTAT provides an estimate of the dust column density thanks to the fit of the silicate extinction band at 9.7 μm. Values of the total extinction, A_V, in the range [2-20] can be derived (Pilleri *et al.*, 2012).

We anticipate that PAHTAT will be particularly useful to analyze data from *JWST*, whose unprecedented angular resolution will enable to probe chemical frontiers in the local universe (e.g., filaments in star-forming regions, or the inner regions proto-planetary disks) and from *SPICA* that will probe the high-redshift universe (e.g., to derive the star-formation rates in young galaxies).

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