

Spectroscopy of Interstellar Carbon Molecules: From Laboratory to Space. Recent Advances in Laboratory Studies and the Search for Carbon Molecules in Interstellar Spectra

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Domain : Astrophysics

Large carbon molecules are an important and ubiquitous component of carbon-bearing materials in space. A long-standing and major challenge for laboratory astrophysics has been to measure the spectra of large carbon molecules in laboratory environments that mimic (in a realistic way) the physical conditions that are associated with the interstellar emission and absorption regions [1]. This objective has been identified as one of the critical Laboratory Astrophysics objectives to optimize the data return from space missions [2]. An extensive laboratory program has been developed to assess the properties of PAHs in such environments and to describe how they influence the radiation and energy balance in space. We present and discuss the gas-phase electronic absorption spectra of neutral and ionized PAHs measured in the UV-Visible-NIR range in astrophysically relevant environments and discuss the implications for astrophysics [1]. The harsh physical conditions of the interstellar medium - characterized by a low temperature, an absence of collisions and strong VUV radiation fields - have been simulated in the laboratory by associating a pulsed cavity ringdown spectrometer (CRDS) with a supersonic slit jet seeded with PAHs and an ionizing, penning-type, electronic discharge. We have measured for the first time the spectra of a series of neutral [3, 4] and ionized [5, 6, 7] interstellar PAHs analogs in the laboratory. An effort has also been attempted to quantify the mechanisms of ion and carbon nanoparticles production in the free jet expansion and to model our simulation of the diffuse interstellar medium in the laboratory [8, 9]. These experiments provide unique information on the spectra of free, large carbon-containing molecules and ions in the gas phase. We are now, for the first time, in the position to directly compare laboratory spectral data on free, cold, PAH ions and carbon nano-sized carbon particles with astronomical observations in the UV-MIR range (interstellar UV extinction, DIBs in the NUV-NIR range, UIR bands in the IR). This new phase offers tremendous opportunities for the data analysis of current and upcoming space missions geared toward the detection of large aromatic systems i.e., the "new frontier space missions" (Spitzer, HST, COS, JWST, SOFIA,...).

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