Spectroscopic Studies of PAHs in Supersonic Jets and Liquid Helium Droplets

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Abstract

Neutral and cationic polycyclic aromatic hydrocarbons (PAHs) are discussed as possible carriers of the diffuse interstellar bands (DIBs), still unassigned astrophysical absorption features observed in the spectra of reddened stars. Despite the importance of this class of molecules for astrophysics and nanophysics (PAHs can be regarded as nanoscale fragments of a sheet of graphite), the spectroscopic characterization of PAHs under well-defined conditions (low temperature and collision-free environment) has remained a challenge. Recently we have set up a cavity ring-down spectrometer combined with a pulsed supersonic jet expansion to study neutral and cationic PAHs under astrophysical conditions. PAHs studied so far include the neutral molecules anthracene and pyrene as well as the cationic species naphthalene$^+$ and anthracene$^+$. Employing another molecular beam apparatus, the same molecules (except of the cationic species) were also studied in ultracold liquid helium droplets. This novel technique combines several advantages of conventional matrix spectroscopy with those of gas phase spectroscopy. Notable advantages are the possibilities to study molecules with rather low vapor pressure, to achieve equilibrium between vibrational, rotational, and translational degrees of freedom, and to use a mass spectrometer facilitating spectral assignments. The most recent studies were devoted to phenanthrene and the more complicated (2,3)-benzofluorene. These molecules were investigated in the gas phase by cavity ring-down spectroscopy and in liquid helium droplets using depletion spectroscopy. For benzofluorene, the present studies constitute the first measurements carried out in the gas phase and in helium droplets. In contrast to previously studied PAHs, the shift induced by the helium droplets was very small (blue shift between 4.5 and 4.9 cm^{-1} for all vibronic bands). In addition to commercially available molecules, we have also studied PAHs which were produced by CO_2 laser

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pyrolysis of benzene/ethylene gas mixtures. Up to now, no coincidence between experimental and interstellar band positions was found.