Red Stars over PAHs

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Polycyclic aromatic hydrocarbon (PAH) molecules are widely considered to be responsible for the 3.3, 6.2, 7.7, 8.6, 11.3, and 12.7 μm emission bands, collectively known as the "unidentified" infrared emission (UIE) bands. One argument often invoked to argue against PAHs as the carriers of the UIE bands is that, the excitation of PAHs is thought to require ultraviolet (UV) photons and therefore, the PAH model is thought to fail in explaining the presence of UIE bands in UV-poor regions (e.g., reflection nebulae and proto-planetary nebulae where the central stars are cool). However, it has also been argued both theoretically and experimentally that the excitation of PAHs does not require UV photons. To explore whether PAHs can be excited sufficiently in UV-poor regions to emit at the UIE bands, we investigate the vibrational excitation of PAHs in circumstellar envelopes around cool carbon stars. These stars have an effective temperature of $T_{eff} < 6000$ K and the UIE emission has been detected in their circumstellar envelopes. To this end, six such stars were selected, i.e., IRAS Z02229+6208, IRAS 20000+3239, IRAS 22272+5435, IRAS 22574+6609, IRAS 23304+6147, W Orionis, and IRAS 13416-624. We model the PAH excitation in these UV-poor systems and calculate the PAH model emission spectra. It is found that, in general, PAHs can be excited sufficiently in these systems to account for the observed UIE emission. We determine the PAH size, charging fraction, and mass and discuss the PAH chemical structure for each of these six UV-poor systems.