Graphene and Carbon Nanotubes in the Interstellar Medium

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Carbon is exclusively formed in the hot interiors of stars through the fusion reactions of three alpha particles (i.e., helium nuclei) and expelled into the interstellar medium (ISM) through stellar outflows and/or supernova explosions in the late stages of stellar evolution. As the fourth most abundant element in the universe and due to its unique property to form three different types of chemical bonds through sp^1, sp^2, and sp^3 hybridizations, carbon can be stabilized in various multi-atomic structures with different molecular configurations (i.e., allotropes), including amorphous carbon, graphite, diamond, polycyclic aromatic hydrocarbon (PAH), fullerenes, graphene, and carbon nanotubes (CNTs).

In this presentation I will focus on graphene and CNTs. I will present (1) our DFT calculations of the electronic and vibrational transitions of graphene and CNTs as a function of carbon atoms (N_C), (2) the infrared (IR) emission spectra of graphene and CNTs which are stochastically excited by single photons in the ISM, and (3) the possible contribution of graphene and CNTs to the UV interstellar extinction. The model-calculated UV extinction and IR emission spectra of graphene and CNTs will then be compared with the astronomical observations, allowing us to constrain the abundances of these nano species in the ISM. The possible connection of graphene and CNTs with the mysterious diffuse interstellar bands (DIBs) will also be examined.