Fifteen Years of Laboratory Astrophysics at Ames

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Tremendous strides have been made in our understanding of interstellar material over the past fifteen years thanks to significant, parallel developments in two closely related areas: observational astronomy and laboratory astrophysics. Fifteen years ago the composition of interstellar dust was largely guessed at, the concept of ices in dense molecular clouds ignored, and the notion of large, abundant, gas phase, carbon-rich molecules widespread throughout the interstellar medium (ISM) considered impossible. Today the composition of dust in the diffuse ISM is reasonably well constrained to cold refractory materials comprised of amorphous and crystalline silicates mixed with an amorphous carbonaceous material containing aromatic structural units and short, branched aliphatic chains. In the dense ISM, these cold dust particles are coated with mixed-molecular ices whose compositions are very well known. Lastly, the signature of carbon-rich polycyclic aromatic hydrocarbons (PAHs), shockingly large molecules by early interstellar chemistry standards, is widespread throughout the ISM.

This great progress has only been made possible by the close collaboration of laboratory experimentalists with observers and theoreticians, all with the goal of applying their skills to astrophysical problems of direct interest to NASA programs. Such highly interdisciplinary collaborations ensure fundamental, in depth coverage of the wide-ranging challenges posed by astrophysics. These challenges include designing astrophysically focused experiments and data analysis, tightly coupled with astrophysical searches spanning 2 orders of magnitude in wavelength, and detailed theoretical modeling. The impact of our laboratory has been particularly effective as there is constant cross-talk and feedback between quantum theorists; theoretical astrophysicists and chemists; experimental physicists; organic, physical and petroleum chemists; and infrared and UV/Vis astronomers.

In this paper, two examples of the Ames Program will be given. We have been involved in identifying 9 out of the 14 interstellar pre-cometary ice species known, determined their abundances and the physical nature of the ice structure. Details on our ice work are given in the paper by Sandford et al.

Our group is among the pioneers of the PAH model. We built the theoretical framework, participated in the observations and developed the experimental techniques needed to test the model. We demonstrated that the ubiquitous infrared emission spectrum associated with many interstellar objects can be matched by laboratory spectra of neutral and positively charged PAHs and that PAHs were excellent candidates for the diffuse interstellar band (DIB) carriers. See Salama et al. and Hudgins et al.

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