2009 Lyman Spitzer, Jr. Lecturer

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Colloquium: Evolving protoplanetary disks ~ Tuesday, May 5, 4:30 ~ Peyton Auditorium

Three additional Astrochemistry lectures ~ May 8, May 11, May 14, 3:30 ~ Peyton Auditorium

The space between the stars is not empty but filled with a very dilute gas with extremely low densities and temperatures. These clouds provide not only the material from which new stars and planets are made but they also form a unique laboratory with conditions not normally encountered on Earth. A surprisingly rich chemistry occurs in these clouds, as evidenced by the discovery of more than 130 different molecules over the last 40 years. Some of these species were found in space before they were identified in a laboratory on Earth. There is ample evidence for the existence of even larger complex organic molecules, including Polycyclic Aromatic Hydrocarbons. In addition, small 0.1 micron-sized solid particles consisting of silicates, oxides and carbonaceous material are mixed with the gas. In the coldest regions, they can be coated with thick ice mantles, thus providing a reservoir of material for icy bodies in exo-planetary systems.

Questions that will be addressed in this lecture series are: How are these molecules formed under these exotic conditions? Where are they found? How do their abundances differ from place to place? What do these molecules tell us about the physical structure of the region? What is the chemical inventory of material available for star- and planet formation? Remarkable progress has been made in all of these areas in the last decade thanks to new observational facilities at infrared and millimeter wavelengths, combined with sophisticated laboratory experiments and theory.

Lecture 1 ~ Friday, May 8, 3:30
Basic molecular processes

Introduction to molecular clouds and observational techniques. Summary of identified interstellar molecules and questions to be addressed. Discussion of basic gas-phase processes, including radiative association, photodissociation, dissociative recombination and ion-molecule reactions. Recent developments in our understanding of grain-surface processes, including the formation of H2 and other simple species. Each basic process will be illustrated with an astrophysically relevant example ranging from chemistry in the early Universe to that in star-forming regions.

Lecture 2 ~ Monday, May 11, 3:30
Chemistry in star-forming regions

Summary of observations and models of the chemistry in low- and high-mass star-forming regions in different evolutionary stages. Distinct phases include (i) the freeze-out onto grains and extreme deuteration found in pre-stellar cores and cold outer envelope; (ii) the ice evaporation in the warm inner envelope once the star has turned on; (iii) high-temperature hot core chemistry in the innermost region; (iv) shock and UV chemistry along the outflow axis. Recent insights into the formation and evolution of water and complex organic, perhaps prebiotic, molecules will be presented.

Followed by voluntary exercise: excitation of interstellar molecules using the on-line RADEX program: make your own predictions for ALMA!

Lecture 3 ~ Thursday, May 14, 3:30
Chemistry in circumstellar disks

Summary of recent developments in models and observations of molecules in protoplanetary disks. Three-layer static model of disks, in which most of the active chemistry and emission arises from warm surface layers that are irradiated by X-ray and FUV emission from the central accreting star. Discovery of surprisingly large abundances of hot water and simple organic molecules in the inner planet-forming zones of disks. Special attention will be given to the importance of an accurate description of the photoprocesses in the gas as grains grow and disks evolve from the gas-rich to the gas-poor phase. Other areas where disk chemistry and physics are linked include the gas temperature structure, disk viscous evolution (mixing), ionization fraction, and the beginnings of planet formation.