Exploiting Tunable Vacuum Ultraviolet Light to Unravel the Synthesis of Complex Organic Molecules in Interstellar and Solar System Ices

Ralf I. Kaiser

[1] ralfk@hawaii.edu
[2] W.M. Keck Research Laboratory in Astrochemistry, Department of Chemistry, University of Hawaii at Manoa, Honolulu, HI 96822, USA

Kuiper Belt Objects (KBOs) - small planetary bodies orbiting the sun beyond Neptune - emerged in their critical role to understand the chemical evolution of the Solar System and how the molecular precursors to life formed and came together to create environments such as on early Earth. This talk presents novel developments in the understanding of the formation of key classes of biorelevant molecules central to the *Origins of Life* in ices of Kuiper Belt Objects (KBOs) – and those related to the interstellar medium - exploring cutting edge low temperature surface science experiments exploiting soft photo ionization with tunable vacuum ultraviolet light coupled with a time of flight mass spectrometric, isomer selective product detection (PI-ReTOF-MS). By probing specific structural isomers without their degradation (fragment-free), the incorporation of tunable vacuum ultraviolet photoionization allows for a critical understanding of reaction mechanisms that exist in extraterrestrial ices compared to traditional methods thus eliminating the significant gap between observational and laboratory data that existed for the last decades thus defining the first inventory of (biorelevant) molecules, which forms the nucleus for evolution of life in our Solar System billions of years ago. Considering that Kuiper Belts have been observed around stars like Vega outside our Solar System as well, this knowledge can be transferred to extrasolar planetary systems thus revolutionizing our understanding of the origin of cosmic life as we know it and eventually revealing the molecular birthplace of life. Since cometary matter (at least partially) originated from the molecular cloud, which provided the molecular feedstock for our Solar System, these investigations also expose how ubiquitous astrobiologically relevant molecules such as glycolaldehyde can be synthesized on ice coated interstellar grains at 10 K via a cosmic-ray initiated non-equilibrium chemistry. With the commission of the Atacama Large Millimeter/Submillimeter Array (ALMA), the detection of more complex organic molecules in space will continue to grow – including biorelevant molecules connected to the *Origins of Life* theme - and an understanding of these data will rely on future advances in hard core physical chemistry laboratory experiments ultimately revealing the level of complexity of astrobiologically relevant molecules which can be synthesized in our Universe.