The measuring the formation of products from reaction at low temperatures using chirped pulse Fourier transform spectroscopy in uniform flows

B. M. Hays, T. Guillaume, D. Gupta, I. R. Cooke, O. Abdelkader Khedaoui, M. Drissi, T. S. Hearne and I. R. Sims

IPR (Institut de Physique de Rennes) - UMR 6251, Univ Rennes, F-35000 Rennes, France.

The formation of complex molecules in the interstellar medium often proceeds at very low temperatures. Predicting the formation mechanisms of these molecules depends heavily on experimental measurements of the rates of reaction at low temperatures. While experiments are available to measure these rates at low temperatures using the CRESU (French acronym for Reaction Kinetics in Uniform Supersonic Flow) technique, the products of these reactions and their branching ratios are usually not measured. This leaves a large gap in astrochemical kinetics databases concerning the product branching ratios of reactions.

The CPUF (Chirped Pulse in Uniform Flow) combines the revolutionary chirped pulse Fourier spectroscopy technique with the CRESU environment, using rotational spectroscopy to unambiguously identify the products of reaction at low temperatures. A new chirped pulse Fourier transform millimeter wave spectrometer was adapted to continuous uniform flow apparatus available in Rennes. The products of fast CN radical reactions with ethane and acetylene were directly observed in the uniform flow, showing proof of concept results from this instrument.

The Fourier transform spectra were heavily affected by the buffer gas used in the CRESU technique in interesting ways. This provided a unique opportunity to explore intermolecular dynamics between the buffer gas and other molecules, specifically the elastic and inelastic scattering of these species. HCN and HNC spectra were compared in the low temperature He environments, where the collisional excitation of these two molecules were found to be very different, especially at low temperatures relevant to molecular clouds. Finally, the CPUF apparatus was extended to sample the uniform flow using a newly developed secondary expansion chamber, where the product branching ratios could be measured from reaction. Future developments will allow for the CPUF technique to be extended to even colder temperatures and more molecular systems.