The use of the CRESU (Cinétique de Réaction en Ecoulement Supersonique Uniforme, or Reaction Kinetics in Uniform Supersonic Flow) technique coupled with pulsed laser photochemical kinetics methods has shown that reactions involving radicals can be very rapid at temperatures down to 10 K or below. The results have had a major impact in astrochemistry and planetology, as well as proving an exacting test for theory. The technique has also been applied to the formation of transient complexes of interest both in atmospheric chemistry and combustion.

Until now, all of the chemical reactions studied in this way have taken place on attractive potential energy surfaces with no overall barrier to reaction. The \( \text{F} + \text{H}_2 \rightarrow \text{HF} + \text{H} \) reaction does possess a substantial energetic barrier (\( \approx 800 \text{ K} \)), and might therefore be expected to slow to a negligible rate at very low temperatures. In fact, this H-atom abstraction reaction does take place efficiently at low temperatures due entirely to tunneling. I will report direct experimental measurements of the rate of this reaction down to a temperature of 11 K, in remarkable agreement with state-of-the-art quantum reactive scattering calculations by François Lique (Université du Havre) and Millard Alexander (University of Maryland).

It is thought that long chain cyanopolyne molecules \( \text{H(C}_2\text{)}_n\text{CN} \) may play an important role in the formation of the orange haze layer in Titan’s atmosphere. The longest carbon chain molecule observed in interstellar space, \( \text{HC}_{11}\text{N} \), is also a member of this series. I will present new results, obtained in collaboration with Jean-Claude Guillemin (Ecole de Chimie de Rennes) and Stephen Klippenstein (Argonne National Labs), on reactions of \( \text{C}_2\text{H}, \text{CN} \) and \( \text{C}_3\text{N} \) radicals (using a new LIF scheme by Hoshina and Endo) which contribute to the low temperature formation of (cyano)polyynes.

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\( ^b \text{S. D. Le Picard, M. Tizniti, A. Canosa, I. R. Sims, I. W. M. Smith, Science 328, 1258 (2010).} \)


