

New light cast on key chemical reactions in interstellar space

July 11 2007

A detailed understanding of key chemical reactions that take place in interstellar space has been provided by groundbreaking research at two U.S. Department of Energy national laboratories and two European universities.

Argonne National Laboratory senior chemist Stephen Klippenstein – along with colleagues at Sandia National Laboratories; the Institute of Physics, University of Rennes, France; and the University of Cambridge, U.K. – has developed a detailed understanding of the dynamics of reactions between neutral radicals and neutral molecules, known as “neutral-neutral” reactions, at temperatures as low as 20 Kelvin, approximately the temperature of interstellar space.

In their work, Klippenstein and his collaborators determined why certain molecules reacted rapidly even at low temperatures by carefully comparing theory and experiment for a sample class of reactions (O₃P + alkenes) that spans the range from non-reactive to highly reactive. The observed results from the experiment closely correlated with theoretical predictions, said Klippenstein.

“It was remarkable,” he said, “just how well theory and experiment agreed throughout the whole spectrum from 20 Kelvin to room temperature. This means that we can rely on theory to predict which reactions will happen quickly.”

Establishing a working model for interstellar chemistry is especially

important given the difficulty of performing large-scale experiments, according to Klippenstein.

“My collaborators have developed some great experimental techniques for measuring these reactions at low temperatures,” he said. “But such experiments are still very time-consuming and are also hard to apply to many reactions. So schemes for predicting the reactivity for arbitrary reactions, either a priori or from extrapolation of measurements at higher temperatures, are of great utility to modelers of interstellar chemistry.”

Prior experimental studies with the CRESU (Reaction Kinetics in Uniform Supersonic Flow) technique demonstrated that a “surprising number” of neutral-neutral reactions remain rapid at very low temperatures. As a result, such reactions can play an important role in the chemistry of interstellar space, in contrast with the conventional wisdom that interstellar chemistry is essentially all ion-based.

The paper, entitled “Understanding Reactivity at Very Low Temperatures: The Reactions of Oxygen Atoms with Alkenes,” appears in the July 6 issue of *Science*.

Source: Argonne National Laboratory

Citation: New light cast on key chemical reactions in interstellar space (2007, July 11) retrieved 14 July 2024 from <https://phys.org/news/2007-07-key-chemical-reactions-interstellar-space.html>

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