Low temperature kinetic studies of atomic nitrogen – radical reactions

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In the interstellar medium, and mainly in dark clouds, the chemistry of atomic nitrogen differs from atomic carbon and oxygen because it cannot form more complex hydride species through reaction with H_3^+ [1]. Instead, atomic nitrogen is thought to react mostly with neutral species which involves the conversion from atomic to molecular nitrogen. Four reactions are implicated in this conversion:

$N + OH \rightarrow NO + H$ [1] followed by $N + NO \rightarrow N_2 + O$ [2]

$N + CH \rightarrow CN + H$ [3] followed by $N + CN \rightarrow N_2 + C$ [4]

Current models using estimated rates for these reactions predict large abundances of N_2 (10^{-5} with respect to total hydrogen). In contrast, N_2 abundances inferred from observations of N_2H^+ are much lower (10^{-6} with respect to total hydrogen).

The measurement of low temperature rate constants for such atom-radical reactions represents a considerable challenge for experimentalists. A new technique to measure rate constants for reactions between two unstable radicals at low temperatures has been developed. The CRESU (Cinétique de Réaction en Ecoulement Supersonique Uniforme) technique has been coupled with microwave discharge methods to produce excess quantities of ground state atomic nitrogen and PLP-LIF (Pulsed Laser Photolysis – Laser Induced Fluorescence) has been employed to produce and follow the decay of the minor reagents (see figures). The relative rate technique has been employed to extract absolute rate constants using known reference reactions.

We will present kinetic results obtained for the reactions of atomic nitrogen with OH [1] [2], CH [3] and CN [4] over the range $56 \leq T/K \leq 296$.

References

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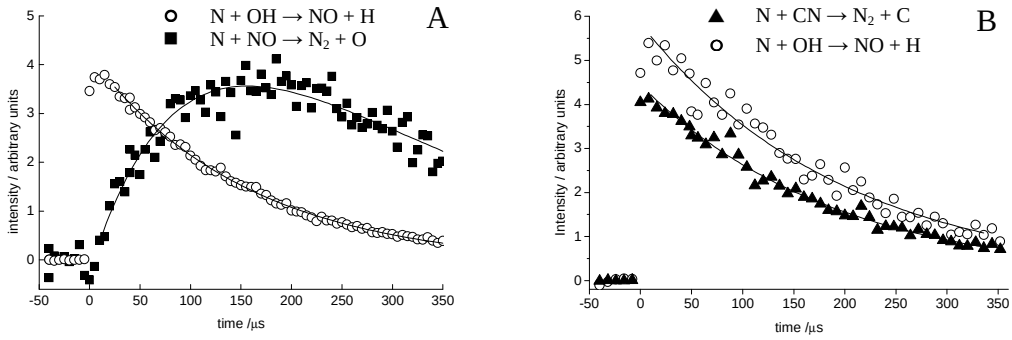

Typical decays obtained at 56 K. A: OH signal, open circles; NO signal, solid squares. B: OH signal, open circles; CN signal, solid triangles.