N89-1669

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND TECHNOLOGY RESUME

TITLE

Chemical Abundances of Comets

PERFORMING ORGANIZATION

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DESCRIPTION *(a. Brief statement on strategy of investigation; b. Progress and accomplishments of prior year; c. What will be accomplished this year, as well as how and why; and d. Summary bibliography)*

Strategy - Observations of NH_2, [OI] and molecular ion spectra in comets represent virtually all of the volatile fraction of a comet nucleus. Their study leads to the N_2, NH_3, H_2O, CO_2, CO content of the nucleus, and thus to important constraints on models of comet formation and chemical processing in the primitive solar nebula. The observations of comet Halley provide the opportunity for the first comprehensive determination of the abundances in a comet nucleus.

Accomplishments - The carbon isotope abundance ratio, $^{12}C/^{13}C = 65 \pm 8$ has been determined for comet Halley from resolved rotational line structure in the CN B-X (0,0) band. This ratio is $\sim$ 30% lower than the solar system value, 89, indicating either an enhancement of ^{13}CN or a depletion of ^{12}CN in the comet. Scenarios consistent with the observed carbon isotope ratio are: 1) formation of the comet at the periphery of the solar nebula in a fractionation-enriched ^{13}CN region, or hidden from ^{12}CN enrichment sources, and 2) capture of an interstellar comet.

Long-slit CCD spectra obtained at the time of the spacecraft encounter of comet Halley have also been analyzed. Scale lengths, production rates and column densities of CH, CN, C_2 and NH_2 were determined. We find that NH_2 can be modeled well with a two-step decay point-source model, and that the ammonia abundance, $NH_3/H_2O \sim 0.003$, $\sim$ ten times smaller than determined from the GIOTTO ion mass spectrometer. The carbon-bearing species could not be fitted with the point-source model which indicates that a significant fraction of these radicals arise from a distributed source such as the CHON particles.

Moderately strong, unidentified molecular ion bands were discovered in the plasma tail spectra of comet Halley. No known laboratory molecular ion spectrum can account for the new cometary bands.

Analysis of pre- and post-perihelion spectra of comet Giacobini-Zinner using a Monte Carlo model confirm the low C_2/H_2O ratio, and indicate a very low NH_3/H_2O ratio.

In Progress - Fluorescence efficiencies and column densities of ions observed in the plasma tail of comet Halley are being determined. The observed ions, CO_2^+, CO^+, CH^+, OH^+, H_2O^+ and N_2^+, derive from the most abundant molecular species in the nucleus. Hence their relative abundances will provide important constraints on the nucleus abundances, the coma chemistry, and ultimately on the chemical processing in the primitive solar nebula.

The N_2/NH_3 abundance ratio in comet nuclei is diagnostic of the physical conditions where comets form in the solar nebula. This abundance ratio will be determined for comet Halley, and other comets in which N_2^+ and NH_2 features are observed.

A dust production model is being developed to determine dust production rates from optical continuum spectra in comets. Pre- and post-perihelion observations of comet Halley will be analyzed for gas and dust production rates as a function of heliocentric distance to determine relative abundances and to test for inhomogeneities in the nucleus.

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