The Comet Kohoutek— H_2O^+ in "Christmas Comet"

During the approach of the Comet Kohoutek in the autumn of 1973 stories abounded describing the elaborate scientific preparations in progress to study this newcomer to the solar system. The National Aeronautics and Space Administration (NASA) organized "Operation Kohoutek" to use the special observational advantages of Skylab, the Mariner — Venus probe, the infrared air borne observatory, and many of the orbiting satellites, while major radio and optical observatories geared their viewing schedules to the comet's passage.

Kohoutek, unfortunately, did not cooperate. Instead of blooming into the "comet of the century" as expected, it was the cosmic disappointment of the seventies, barely discernable in the evening skies of January 1974 when it had attained maximum brightness. Astronomers pronounced it a dusty comet, congealing in toffee-apple fashion on the surface, thus preventing the vaporization necessary to the formation of a visually spectacular tail.

The publicity generated by Kohoutek's appearance was focussed almost entirely on the methods of observation, the huge telescopes, the space probes, and the satellites, with little information on the nature of the expected flood of data, or how scientists would translate it into meaningful information. It therefore came as a surprise when one of the more important discoveries resulting from the comet's visit originated in a darkened physics laboratory.

Through the collaborative efforts of Dr. Gerhard Herzberg, Nobel Laureate and NRC Distinguished Research Scientist, and Dr. Hin Lew of the Division of Physics' Spectroscopy Section, the molecular ion H_2O^+ was positively identified as a constituent of the comet's tail. Although theoretical considerations had long suggested the existence of the ion in comets, the absence of information on its spectrum had precluded any positive identification.

"The outer reaches of space are explored almost entirely by analysing the electromagnetic spectrum," says Dr. Herzberg, "and to identify a specific substance, one must know beforehand what its spectrum looks like. Our program of production and characterization of molecular ions has been set up with a view to explaining some of the unidentified features in the astrophysical literature. Dr. Lew had already produced H_2O^+ in the laboratory and completed much of the spectral analysis — a task that took some months — when the first photographs of the Kohoutek spectrum were received. Like so many of the events in science, this coinciding of the laboratory advance and the arrival of the comet was purely fortuitous; the work on H_2O^+ was simply one result in a larger program of molecular ion studies set up long before the appearance of Kohoutek."

The modus operandi of the program is to produce ions thought to be present in the heavens, determine their emission or absorption spectra (or both), and then review the catalogue of unidentified astronomical features to see if the new data fits the old. The primary problem in obtaining laboratory molecular ion spectra is the strong tendency for ions to recombine with other molecules or fall apart into constituent atoms. The task of identifying them in outer space lies as much then in their production and characterization in the laboratory as in picking up their spectra in a telescope.

"The H_2O^+ ion is produced in an apparatus in which neutral water is bombarded with electrons," explains Dr. Lew. "A bank of tungsten filaments is heated until they begin emitting electrons, which are accelerated toward an anode across an area