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SPECTROSCOPIC OBSERVATIONS OF COMET AUSTIN (1989c)

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ABSTRACT

Longslit CCD spectra($\lambda = 5100-6400$ Å, $\Delta\lambda \sim 3$ Å) were obtained with the Michigan-Dartmouth-MIT 1.3 meter telescope in May 1990($r = 0.74$ AU, $\Delta = 0.50$ AU). The spectra have been reduced with IRAF. Spectral extractions offset sunward and tailward from the nucleus were analyzed. Species identified in the spectra include: C_2, NH_2(10-0), NH_2(9-0), H_2O^+, and CO^+. Spatial extractions of rotational line intensities in the NH_2(10-0) band extend $\sim 10^{4.5}$ km from the nucleus. A fit of the vectorial model to the NH_2(10-0) spatial profile is consistent with an NH_3 parent molecule. The NH_2 production rate and an ammonia to water abundance ratio, NH_3/H_2O~0.3% have been derived. The ammonia abundance obtained for comet Austin is consistent with that found for several other comets, and is indicative of comet formation under very homogeneous conditions.

1. INTRODUCTION

The ammonia abundances of comets provide a sensitive diagnostic for models of comet formation. If comet volatiles originated from condensation of solar nebula gases, the ammonia/water abundance ratios of comet comae provide unique probes of the degree of homogeneity in the solar nebula 4.5 billion years ago. If, on the other hand, comets represent conglomerates of icy interstellar grains which survived processing in the proto-solar nebula collapse phase, then the ammonia/wateer ratios in comets represent the conditions prevailing in the precursor dense molecular cloud. Ammonia has not yet been directly detected in a comet, and was not uniquely identified in the *in situ* mass spectrometer measurements of the Giotto spacecraft in comet Halley (Krankowsky *et al.* 1986). The amine radical (NH_2) is observed in fluorescence in comet spectra, and has been used to derive ammonia abundances in several comets. For six comets, the ammonia abundances indicate production rate ratios in the range, $Q(NH_3)/H_2O$~0.1-0.5% have been found for the group of long and short period comets. (Tegler and Wyckoff 1989, Magee-Sauer *et al.* 1989, Wyckoff, Tegler and Engel 1991, Schleicher *et al.* 1990). The EUV solar flux photodissociates NH_3 into NH_2 with a branching ratio of 97%, and there are no other known significant sources of NH_2 observed in comets, so that the abundance of NH_2 essentially gives a direct measurement of the ammonia content of comets (Tegler 1989, Tegler and Wyckoff 1989, Wyckoff, Tegler and Engel 1991, Tegler etal 1991).

In December 1989 a new comet was discovered by R. Austin (Bortle 1990), which was later shown to be a long-period comet with a parabolic orbit. Its perihelion distance was one of the closest to the sun in recent years (q ~0.37 AU), and the comet attained an apparent visual magnitude ~0.1 shortly after perihelion which occurred 1990 April 9.97 UT. Here we present spectroscopic observations of comet Austin (1989c) from which we derive an ammonia/water abundance ratio. We also present spectra of the plasma tail of comet Austin from which the neutral species' coma spectrum has been subtracted. The tail spectrum shows clear evidence for the unidentified bands first discovered in the ion tail spectrum of comet Halley. Here the unidentified molecular ion bands show resolved structure for the first time.

2. OBSERVATIONS

The long-slit spectra were obtained 4-8 May 1990 with the Michigan-Dartmouth-M.I.T. 1.3-m telescope and CCD spectrograph when the comet had a geocentric distance ~0.5 AU and a heliocentric distance ~0.8 AU. The slit size projected on the sky was 1.5 arcsec × 540 arcsec, which scales to 540 km × 190,000 km at the comet on May 4. The spectra cover the wavelength range, 5100-6400 Å, with a spectral resolution ~3.1 Å(FWHM), and a sampling of 3 pixels/FWHM. The scale perpendicular to the direction of dispersion corresponded to 1.35 arcsec/pixel. The spectrograph slit was oriented along the projected tail axis of the comet and typical integration times ranged from 600 to 3600 s. The spectra were reduced with the software reduction package, Image Reduction and Analysis Facility(IRAF) developed and distributed by the National Optical Astronomical Observatories(NOAO). A spectrum at a projected distance ~16,000 km from the comet nucleus extracted from the two-dimensional long-slit CCD image is shown in Figure 1.

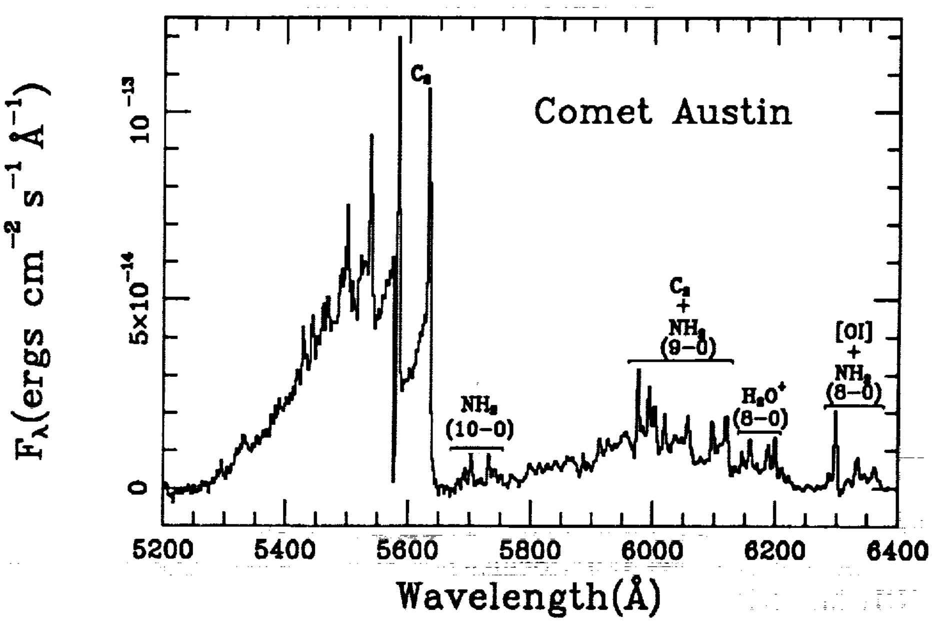

Figure 1 - Observed spectrum of Comet Austin(1989c) extracted from a CCD spectral image(resolution ~3 Å) obtained with the 1.3-m Michigan-Dartmouth-MIT telescope 4 May 1990. The spectrum shows the neutral radicals NH_2, C_2, and the H_2O^+ ion features offset ~16000 km from the comet nucleus. The [OI] lines have been corrected for night sky contamination.

Integrated fluxes were obtained from a spectrum extracted ~8300 km from the nucleus for the observations on the night of May 4. In Figure 2 we show the spectrum of the plasma tail ~34,600 km from the comet nucleus.

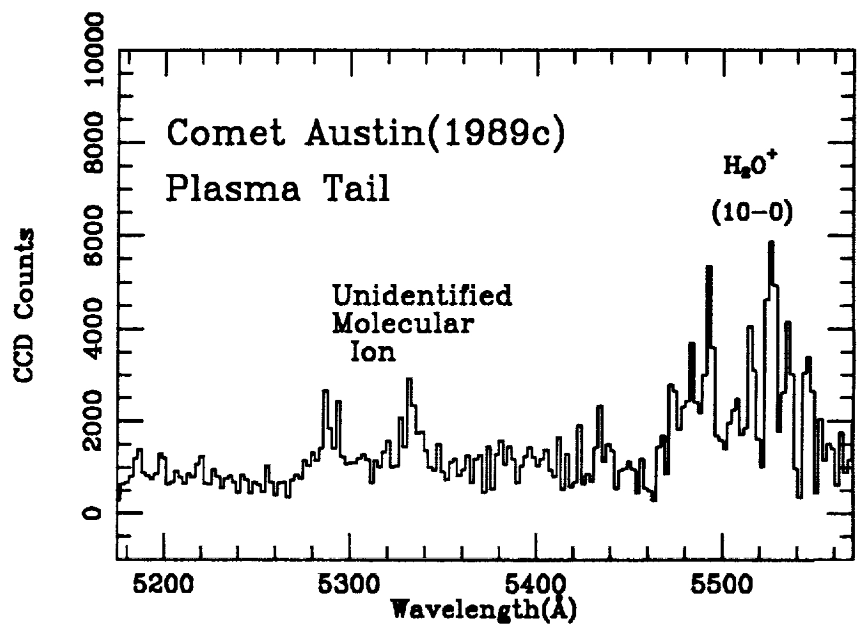

Figure 2 - Observed tail spectrum of Comet Austin(1989c) extracted 33,000 km (1.6 arcmin) tailward from the nucleus. The extraction includes 10,000-57,000 km, and shows the strongest unidentified ion features near 5300 Å as well as the (10-0) band of H_2O^+ at 5500 Å .

III. RESULTS

The spatial profile of NH_2 extracted from the spectrum exhibited a sizescale fro the Nh_2 distribution consistant with photolysis of NH_3 (Heyd and Wyckoff 1991). Therefore we assume that the observed NH_2 derives predominately from ammonia released from the comet nucleus. The flux of the (10-0) NH_2 band at 5700 Å is a spectral extraction 1.5 X 8.1 arcsec, measured at a projected distance 8,300 km tailward from the nucleus was, F = 2.3 X 10^{-13} erg cm^{-2} s^{-1}. for a fluorescence efficiency, g = 0.0053 s−1, a column density, N(NH_2 = 3 X 10^{11} cm^{-2} was derived. The production rate derived using the vectorial model (Festou 1981), was Q(NH_2) = 2 X 10^{26} s^{-1}, which for a branching ratio of 97% for $NH_3 \rightarrow NH_2$ corresponds to an ammonia production rate, Q(NH_3) = 2 X 10^{26} s^{-1}. Scott Budzien (private communication) determined the OH production rate from IUE spectra of comet Austin on the approximte same date as our observations, and found Q(H_2O) = 8 X 10^{28} molecules s^{-1}. Thus we derive Q(NH_3)/Q(H_2O) = 0.003 in good agreement with previous results which are in the range 0.1-0.5 %.

The unidentified ions indicated in Figure 2 were observed in comet Halley, and do not correspond in wavelength to any known molecular ion so far observed in laboratory spectra (Herzberg 1990, private communication).

VI. References

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