CN AND NH_2 ATMOSPHERES OF COMET C/1999 J3 (LINEAR)

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Observations of Comet C/1999 J3 were made at the 2-m telescope of the Pik Terskol Observatory on September 19, 1999. Narrow-band CCD images of the CN, NH_2, and dust atmospheres have been recorded using the two-channel focal reducer of the Max-Plank-Institute for Aeronomy. To fit distributions of the CN and NH_2 molecules in the comet atmosphere Monte Carlo model was adopted. Model calculations were successful with photodissociation lifetimes equal to $\tau_{\mathrm{CN}} = 1.5\times10^5$ s and $\tau_{\mathrm{CN}parent} = 3.2\times10^4$ s for CN and its parent, $\tau_{\mathrm{NH_2}} = 1.0\times10^5$ s and $\tau_{\mathrm{NH_2}parent} = 5.0\times10^3$ s for NH_2 and its parent, respectively. These results are in agreement with HCN as the main source of the CN radicals and NH_3 as the main source of the NH_2 radicals in the atmosphere of Comet C/1999 J3 (Linear). The gas-production rates of CN, Q(CN)=3.8×10^{25} mol^{-1}, and NH_2, Q(NH_2)=2.6×10^{25} mol^{-1}, have been determined as well. These values are about 0.24% and 0.16%, respectively, of the water production rate.

OBSERVATIONS AND DATA REDUCTION

Observations of Comet C/1999 J3 were made at the 2-m telescope of the Pik Terskol Observatory on September 19.004, 1999, when the comet was close to its perihelion. The 2-channel focal reducer of the Max-Planck-Institute for Aeronomy equipped with CCD detectors was used to study its neutral atmospheres (Jockers, 1997). Observed sky fields were 7.8×7.8 arcmin with a pixel size of 1.0 arcsec and 7.8×5.2 arcmin with a pixel size of 0.8 arcsec in the blue and red channels, respectively. The interference filters IF390 ($\lambda_0 = 389.4$ nm, FWHM = 10.5 nm) and IF662 ($\lambda_0 = 662.1$ nm, FWHM = 5.9 nm) were chosen to isolate the emissions of the CN and NH_2 molecules. The corresponding underlying continua were estimated using observations through interference filters IF642 ($\lambda_0 = 641.6$ nm, FWHM = 2.6 nm) and IF443 ($\lambda_0 = 443.2$ nm, FWHM = 4.4 nm).

Original CCD frames were bias subtracted, flat-fielded and cleaned from cosmic events. Star trails were also removed from the comet images. The cometary atmosphere filled the available sky field to a large extent. Nevertheless, the night sky level was estimated and subtracted. The absolute intensity scale for cometary counts was determined from observation of the standard star 15 UMa. Its flux was taken from Voloshina *et al.* (1982).

TIME SCALES AND GAS PRODUCTION RATES

For the analysis of our data we have taken the random walk model, which is based on Monte Carlo simulation. The details of the algorithm were described by Combi and Smyth (1988). Adequacy of our calculations was tested by comparison of the observed surface distribution of the analyzed species with the calculated one. The Chi-square goodness-of-fit test has been adopted for this purpose.

CN molecule. Although CN is the second species detected in comets, so far there is no agreement among researchers regarding the nature of its parent. The most plausible hypothesis is that the HCN molecule is the major contributor of this radical in the cometary atmosphere.

According to the theoretical prediction provided by Huebner and Link (1999), lifetimes for HCN and CN decrease from 7.94×10^4 s and 3.15×10^5 s to 3.19×10^4 s and 1.34×10^5 s from the solar activity maximum to minimum.

We satisfactorily fitted the CN atmosphere observed with lifetimes equal to 1.5×10^5 s for CN and 3.2×10^4 s for its parent. Taking into account that we made our observations in September 1999, when the Sun was close to the maximum of its activity, we can conclude that there is an excellent agreement between the observed and calculated data. So, we think that just HCN is the dominant source of CN in the atmosphere of Comet C/1999 J3 (Linear).

NH_2 molecule. Previous observations of the NH_2 surface brightness distributions in comets were mainly obtained from long-slit spectra. Because the NH_2 emission bands are weak and in many cases blended with features of other species, it is very difficult to interpret them. Nevertheless, in 1989 Tegler and Wyckoff (1989) came up with a proposal that NH_3 is the parent of NH_2.

According to Huebner and Link (1999) there are several possibilities for the NH_2 parent, *i.e.*, NH_3, to be dissociated into NH_2 and other particles, but the reaction displayed below is the dominant one under solar irradiation

$$\mathrm{NH_3} + h\nu = \mathrm{NH_2(X^2B_1)} + \mathrm{H}.$$

About 96% of NH_2 appears in the cometary atmosphere in this way. In this reaction life times for NH_3 and NH_2 are decreased from 5.65×10^3 s and 4.65×10^5 s to 5.00×10^3 s and 2.94×10^5 s when the solar activity varies from low to high.

We interpret here the two-dimensional NH_2 atmosphere. Our computed surface profiles are in reasonably good agreement with the observed ones, if we adopt theoretical values for the time scales of NH_2 destruction, $\tau_{NH_2} = 1.0\times10^5$ s, and $\tau_{NH_2 parent} = 5.0\times10^3$ s for destruction of its parent, the NH_3 molecule. So, we conclude that NH_3 is probably the dominant source of NH_2 in the coma of Comet C/1999 J3 (Linear).

Gas production rates. The total number of the analyzed molecules in the cometary coma, N_{obs}, is related to the total flux of the observed band measured at the Earth by

$$\mathrm{N}_{obs} = \frac{4\pi\Delta^2 \mathrm{F}_{obs}}{g}, \tag{1}$$

where g is the fluorescence efficiency factor of the observed band, Δ is the geocentric distance of the comet, and F_{obs} is the total flux of the observed band. The fluorescence efficiency factor (g–factor) is assumed to vary as r^{-2}, where r is heliocentric distance in AU.

As we know the model amount of the analyzed molecules, N_{mod}, and model production rate, Q_{mod}, from the model experiments then

$$\mathrm{Q}_{obs} = \frac{\mathrm{N}_{obs}}{\mathrm{N}_{mod}} \mathrm{Q}_{mod}. \tag{2}$$

The g-factor for CN has been taken from A'Hearn *et al.* (1995). We used the value of 2.4×10^{-13} erg s^{-1}mol^{-1} valid for the heliocentric velocity of Comet C/1999 J3 (Linear) at the moment of observation. According to equation (2) we have Q(CN)=3.8×10^{25} mol^{-1}.

To determine the gas production rate for NH_2 we use the g-factor for the (0,7,0) band as computed by Tegler and Wyckoff (1989), *i.e.*, 1.26×10^{-14} erg s^{-1}mol^{-1}. It should be noted that this value was doubled in our calculations, because according to C. Arpigny statement only half of the population of NH_2 molecules contributes to the odd, *e.g.*, (0,7,0) transitions, while the other half contributes to the even, *e.g.*, (0,8,0) transitions. This correction leads to the NH_2 production rate $Q_{NH_2} = 2.6\times10^{25}$ mol s^{-1}.

The water production rate for this comet has been determined by Jockers *et al.* (2001) from H_2O^+ observations. Using MHD similarity law the value of 1.6×10^{28} mol s^{-1} was found. Comparison with our data evidences that Q(CN)/Q(H_2O)=0.24% and Q(NH_2)/Q(H_2O)=0.16%. These results are in agreement with available data for previously observed comets.

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