VARIATIONS OF LINES SELECTED IN THE COMET HALLEY SPECTRUM

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Some results of processing the spectrophotometry of Comet Halley are presented in this paper. At the end of preperihelion period the spectral observations of Comet Halley had been performed at the 6-m telescope (SAO, Russia) to ensure a good combination of the spectral (less than 0.1 nm per channel), angular (4 arcsec) and time (5–10 min) resolution. Autocorrelational and crosscorrelational functions and Fourier transformations for the main lines are obtained. We have determined two periods of variations and showed an uniformity of chemical composition of ejecting comet material.

INTRODUCTION

The TV-scanner in the Nasmyth's focus of the 6-m telescope was used as the spectral device for dynamical spectroscopy of Comet Halley. The applied diffraction grate gave the inverse dispersion of 5 nm/mm. The length of a spectrum on the inlet of the image intensifier was equal to 18 mm. The scanner gave the number of photoelectron events in each of 1024 spectral channels. Thus, the width of the channel was of about 0.09 nm. The whole covered spectral region was of 332–660 nm. The spectrograph with a long (> 40 arcsec) slit was used. The width of the slit was set in the range 0.2–1.5 arcsec. A special mask was attached to the slit to cut from it two rectangular diaphragms. The height of each was equal to 4 arcsec. So, we had two space channels separated by 40 arcsec and every exposure gave two one-dimension spectra of two different points of the comet atmosphere.

Four modes of the diaphragm pointing were used: N – the nucleus and the region at 40 arcsec from it; C – two regions of the coma each at 20 arcsec from the nucleus between its; NN – the near-nuclear region at 4 arcsec from the nucleus and the point in the atmosphere at the nucleocentric distance 36 arcsec; S – one of the diaphragms was accompanying the occulted star, while another was tracing the coma.

A total number of obtained spectra is of about 500. Observations are described in detail in [1, 3]. The primary processing the spectra has been carried out by H. K. Nazarchuk with the software developed in SIPRAN-language in SAO. This processing removed the effect of geomagnetic field on the image intensifier and the atmospheric extinction. In this paper we study only N mode in the spectral region of 400–510 nm.

CALCULATIONS

The autocorrelation functions and Fourier transformations for some lines are shown in Figs. 1–4. The correlation function is

$$K(\tau) = \int_{-\infty}^{+\infty} F(t)F(t+\tau)dt, \tag{1}$$

where $F(t) = \sum_{k=1}^{N} A(t)\delta(t-\tau_i)$ and from this after some transformations [2] we have

$$K(\tau) = \frac{1}{T}\sum_{i=1}^{N} C_k\delta(t-\tau_k), \tag{2}$$

where $\tau_k = t_j - t_i$, $C_k = A_iA_j$, $K(\tau)$ is a discrete value of the autocorrelation function. To obtain the continuous function instead of the discrete one we used the smoothing by the convolution it with the Gauss core.

$$y(\tau) = C\sum_{i=1}^{N} K(\tau)_i exp(-(x(i)-X)^2/d), \tag{3}$$

where $d = 2\sigma^2$, $C = 1/(\sigma\sqrt{2\pi})$, $N = 28$ – number of measurements in series, σ – the constant for smoothing of oscillations on the frequency of sampling. This method is described in detail in [3, 4].

Three types of crosscorrelations are under investigation here: a) crosscorrelation between lines of the same element for the nucleus and coma at 40 arcsec from nucleus separately (Fig. 5); b) crosscorrelations between lines of different elements for the nucleus and coma at 40 arcsec from nucleus separately (Fig. 6); c) crosscorrelations between the nucleus and coma for the same lines (Figs. 7, 8). Crosscorrelations were calculated by the formula:

$$K(\tau) = \frac{1}{T}\sum_{k=1}^{N} C_k \delta(t - \tau_k), \tag{4}$$

where $\tau_k = |t_{1j} - t_{2i}|$, $C_k = A_{1i}A_{2j}$.

ANALYSIS

The method of smoothing and the choice of the parameters are the same as in (3). As our results show, in all the cases we have a good agreement between all the lines. It says about a common mechanism for time variations of all the lines and the chemical homogeneity of the nucleus. We propose a mechanism, when gases of the parent molecules, which generate such species as CN, CH, C_2, NH_2, are ejecting from the active regions of the nucleus.

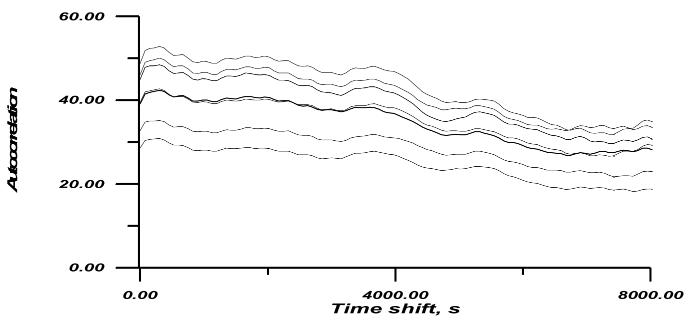

Figure 1: Autocorrelations of CN lines for nearnuclear region

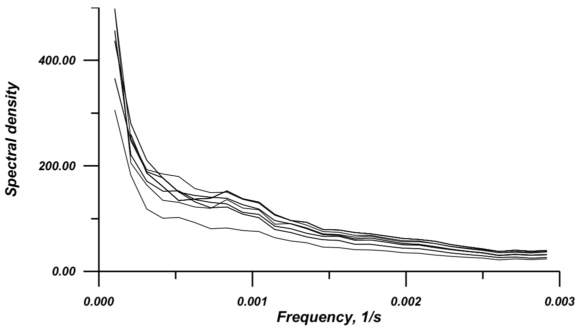

Figure 2: Fourier transformations of CN lines for near-nuclear region

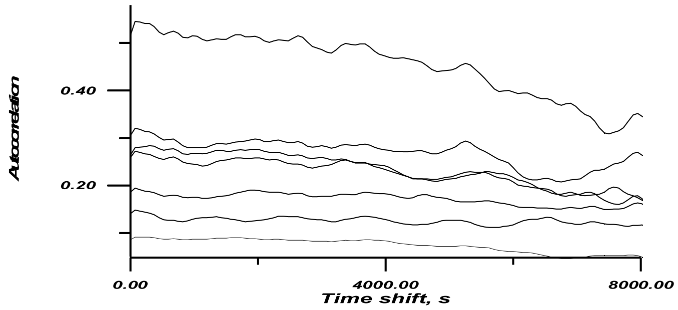

Figure 3: Autocorrelations of CN lines for coma

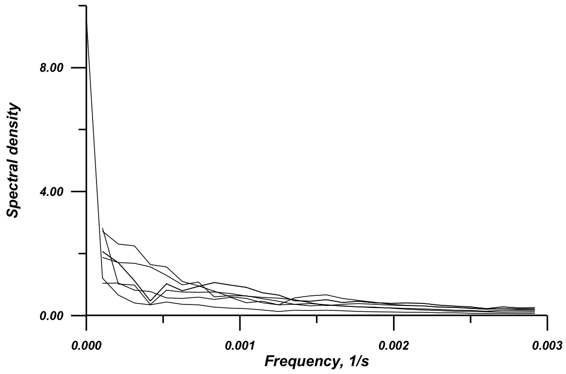

Figure 4: Fourier transformations of CN lines for coma

Fourier transformation of the crosscorrelation functions confirms the similar time behavior of all the lines studied. This analysis confirms the conclusion about the uniformity of the chemical composition of comet material ejected from the active regions. The synchronic behavior of the lines studied can be explained by variations in the rates of evaporation which are much shorter then the axial rotational period and are equal to $2^{\mathrm{h}}20^{\mathrm{m}}$ and $\sim 40^{\mathrm{m}}$ (?), respectively. The presence of these periods is connected with the mechanisms of evaporation and ejection. Their stability should be examined additionally, because their time variations presented here are tentative estimates.

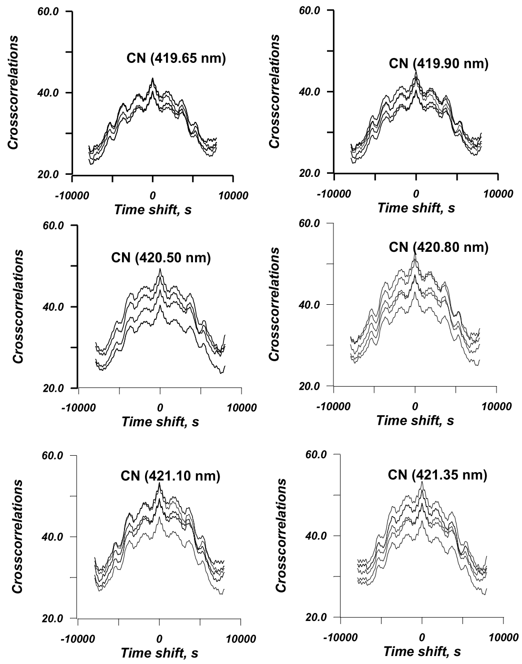

Figure 5: Crosscorrelations of CN lines for nearnuclear region

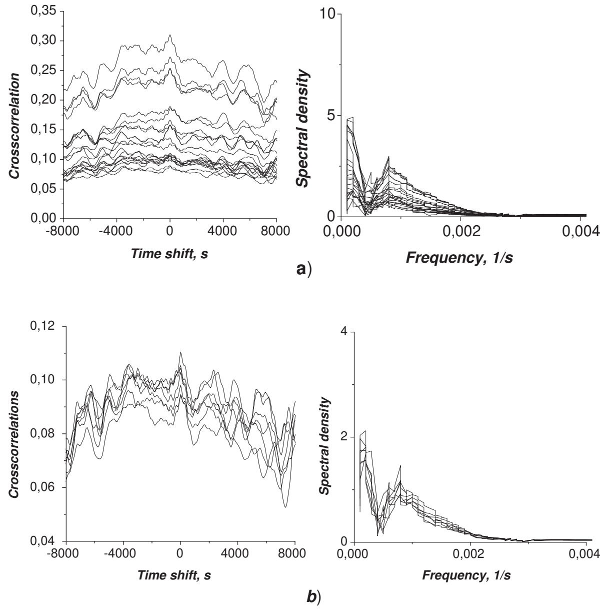

Figure 6: Crosscorrelations and Fourier transformations of CN (419.65 nm) line with: a) C_2 lines; b) NH_2 lines for coma

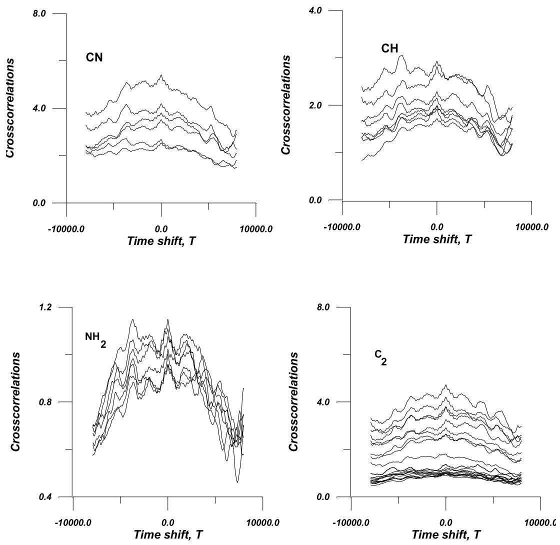

Figure 7: Crosscorrelations between the nucleus and coma for investigated spectral lines

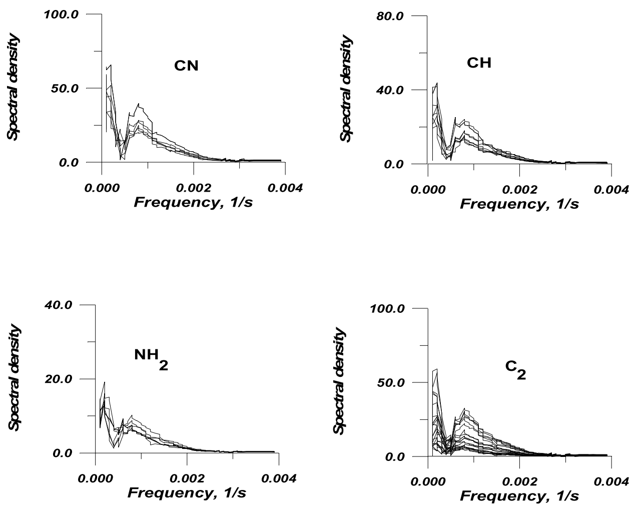

Figure 8: Nucleus – coma Fourier transformations for all investigated lines

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