CARBON-CONTAINING NEUTRALS AND THEIR SPATIAL DISTRIBUTION IN THE HALLEY COMET COMA

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Introduction.

Carbon plays a major role in the physical and chemical processes in the Solar system, due to its quantity and great chemical diversity and, mostly - to its great biological significance. The observations of Halley's comet show that carbon is the main constituent of the cometary nucleus. Emissions of different carbon-containing radicals and ions are registered. The C_2, C_3, CH и CN emissions are some of the strongest in the visible region. In order to investigate the separate bands with spectrophotometric observations, it is necessary to separate correctly their glow from the measured spectra.

In order to study the carbon-containing neutrals glow, the spectra in the near UV and visible region are used, registered by the three-channel spectrometer (TCS) on board the VEGA-2 Interplanetary station in the Sun coma on 9 March 1986. The spectra are totally 1035, 667 of which in mode A when the instrument scans a rectangular region with 2°x1.5°sizes, 15x7 positions and, 368 in mode B when VEGA-2 is closest to Halley's comet and TCS scans only along the central line – 15 positions, a spectrum being registered in each position.

II. Separation of the carbon-containing neutrals emissions by the TKS - registered spectra.

The correct separation of the cometary components emissions by the registered spectra is of crucial importance for the analysis of their distribution around the cometary nucleus.

The precision of a given band separation depends on the selected wave interval width, on the method for calculating the spectral index **u**, which determines the dust continuum course [1] and on the way for normalizing the dust continuum to the measurement data. A criterion for the quality of the method for separating the column intensity of a specific emission by the measured spectra can be the type of its dependence on the projected distance to the nucleus or, the **p**-parameter (the perpendicular from the nucleus to the line of observation). The more compact this dependence (the points around a given curve are grouped more densely), the better the glow of the investigated constituent is separated.

II.1. Calculation of the spectral index *u* for each spectrum.

The spectral index **u** determines the form of the curve, describing the dependence of the dust continuum intensity on the wavelength:

$$I_d=I_s\lambda^{-u+2}$$

The investigations show that with changing parameter **u** even by 0.1, the dust continuum changes noticeably. This requires **u** to be calculated most precisely. Until now it was calculated by a linear regression on the basis of 11 dust points as the regression coefficient was determined by the least squares method. The intensity was obtained by averaging 5 consecutive pixels (30 Å), centered on the respective dust line [1].

The dust points involved in the calculations are reconsidered and the intensity average deviation values are examined for each line as well as the length of the confidence interval for parameter **u**, depending on its inclusion and exclusion.

The dust line at 4100 Å cannot be used for calculations of spectra, measured by TCS because the adjacent cometary emissions cannot be well separated in this region. Instead, the calculations include the 3760 Å line. The dust lines 4250 Å, 6770 Å и 6840 Å also drop off. The computing of the spectral index **u** is made on the basis of the following 8 dust lines: 3760, 4520, 4860, 4890, 5260, 6100, 6250, 6500 Å, as the average intensities of 3 pixels, centered along the respective wavelength in the non-deconvoluted spectra are used.

The confidence interval of 95 % for the spectral indices, thus obtained, is several times smaller and the statistical regression coefficient is several times larger than in the previous calculations. The parameter is obtained within the limits of 3÷3.4 for 95% of the spectra and, for the remaining 5 % the interval is extended from 2.1÷3.7. For all 1035 spectra $\mathbf{u_{cp.}}$=3.1768, $\mathbf{du_{cp.}}$=0.1896, for mode A (667 spectra) $\mathbf{u_{cp.}}$=3.2126, $\mathbf{du_{cp.}}$=0.2282, for mode (368 spectra) $\mathbf{u_{cp.}}$=3.1119, $\mathbf{du_{cp.}}$=0.1197.

II.2. Dust continuum norming to the measurement data.

So far, in order to subtract the dust continuum from a given cometary emission, it was normed to its closest dust line, as the minimum in a definite interval around this line was searched [2]. The attempts have shown that if the dust line is not well selected (for example, 4100 Å) or, the found minimum is not suitable, considerable errors can be made in the determination of the investigated emission intensity, displayed in the large distribution of points in the **p**-parameter dependence.

To avoid this and to obtain more precise data, subject to investigation and analysis, the norming coefficient of the dust continuum is determined by a linear regression on the minima of the deconvoluted spectra in the following 7 dust intervals: 3660÷3800 Å, 4500÷4650 Å, 4819÷4915 Å, 5214÷5333 Å, 6064÷6141 Å, 6206÷6306 Å, 6450÷6600 Å.

The obtained continuum and its norming correspond well to every spectrum. Fig.1 presents 2 spectra with different intensity and the dust continuum for each of them, determined in the above-described way. Vertical lines show the seven minima of each spectrum according to which the dust continuum is normed.

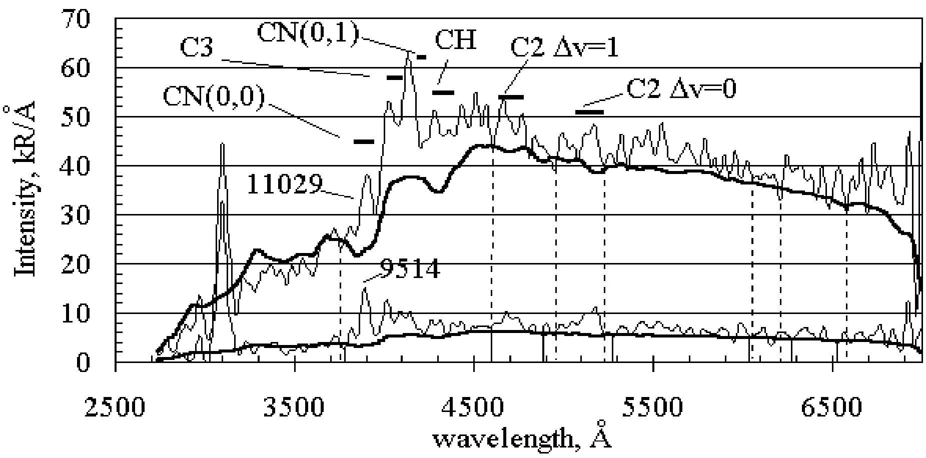

Fig.1. Two spectra on 9.03.1986 with different intensities, registered at board time 9514 sec. and 11029 sec. (board time 0 sec. corresponds to 4:12:38 UT). A darker line below the spectra marks the dust continuum, determined in the above-described way. Vertical lines show the seven minima of each spectrum according to which the dust continuum is normed. Horizontal lines mark the intervals in which the CN, C_3, CH and C_2 bands intensities are summed up

III. Determination and analysis of the emissions intensity, depending on the projected distance to the nucleus.

III.1. Determination of CN, C_3, CH and C_2 intensities.

In order to determine the carbon-containing neutrals intensities, the intensities within intervals of the processed spectra, covering almost the entire glow region of the examined bands are summed up.

The following intervals are used: CN(0,0) – pixels 343÷357, λλ 3842÷3933 Å, CN(0,1) – pixels 401÷404, λλ 4193÷4217 Å, C_3 – pixels 374÷382, λλ 4030÷4084 Å, CH – pixels 415÷426, λλ 4277÷4346 Å, C_2 $\Delta v=0$ – pixels 548÷570, λλ 5076÷5214 Å, C_2 $\Delta v=1$ – pixels 476÷496, λλ 4645÷4755 Å.

These intervals are marked by horizontal lines over the spectra in Fig.1.

III.2. Dependencies of the emissions intensities on the p-parameter.

In the near-nucleus region, the environment cannot be treated as optically thin. The need of an estimate of this fact is clearly seen in the case of the dust continuum (Fig.2). The continuum course with the **p**-parameter coincides the best with the curve, obtained when the optical depth of the inner coma environment is taken into account. It is obtained, that $\tau=1$ at about 200 km.

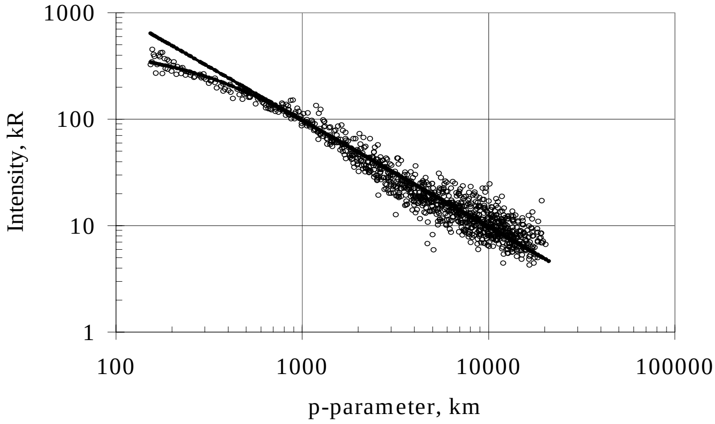

Fig.2. The measured dust continuum. The straight line presents the dependency I=1/p, and the curved in the near-nucleus region one – the same dependency, when the optical depth of the inner coma environment is taken into account. It is obtained, that $\tau=1$ at about 200 km.

The obtained dependencies of the examined emissions intensities on the **p**-parameter are more compact than those obtained in the previous way [2], especially in the cases of C_3 and CH. A larger distribution of the points is observed already with the CN(0,1) intensities which probably is due to the fact that this band is weaker and is mixed with a stronger one, which is seen in Fig. 1. It is possible such emissions to be separated by using non-deconvoluted spectra and very narrow intervals, in which to sum up the intensities.

Fig.3 shows the dependencies of CN(0,0), C_3, CH and C_2 $\Delta v=0$ intensities, corrected with the optical depth, on the **p**-parameter. The curves represent the Haser's law. The needed parameters for the different constituents are taken from [3]. For all emissions a better compliance with Hazer's law is seen than the established by Werner et al. [2] one. The deviation at **p**<1000 km, especially expressed for CN and C_3 [2], is eliminated. It obviously has been a result of incorrectly subtracted dust continuum.

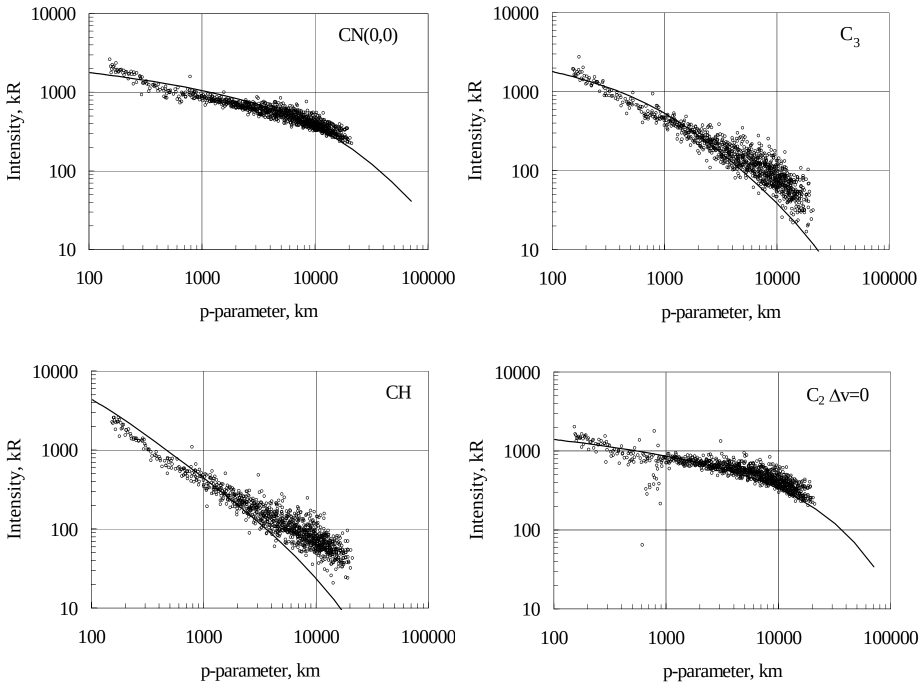

Fig.3. Intensity dependencies on the perpendicular distance, obtained from all spectra measured on 9 March. The dust continuum is extracted in the way, described in this work. Data correction with the optical depth is performed. The curves represent Haser's law.

The dependence of CH on the **p**-parameter is close to the one, obtained by Arpigny et al. [4], with ground-based observations of Halley's comet on 16 March 1986. The results for CN, C_3 and CH are similar to the ones, obtained by Umbah et al. [5], in the **p**-region, which is common for them.

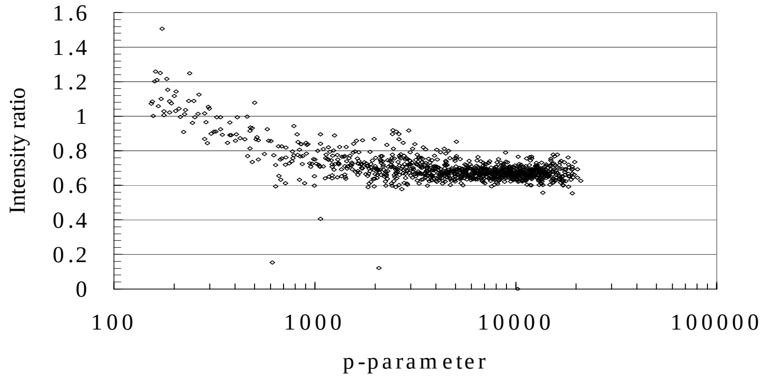

Fig.4. Intensity ratio of the Δv=1 to Δv=0 sequences of C_2. The intensity courses differ from each other to distances of about 2000 km from the comet Halley nucleus.

The obtained intensity of Δv=1 of C_2 sequence of Swan's system decreases more quickly with increase of the **p**-parameter as compared to that of Δv=0. Fig.4 shows the ratio of these sequence intensities versus **p**. It is seen that the Δv=1 and Δv=0 intensity courses differ up to about 2000 km from the Halley comet nucleus. At greater distances to the nucleus the ratio remain almost constant, its values being distributed in an interval less than 0.2. The change of this intensity ratio towards **p** is established and investigated by many authors [6] and it is explained by the cascade transitions between the singlet and triplet conditions, which allow population change of the lowest vibrational levels. The range of the change we have obtained is the same as the one, registered by Vanýsek and Valníček [6].

IV. Conclusions.

An improved method is applied to subtract the dust continuum from the spectra of Halley's comet, registered by TCS on board the Vega-2. For each spectrum, the spectral index **u** is calculated by 8 dust points, selected so as the confidence interval to be the least possible. The dust continuum is normed by 7 dust regions on the basis of a linear regression.

The evaluation of the dust continuum in this way is reliable and the intensities of the carbon-containing neutral emissions CN, C_2, C_3 and CH are obtained more precisely. The obtained dependencies of the intensity on the **p**-parameter are with higher quality. Compliance is established with Hazer's model. The peculiarities of those molecules glow, published so far, are confirmed.

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