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The Lifetime of C_2 and CN Molecules in Cometary Atmospheres
Part II

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The colour-diaphragm effect, i.e. the systematic change of the colour with diameter of the photometer diaphragm was studied in a preceding paper (Acta Universitatis Carolinae, Mathematica et Physica, No. 1 (1965), pp. 23–40 = Publ. Astron. Institute of the Charles University of Prague No. 44) = Paper I. In the present study the possibility of using the colour diaphragm effect for estimation of the lifetime differences of CN and C_2 molecules is discussed. It is shown that the proposed method may be very useful in studying faint objects.

In the last section some corrections to Paper I are given.

I. Introduction

The colour-diaphragm effect was found with Comets 1958 III, 1960 III, 1955 IV, 1955 V and 1955 III. In all these cases the colour-diameter trend of the diaphragm was directly proportional, i.e. the $B-V$ colour increased with the diameter of diaphragm (see (VANÝSEK 1965).

This effect was opposite in trend or was not ascertained in comets with a pronounced continuous spectrum, such as 1955 VI (Baade), 1959 VIII (Giacobini-Zinner) and 1963 III (Alcock). According to VANÝSEK and TREMKO (1964) no change of colour with diameter was found with Comet Humason 1962 VIII in which the emission of CO^+ dominated while the typical cometary bands were weak. Recently, this effect has been found for the ultraviolet region of the *UB*-colour of Comet Everhart 1964 IX (BOUŠKA and MAYER 1966). The occurrence of this effect depends obviously on the actual distribution of molecules in the cometary atmosphere, and on the relative sensitivity of the photometer.

2. A simple method for estimation of differences in lifetimes of C_2 and CN

Because photometers are usually designed for the stellar three-colour photometry only the *UBV* system is used for cometary measurements, too. It should be noted that it is just the *B*-array which is not quite suitable for the photometry of comets while the

V-colour array practically includes only the $C_2(\Delta v = 0)$ band. The continuum, $C_2(\Delta v = + 1)$ as well as the CO^+ emission are pronounced in the B-colour array. The C_2 bands lie in regions where the right or left wings of the transmission curve of the U- and B-colour arrays are situated. The sensitivity of an actual photometer depends on the individual arrangement, the transmission of filters and the sensitivity curve of the photomultiplier.

Special colour systems realized even by the combination of normal glass filters are more suitable. Sinton used a combination of the glass filters defining the narrower array in the B- and V-colours denoted B_2 and G, respectively. The B_2 colour separates the CN and C_3 emissions from B and the G-colour excludes the C_2-emission in the V-colour array.

A combination of a UG 2 (1mm) filter (normal filter for the U-colour array) with a WG 9 (2mm) filter can be used for the isolation of the CN-band (Vanýsek and Tremko, loc. cit.).

However, a single measurement in the U- and V-colours may also be useful because the domination of CN and C_2 in the colour array guarantees at least unsignificant contamination by other emissions of the measured flux. Consequently, the U- and V-measurements can be used for determination of the differences in lifetimes of both molecules by a simple way.

Supposing that at greater distances from the nucleus the surface brightness of emission band $\bar{\lambda}$ changes

$$S(\varrho, \bar{\lambda}) = S(\varrho_1, \bar{\lambda})\varrho^{\varkappa_\lambda} \tag{1}$$

when the average $\bar{\varkappa}_\lambda$ is nearly constant for the given range of ϱ. The measured brightnesses U for CN (0,0) and V for $C_2(0,0)$ are integrated over pass-bands $\bar{\lambda}(U)$ and $\bar{\lambda}(V)$, respectively

$$\begin{aligned} U &= -2.5 \log \int_{\lambda(U)} S(\varrho, \lambda)\, Q(\lambda)\, \mathrm{d}\lambda \\ V &= -2.5 \log \int_{\lambda(V)} S(\varrho, \lambda)\, Q(\lambda)\, \mathrm{d}\lambda \end{aligned} \tag{2}$$

where $Q(\lambda)$ is the efficiency factor of the photometer in the given colour range. Then

$$(U\text{-}V)_{\varrho_1} - (U\text{-}V)_{\varrho} = 2.5 \log \varrho \alpha_{UV} \tag{3}$$

and

$$\frac{\mathrm{d}(U\text{-}V)_{\varrho}}{\mathrm{d}\varrho} = \frac{1}{\varrho}\, 1.086\, \alpha_{UV}\,, \tag{4}$$

where $\alpha_{UV} = \varkappa_U - \varkappa_V$. The accuracy of colour is about $\pm\, 0.03^{\mathrm{m}}$, the accuracy of the determined α_{UV} is then about 10 %.

For instance, when the new increase of U–V is taken into consideration, too, for Comets 1955*f* and 1959*k* it was found that $\alpha_{UV} = +0.27$ and $+0.30$, respectively, which is in good agreement with $\varkappa$ determined directly, separately for each colour (see Table 4 from Paper I with corrected values in the last section).

From measurements of Comet Everhart (see Table 1) follows $\alpha_{UV} = -0.09$ for September 28 and -0.21 for October 3.8, respectively.

In the case of Comets 1959*k* and 1955*f* the positive values of α_{UV} indicated that the lifetime of CN is shorter than that of C_2 while in the case of Comet 1964*h* this relation is opposite.

The estimation of lifetime differences $\frac{\tau_C - \tau_{CN}}{\tau_C}$ depends, of course, on the knowledge or supposition of τ for CN or C_2. When the determination of α_{UV} involves regions in which $\bar{\varkappa}_U$ and $\bar{\varkappa}_V$ are near 1 (usually at the distance of 10^4 to 10^5 km from the nucleus) the values of $\frac{\tau_C - \tau_{CN}}{\tau_C}$ can be used.

The intensity differences in various diaphragms for CN and C_2 measured by an easy accurate photoelectric method in *U* and *V*-colour array in narrower bands permit direct estimation of the lifetime differences of CN and C_2 (or other constituents). This method may be very useful for faint comets with typical cometary emissions when a detailed study of the emission distribution is not available.

Table 1. *Colour differences* U-V *of 1964 IX*

Date 1964	log ϱ''	U-V	± m.e.
September 28.8	1.954	+0.22	0.001
	1.718	0.25	0.025
	1.531	0.31	0.010
October 3.8	1.954	0.19	0.030
	1.718	0.38	0.001
	1.531	0.41	0.030

Table 2. *Table for estimation of lifetime difference*)*

α	0	0.1	0.2	0.3
$\frac{\Delta\tau}{\tau}$	0	0.1	0.25	0.4

*) valid for $\bar{\varrho}$ where $\bar{\varkappa} \approx 1$ only

3. Corrections to Paper I

In Paper I unfortunately some misleading errors in the notation of tables and figures

Table 3 = *corrected Table 4 Paper I. Values of* $\bar{\varkappa}$ *(1959k)*

Date	log ϱ (km)	*V*	*B*	*U*	*G*	B_2
January 30, 1960	5.11	0.873	0.964	0.910	0.764	1.163
	5.35	1.066	1.153	1.100	1.100	1.118
	5.50	1.250	1.188	0.984	1.203	1.203
April 29, 1960	3.90	1.045	1.121	0.497	0.471	1.376
	4.30	0.543	0.688	0.706	0.525	0.724
	4.75	0.611	0.699	0.681	0.629	0.786
	4.94	0.703	0.844	0.813	0.734	0.891
	5.10	0.946	1.054	1.000	0.919	1.108
May 7, 1960	4.30	0.608	0.621	0.583	0.492	0.738
	4.57	0.569	0.711	0.729	0.551	0.764
	4.80	0.643	0.783	0.730	0.765	0.800
	5.04	0.875	1.016	0.906	0.813	1.125

and numerical errors in Table 4 are given. The text of Paper I should be changed as follows:

on page 24 and 32 Comet Giacobini-Zinner should be denoted 1959*b* instead of 1958*b* and 1959*k*;

on pag. 27 the second sentence from above should read: . . . "as is seen in Figure 6, since *G–V* exhibits no dependence (Fig. 8)";

Table 4 = *Table 5 Paper I. Values of* $\bar{\varkappa}$ *(1959k)*

Date	$\overline{\log \varrho}$	$C_2(\Delta v = +1)$	Continuum
May 1, 1960	4.4	0.25	0.14
	4.7	0.4	0.75
	5.0	1.5	4.9

on page 36 read $\beta_1 \gg \beta_0$ instead of $\beta_1 \ll \beta_0$;

in Fig. 6 full circles denote *U–B* while the open ones denote B_2–*G*;

Table 4 shows a systematical error of about 10% to 20% in average values of $\bar{\varkappa}$ for Comet 1959*k*. New results with higher accuracy are presented in following tables. The very low values of $\bar{\varkappa}$ near the nucleus in the last paper which are derived from O'Dell's measurements (O'Dell 1961) are most probably caused by low resolving power of the used instrument.

References

Bouška J., Mayer P., 1966, BAC 17, 84.

O'Dell O. R., 1961, ApJ 133, 35.

Vanýsek V., 1964, Acta Univ. Carol., Math et Phys., No 1 = Publ. Astr. Inst. Charles University, No 44.

Vanýsek V., Tremko J., 1964, BAC 15, 233.