Jan Bouška; A. Mrkos

Spectrophotometry of the comet 1975 IX

Acta Universitatis Carolinae. Mathematica et Physica, Vol. 18 (1977), No. 2, 55--60

Persistent URL: http://dml.cz/dmlcz/142405

1977 ACTA UNIVERSITATIS CAROLINAE – MATHEMATICA ET PHYSICA VOL. 18, NO. 2, Pag. 55–60

Spectrophotometry of the Comet 1975 IX

J. BOUŠKA and A. MRKOS

Department of Astronomy and Astrophysics, Faculty of Mathematics and Physics, Charles University, Prague*)

Received 15 March 1976

From the spectrograms of the comet and of the comparison stars the monochromatic fluxes of the CN and C_2 bands and the relative intensities of the continuum were obtained. From these values the total numbers of CN and C_2 molecules in the cometary head were computed and the relative spectrophotometric gradient was determined.

Спектрофотометрия кометы 1975 IX. Из спектрограмм получены монохроматические яркости полос CN и C_2 и континуума. З етих яркостей определалос число молекул CN и C_2 в голове и относительный градиент.

Ze spektrogramů komety a srovnávacích hvězd byly určeny monochromatické jasnosti emisních pásů CN a C_2 a relativní intenzity kontinua. Z těchto jasností byly stanoveny celkové počty molekul CN a C_2 v kómě a relativní spektrofotometrický gradient.

1. Observation

The comet Kobayashi-Berger-Milon 1975 IX was very bright at the end of July and during the first half of August 1975. During this period five spectra of the comet were exposed at the Kleť Observatory with a small Schmidt camera (200/150 mm, $f/3$) with 7° objective prism (Table 1). Dispersion of the spectra was about 10^{-4} near $H\gamma$. As negative material the ORWO NP 27 film was used.

The spectra of the comet and those of the comparison stars (Table 2) were

Table 1.

No	1975 (UT)	Exposure Time	Comparison Stars
1	July 30.88	20^m00^s	6, 7, 8, 9
2	August 6.91	30 00	1, 2, 3, 4, 5
3	August 8.89	35 40	3, 4, 10, 11, 12
4	August 9.87	30 00	3, 4, 10, 11, 12
5	August 10.87	21 15	3, 4, 10, 11

*) 150 00 Praha 5, Švédská 8.

Table 2.

No	SAO SC	m	Sp.	No	SAO SC	m	Sp.
1	028130	7.4	F0	7	029098	6.5	A3
2	028327	6.0	K2	8	029121	6.0	K5
3	028366	4.8	G7	9	029217	7.4	F8
4	028400	6.2	F8	10	044127	5.6	K2
5	028413	6.2	F8	11	044141	6.5	K0
6	029090	6.7	A2	12	044145	7.6	A3

Table 3.

No	$F(CN)$	$F(C_2)$
1	5.6×10^{-17}	1.6×10^{-17}
2	7.4×10^{-17}	2.4×10^{-17}
3	5.6×10^{-17}	1.4×10^{-17}
4	2.9×10^{-17}	2.2×10^{-17}
5	4.2×10^{-17}	2.2×10^{-17}

measured on the Zeiss registering microphotometer. During the observation period the comet was situated in the region of the sky, which was very poor on stars. Therefore it was necessary to use, as the comparison stars, those of not too covenient spectral class. The corrections were taken from [1].

In the spectra of the comet 1975 IX many emission bands were found which are usually observed in cometary heads, especially the bright bands of molecules CN, C_2, C_3 and further CH, NH_2. The spectra covered the spectral region between wave-lengths approximately equal to 370–750 nm. The type of the spectra of the comet 1975 IX was *C2E3c* (0.8) in the spectral clasification proposed recently by Bouška [2].

Table 3 contains the fluxes of the emission bands CN (0,0) and $C_2(\Delta v = +1)$. These fluxes are expressed in W cm^{-2} nm^{-1}, and the atmosheric extinction was taken into consideration.

2. Number of Molecules CN and C_2 in the Coma

The total number $N(x)$ of molecules in the cometary head contributing to the certain emission band is given by [3]

$$N(x) = Lj(\Delta v) \tag{1}$$

where L is the luminosity and $j(\Delta v)$ the emission coefficient for the given band. The luminosity is

$$L = 4\pi \Delta^2 F \tag{2}$$

where Δ is the geocentric distance of the comet and F the flux of the emission band. The emission coefficient is given by

$$j(\Delta v) = \frac{m_e}{\pi e^2} \frac{1}{f_{v',v''} p_{v',v''} \varrho(\nu, r)} \tag{3}$$

where m_e is the electron mass, e the electron charge, $f_{v',v''}$ the oscillator strength, $p_{v',v''}$ the vibrational transition probability and $\varrho(\nu, r)$ the solar radiation density.

The total number of molecules in the cometary coma is thus

$$N(x) = C F \Delta^2 f_{v',v''}^{-1} p_{v',v''}^{-1} \varrho_0^{-1}(\nu) r^2. \tag{4}$$

where $\varrho_0(\nu)$ is the solar radiation density at the distance $r = 1$ AU. If the flux is expressed in W cm^{-2} nm^{-1} and Δ and r in Astronomical Units, the numerical value of the constant C is

$$C = 3.531 \times 10^{24}.$$

The values of the oscillator strength, transition probability and density of the solar radiation for the CN (0,0) and C_2 (1,0) bands are shown in Table 4 [4].

Table 4.

Mol.	λ(nm)	Electronic transition	v', v''	f	p	$\varrho_0(\nu)$
CN	388.4	$B^2\Sigma^+ - X^2\Sigma^+$	0,0	2.6×10^{-2}	0.920	1.90×10^{-20}
C_2	473.7	$A^2\Pi_g - X^3\Pi_u$	1,0	3.1×10^{-3}	0.237	5.47×10^{-20}

Table 5.

No	N(CN)	$N(C_2)$
1	0.56×10^{29}	1.90×10^{29}
2	1.06×10^{29}	3.96×10^{29}
3	0.87×10^{29}	2.46×10^{29}
4	0.47×10^{29}	4.03×10^{29}
5	0.70×10^{29}	4.13×10^{29}

The computed values of $N(x)$ are given in Table 5. The heliocentric r and geocentric Δ distances of the comet were taken from Marsden's ephemeris [5].

The mean value of the total number of molecules in the coma of the comet 1975 IX was 7.3×10^{28} for CN and 3.3×10^{29} for C_2. During the observation period the diameter of the coma was about 2.0×10^5 km. Using this value the average density of the molecules CN in the coma was about 0.02 cm^{-3} and of the molecules C_2 about 0.08 cm^{-3}.

The mean values of the total number of molecules in the head of the comet 1975 IX and also the relative abundance

$$N(C_2) / N(CN) = 4.5$$

are very similar to the corresponding values for other bright comets [3, 4, 6, 7]. Only the average density of both the molecules CN and C_2 seems to be somewhat smaller than that for other bright comets.

3. Relative Spectrophotometric Gradient

The relative spectrophotometric gradient (Comet, Sun) is given by the well-known relation

$$G\,(\text{Comet, Sun}) = \frac{1}{\log e}\,\frac{d \log (I\,(\text{Comet})/I\,(\text{Sun}))}{d\,\lambda^{-1}} \qquad (5)$$

where I are the intensities of the continuum. On the plates Nos 2 through 5 were exposed also the spectra of the star No 3 (5 CVn, SAO SC 028366), which is a

Table 6.

	5 CVn	Sun
Spectrum	G7 III	G2 V
V	+4.80	−26.74
$B - V$	+0.87	+0.64
$V - R$	+0.68	+0.52

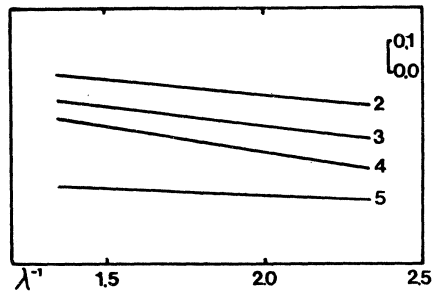

Fig. 1.

photometric standard of the Arizona-Tonantzintla Catalogue [8]. Spectrum, brightness and color indexes $B - V$ and $V - R$ of this star are shown in Table 6. From the spectrograms it was possible to determine the ratios of the intensities of the continua of 5 CVn and the comet

$$\log \frac{I(5\ \text{CVn})}{I(\text{Comet})}\,,$$

which are shown in Figure 1 as a function of λ^{-1}. From these values the relative

spectrophotometric gradient G (Comet, 5 VCn) was determined. The numerical values of this gradient are summarized in Table 7.

From the color indexes of the Sun (Table 6) [9] and of the star 5 CVn it is possible to determine the relative spectrophotometric gradient G (5 CVn, Sun) using the well-known relation

$$G\ (5\ \mathrm{CVn},\ \mathrm{Sun}) = \frac{1}{2.5 \log e} \frac{d\,(m(\mathrm{Sun}) - m\,(5\ \mathrm{CVn}))}{d\,\lambda^{-1}} \,. \tag{6}$$

The numerical value of this gradient is in the spectral region 430—720 nm

$$G\,(5\ \mathrm{CVn},\ \mathrm{Sun}) = +0.37\,.$$

Table 7.

No	G (Comet, 5CVn)	G(Comet, Sun)	φ
2	−0.23	+0.14	92.6°
3	−0.28	+0.09	93.4
4	−0.37	0.00	93.6
5	−0.19	+0.18	93.6

The relative spectrophotometric gradient (Comet, Sun) is then

$$G(\mathrm{Comet,\ Sun}) = G(\mathrm{Comet,\ 5\ CVn}) + G(5\ \mathrm{CVn,\ Sun})\,.$$

The spectrophotometric gradients G(Comet, Sun) determined from the spectrograms Nos 2 through 5 are summarized in Table 7, which also contains the values of the phase angle φ of the comet.

The mean value of the spectrophotometric gradient (Comet, Sun) for the mean phase angle $\bar{\varphi} = 93.3°$ is $\overline{G} = +0.10$ and is in a very good agreement with the spectrophotometric gradient of other comets for the phase angle $\varphi \sim 90°$, first of all with that of the comet Arend-Roland 1957 III [10].

Acknowledgment

The authors wish to thank Professor V. Vanýsek and Dr. P. Mayer for many valuable discussions.

References

[1] M. Golay: Introduction to astronomical photometry. D. Reidel, Publ. Comp., Dordrecht, 1975; p. 80.

[2] J. Bouška: The study of comets. NASA Washington, 1976; p. 840.

[3] M. K. V. Bappu, K. R. Sivaraman: Mon. Not. R. astr. Soc. 137, 151; 1967.

[4] L. Kohoutek: The study of comets, NASA Washington, 1976; p. 50.

[5] B. G. Marsden: IAU Circ. 2800; 1975.

[6] V. Vanýsek: Nature et origine des comètes. Liège 1966; p. 255.

[7] J. Bouška, A. Mrkos, E. Müllerová: Bull. astr. Inst. Czech. 28, 288; 1977.
[8] Sky Telescope 30, 24; 1965.
[9] H. L. Johnson: Comm. Lunar Planet. Lab., 3, 73; 1965.
[10] K. Pflug: Astron. Nachr. 290, 215; 1967.