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MONOCHROMATIC OBSERVATIONS OF COMET TAGO-SATO-KOSAKA 1969G (1969IX)

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Isophotes have been determined from 10 narrow-band filter photographs of Comet Tago-Sato-Kosaka 1969g (1969IX) taken between February 11 and 14, 1970. The five interference filters used were centered on the CN λ3883Å, C_2 λ4737Å, C_2 λ5165Å, C_3 λ4050Å sequences, and the continuum at λ5300Å. Gradients of intensity in various directions from the nucleus have been derived from the isophotes.

Key words: Comet Tago-Sato-Kosaka 1969g (1969IX) – monochromatic observations-comets-isophotes of comets

1. INTRODUCTION

Narrow-band filter observations of comets are more relevant to the physical and chemical processes occurring in cometary heads and tails than commonly used broad-band filter observations. They furnish data on the variation of surface brightness for different emission bands and the continuum with positions in the comet and on differences in the distribution of these components. They also show changes in the cometary head and tail with time and heliocentric distance. This data provides information on the nature of radical formation in comets, on the release of mass to interplanetary space, and on the interaction of the solar wind with the ejected material. The value of such data for studying the coma has been emphasized by Malaise (1966). He also discusses the limitations of the different observing procedures and requirements for satisfactory observations. Photographic isophotes of Comet Schaumasse (1952III) in the red and blue covering broad spectral ranges were published by Yoss (1953). Monochromatic images for CN λ3883Å and C_2 λ4730Å were obtained by Vorontsov-Velyaminov (1960) from objective prism plates. Corrections for overlapping images were applied in order to determine isophotes for each of the molecular emissions. Miller (1964, 1967, 1969) and Dewey and Miller (1966) have used interference filters to obtain monochromatic photographs of several comets in the light of the C_2 λ5165Å band and the continuum. Borra and Wehlau (1971) obtained photographs of Comet Bennett (1970II) with interference filters for the CN λ3883Å band, the continuum at λ4870Å, and the C_2 λ5165Å band. Photoelectric scans and multiple diaphragm observations in combination with interference filters have been used to obtain radial intensity distributions for several comets e.g., Schmidt and van Woerden (1957), O'Dell and Osterbrock (1962). Such photoelectric measurements yield data of high accuracy but in only one direction at a time if scans are made or an average over the head if diaphragms are used.

Isophotes derived from a selected set of narrow-band filter photographs covering several cometary emissions are presented here. Intensity profiles along the radius vector have also been determined.

2. EQUIPMENT

The observations were made in the Cassegrain focus of the 91 cm (36″) telescope of the National Aeronautics and Space Administration, Goddard Space Flight Center (GSFC), located 23 km northeast of Washington, D.C. and 3 km northeast of the GSFC. The telescope is a Ritchey-Chretien instrument with a focal ratio of

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f/14.3 and a plate scale of 15.75 arc sec. per mm at the Cassegrain focus. The photographs were taken using an RCA twostage magnetically focussed C33011 image intensifier which has a S-20 photocathode. The image on the P-11 output phosphor of the tube was photographed by a f/2 transfer lens using Kodak IIa-O plates baked at 50°C for at least 50 hours to enhance their sensitivity. The image tube module was attached to an X-Y guide box which had a filter slide enabling a $2\times2''$ filter to be placed in the converging beam in front of the image intensifier.

Various interference filters were selected to study the continuum at λ5300Å, the C_2 (0,0) and C_2 (1,0) Swan band sequences at λ4737Å and λ5165Å, the CN (0,0) violet band at λ3883Å, and the C_3 emissions around λ4050Å. All filters were manufactured by Thin-Film Products, Inc. The characteristics of the interference filters used and the corresponding cometary emission are given in table 1.

Comet Tago-Sato-Kosaka had a very strong emission spectrum and a narrow, weak continuum. The filter photographs of emission bands were essentially uncontaminated by continuum radiation except for a small region of about 500 km near the nucleus.

A Kodak 21 step wedge wedge was photographed onto the edge of each plate after each exposure with an exposure time roughly equal to that at the telescope in order to provide a sensitometric calibration. A Wratten no. 47 filter in front of the sensitometer camera modified the spectral energy distribution of the fluorescent lamp in the sensitometer to approximate that of the P-11 phosphor of the image intensifier. The plates were developed in Kodak D-19 developer for 4.5 min. at $20°\pm1°$C after sensitometry.

3. OBSERVATIONS

The orbital parameters of Comet Tago-Sato-Kosaka 1969g (1969IX) given by Marsden (1972) are:

$e=0.99992$
$q=0.47$ AU
$\omega=267\overset{\circ}{.}8$
$\Omega=101\overset{\circ}{.}0$
$i=75\overset{\circ}{.}8$
$T=1969$, December 21.27 ET.

Ten photographs suitable for reduction were obtained on three successive nights between February 11-12, 1970 and February 13-14, 1970 with the 36″ f(14.3) reflector at the Goddard Space Flight Center. During this time interval, the heliocentric distance, r, and the geocentric distance, Δ, were $r\sim1.3$ AU and $\Delta\sim0.8$ AU. Six photographs were used from the first night, and 2 rom each ollowing night. The exposure times of the photographs were 10 minutes, except for the last plate which was exposed for 6 minutes. The essential observational data for the photographs of the comet are listed in table 2.

4. REDUCTION OF OBSERVATIONS

The plates were measured with a Photo-Metrics EDP scanning microscope. Most plates were scanned with a 100 micron diameter aperture (1.6″) but a 200 micron (3.2″) aperture was used for some. The machine traces a spiral pattern and produces a plot showing contours of equal ensity. These contours were then converted to isophotes through use of the calibration obtained by scanning the calibration wedge on each plate. Figures 1 through 10 present the isophotes obtained from the photographs that were measured. In these figures, the tail axis runs parallel to the abscissa with the tail pointing to the right. The projected distance from the nucleus is given in units of 10^3 km, and the relative intensity for each isophote is given in arbitrary units. The nucleus is taken as the point of greatest intensity. Vignetting occurred near one edge of the original image tube plates, so the isophotes in the diaphrams were restricted to the region not affected by vignetting.

The luminosity profiles along the sun-comet line are shown in figures 11 through 13. The scale on the abscissa gives the distance from the nucleus in units of 10^3 km. The ordinate is the logarithm of the intensity in arbitrary units.

5. DISCUSSION OF THE OBSERVATIONS

A detailed analysis and discussion of the material presented here are currently being carried out and will be published later. Some preliminary descriptive remarks about the isophotes and profiles can now, however, be presented.

On February 11-12, CN λ3883Å (figure 1) and C_2 λ5165Å (figures 2 and 3) show nearly circular isophotes out to the limits of the measurements, (nearly circular isophotes out to the limits of the measurements, (nearly 10^5 km). There is a very slight elongation perpendicular to the radius vector from the sun. The two plots for C_2 λ5165Å taken within 20 minutes (figure 2 and 3), are nearly identical. All images have nearly circular isophotes within 25000 km but have a tendency to show a slight elongation perpendicular to the radius vector.

On February 11-12, a C_2 λ4737Å photograph (figure 4) shows a pronounced antisolar elongation. On the following night, the C_2 λ5165Å isophotes (figure 7) show an antisolar elongation. The CN λ5165Å images on February 12-13 (figure 8) and February 13-14 (figure 10) are elongated toward the sun beyond 25000 km.

The continuum photograph for February 11-12 (figure 5) shows pronounced asymmetry as close to the nucleus as could be resolved. The isophotal structure appears to show the beginning of a dust tail.

The C_3 isophotes on February 11-12 (figure 6) are circular out to only 10000 km and then are extended in the antisolar direction. The C_3 λ4050Å and the C_2 λ4737Å bands are not as strong as the CN λ3883Å and the C_2 λ5165Å bands. They are more affected by contamination from the continuum, so the tail-ward extension observed in the first two bands probably show the influence of the dust tail.

Figures 11 through 13, show that the intensity gradients for CN and both C_2 bands are very similar. The C_3 gradient shown in figure 11 is flatter than any of the others. The continuum profile is unlike the others, being concave upwards, and steeper near the nucleus. The asymmetry clearly shows in the profile. In the antisolar direction, the gradient beyond 10^3 km is less than for any other species.

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Table 1 Wavelengths of maximum transmission (λ_C). Full width at half maximum (FWHM), and Peak transmission (T_C), of the interference filters, and corresponding cometary emission

Filter	λ_C(Å)	FWHM (Å)	T_C(%)	Cometary Emission
CN	3884	74	43	CN-Violet band $B^2\Sigma - X^2\pi$, (0,0)
C_2	4738	54	76	C_2 - Swan system $A^3\pi - X^3\pi$, (1,0)
C_2	5172	51	73	C_2 - Swan system $A^3\pi - X^3\pi$, (0,0)
C_3	4063	93	58	Large group of lines and blends around λ4050Å
Con	5300	50	81	Continuum

Table 2 Monochromatic photographs of Comet Tago-Sato-Kosaka 1969g (1969IX)

Figure Number	Date (UT) (Middle of Exposure)	Exposure Time (Minutes)	Emulsion (Kodak)	Filter (λ_C in Å)	r (AU)	Δ (AU)
	1970					
1	Feb. 11.993	10	IIa-O	CN 3884	1.239	0.799
2	12.003	10	IIa-O	C_2 5172	1.239	0.799
3	12.015	10	IIa-O	C_2 5172	1.239	0.799
4	12.026	10	IIa-O	C_2 4738	1.239	0.799
5	12.035	10	IIa-O	Con5300	1.240	0.800
6	12.047	10	IIa-O	C_3 4063	1.240	0.800
7	Feb. 13.013	10	IIa-O	C_2 5172	1.257	0.828
8	13.026	10	IIa-O	CN 3884	1.257	0.826
9	Feb. 14.018	10	IIa-O	C_2 5172	1.275	0.854
10	14.026	6	IIa-O	CN 3884	1.275	0.854

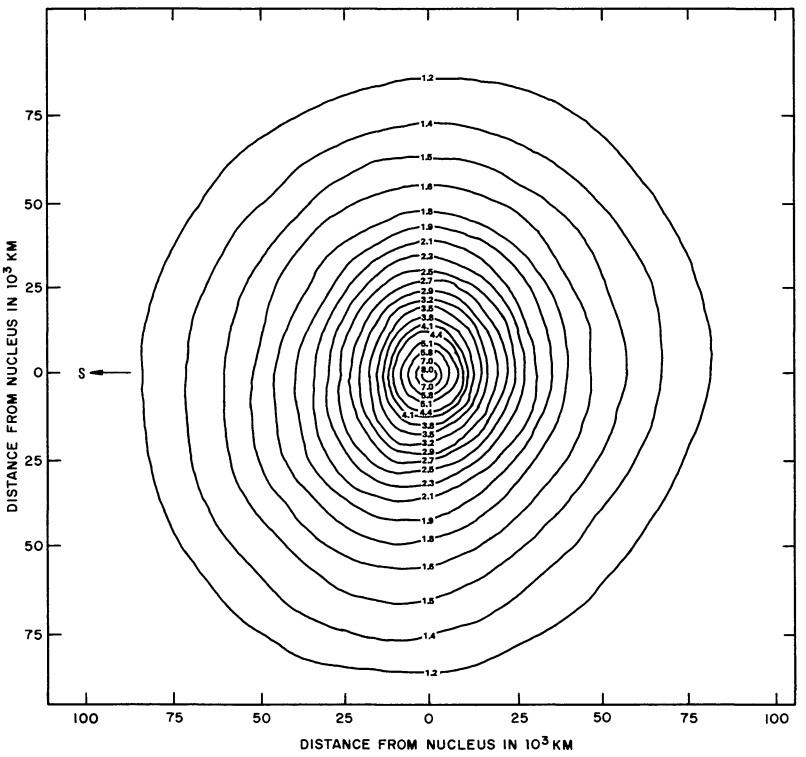

Figure 1 Isophotes for CN λ3884Å, February 11.993 UT, 1970, $r = 1.239$ AU, $\Delta = 0.799$ AU.

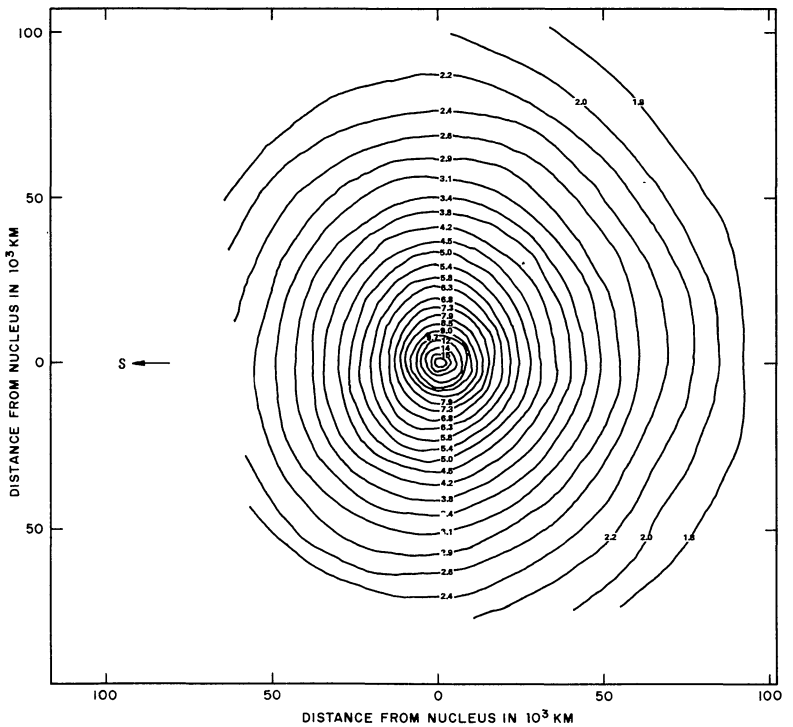

Figure 2 Isophotes for C_2 λ5172Å, February 12.003 UT, 1970, $r = 1.239$ AU, $\Delta = 0.799$ AU.

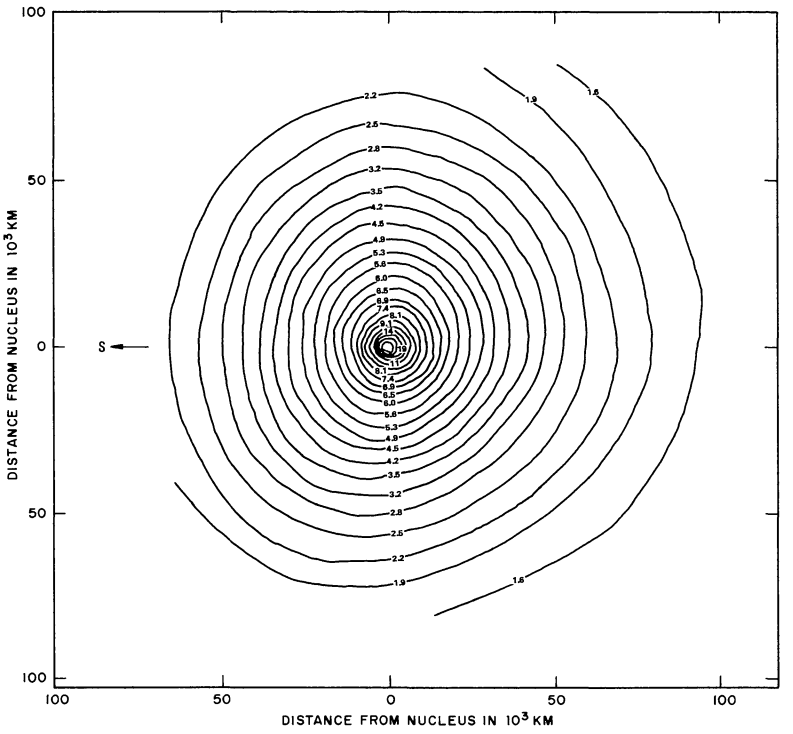

Figure 3 Isophotes for C_2 λ5172Å, February 12.015 UT, 1970, $r = 1.239$ AU, $\Delta = 0.799$ AU.

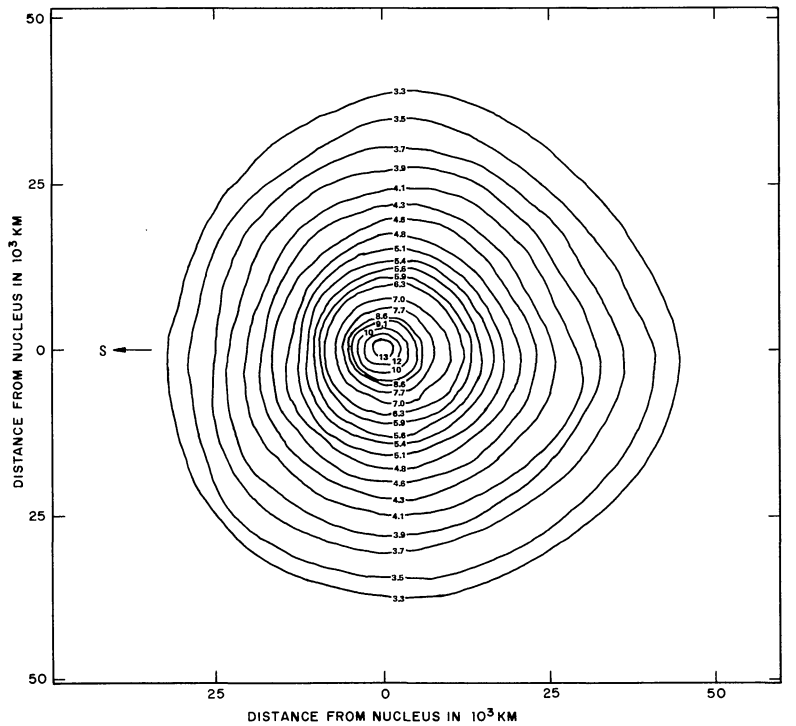

Figure 4 Isophotes for C_2 λ4738Å, February 12.026 UT, 1970, $r = 1.239$ AU, $\Delta = 0.800$ AU.

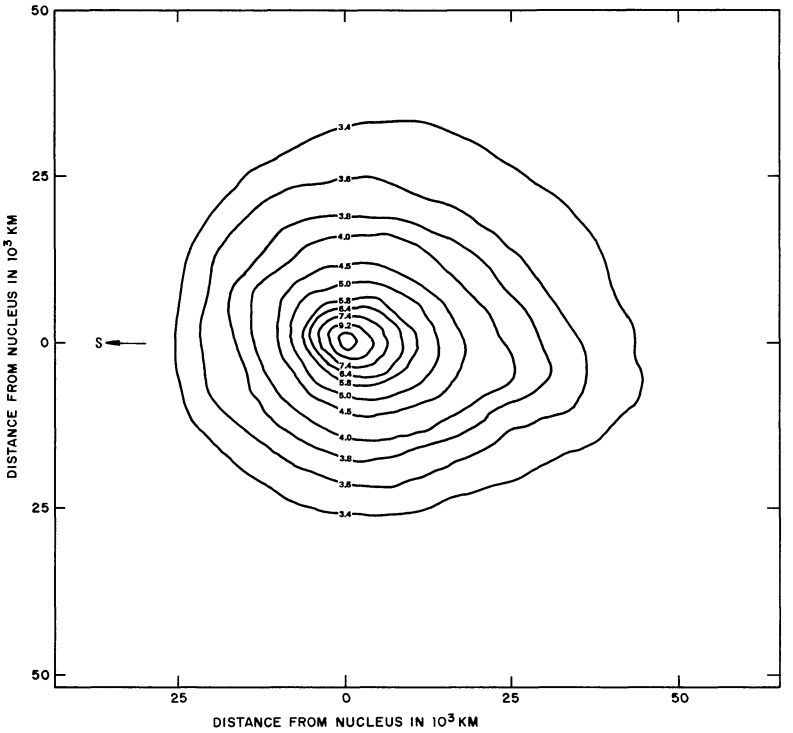

Figure 5 Isophotes for Continuum λ5300Å, February 12.035 UT, 1970, $r = 1.240$ AU, $\Delta = 0.800$ AU.

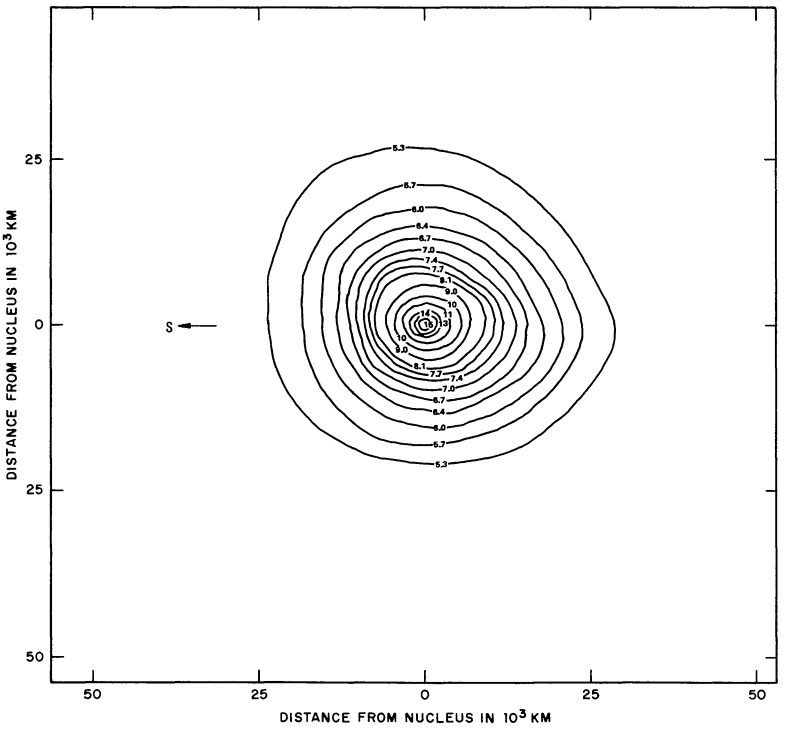

Figure 6 Isophotes for C_3 λ4063Å, February 12.047 UT, 1970, $r = 1.240$ AU, $\Delta = 0.800$ AU.

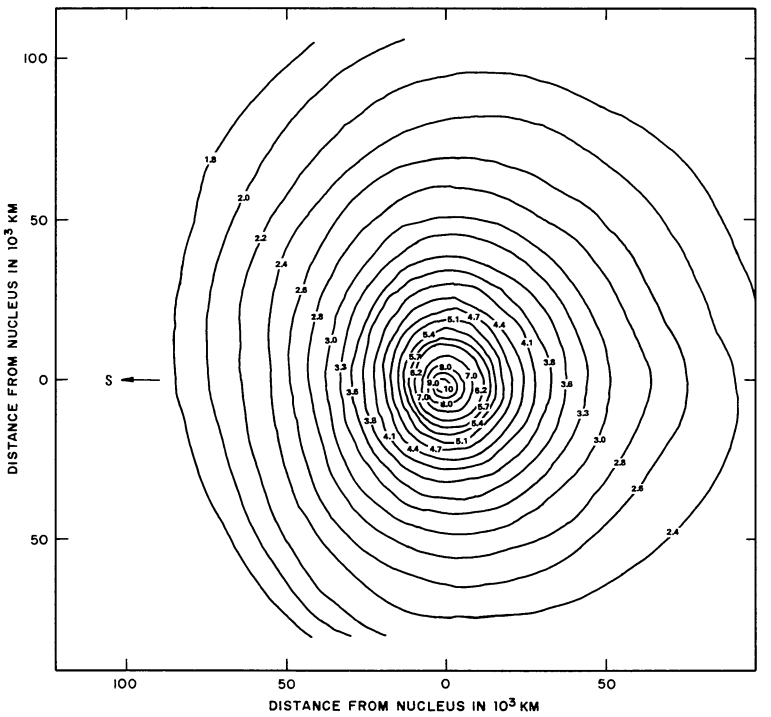

Figure 7 Isophotes for C_2 λ5172Å, February 13.013 UT, 1970, $r = 1.257$ AU, $\Delta = 0.826$ AU.

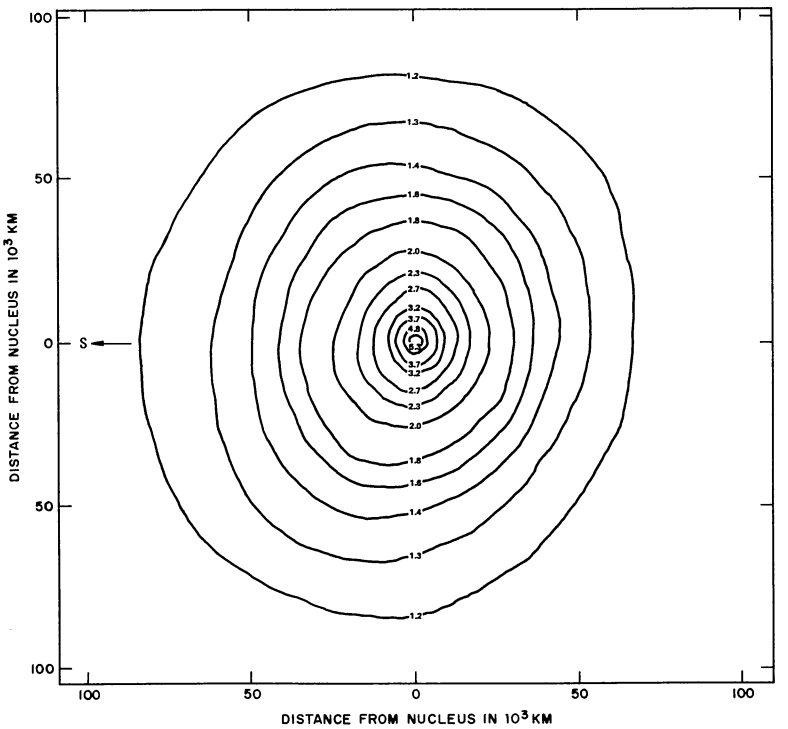

Figure 8 Isophotes for CN λ3884Å, February 13.026 UT, 1970, $r = 1.257$ AU, $\Delta = 0.826$ AU.

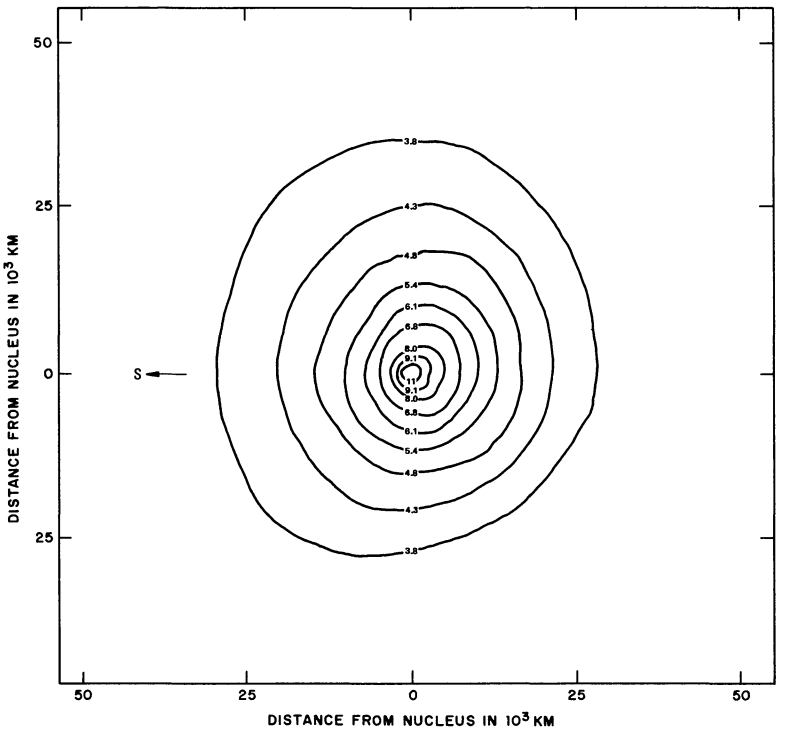

Figure 9 Isophotes for C_2 λ5172Å, February 14.018 UT, 1970, $r = 1.275$ AU, $\Delta = 0.854$ AU.

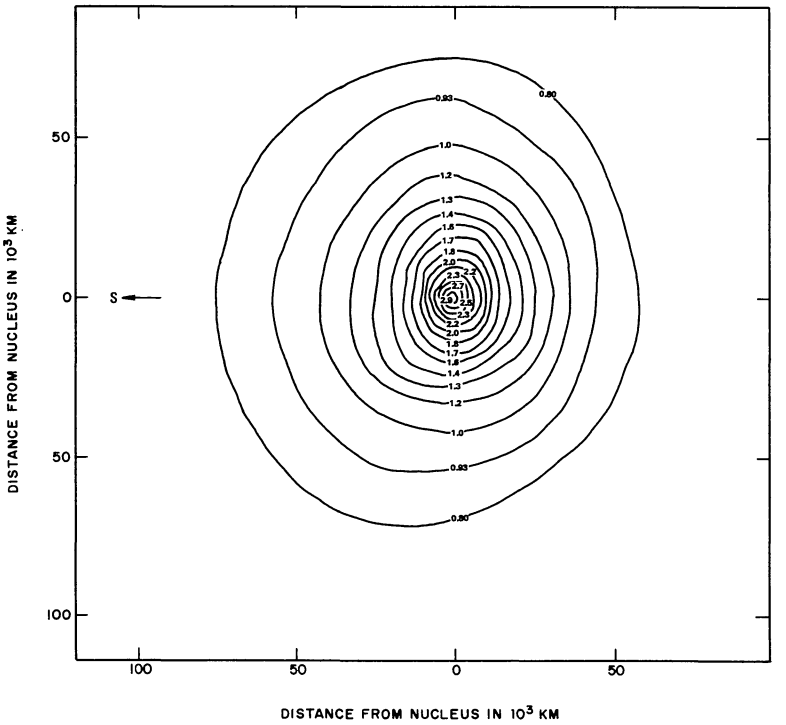

Figure 10 Isophotes for CN λ3884Å, February 14.026 UT, 1970, $r = 1.275$ AU, $\Delta = 0.854$ AU.

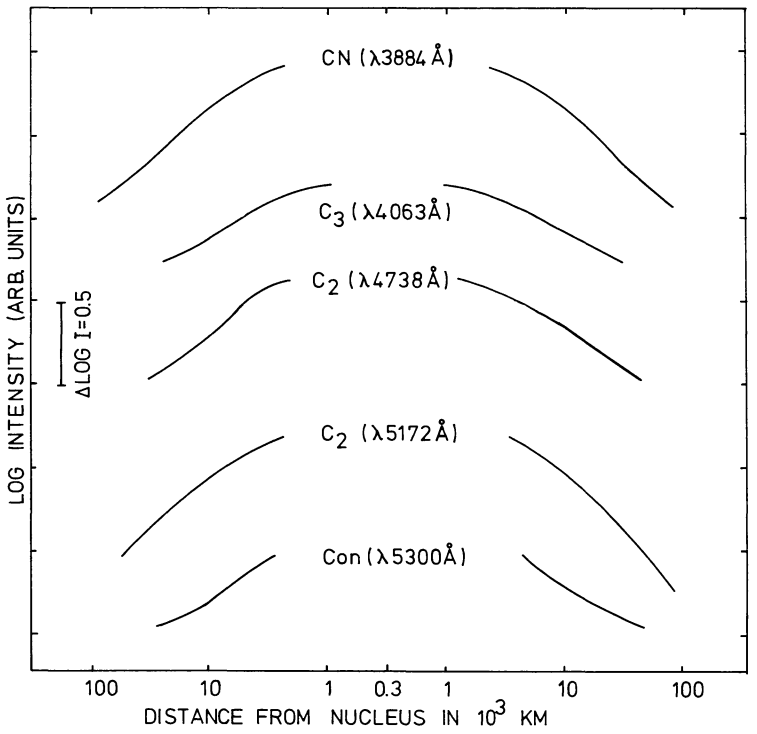

Figure 11 Intensity gradients along the sun-comet line (sun toward the left) for CN λ3884Å, C_3 λ4063Å, C_2 λ4738Å, C_2 λ5172Å, and Continuum λ5300Å, February 11 and 12 UT, 1970.

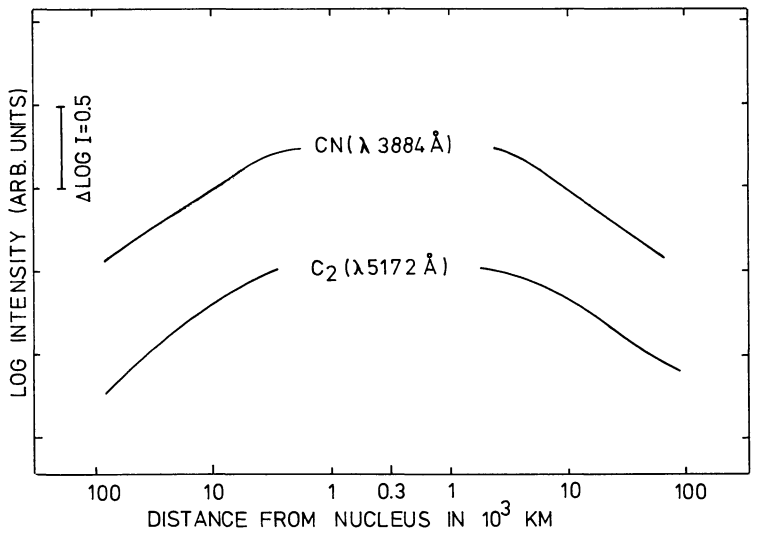

Figure 12 Intensity gradients along the sun-comet line (sun toward the left) for CN λ3884Å and C_2 λ5172Å, February 13 UT, 1970.

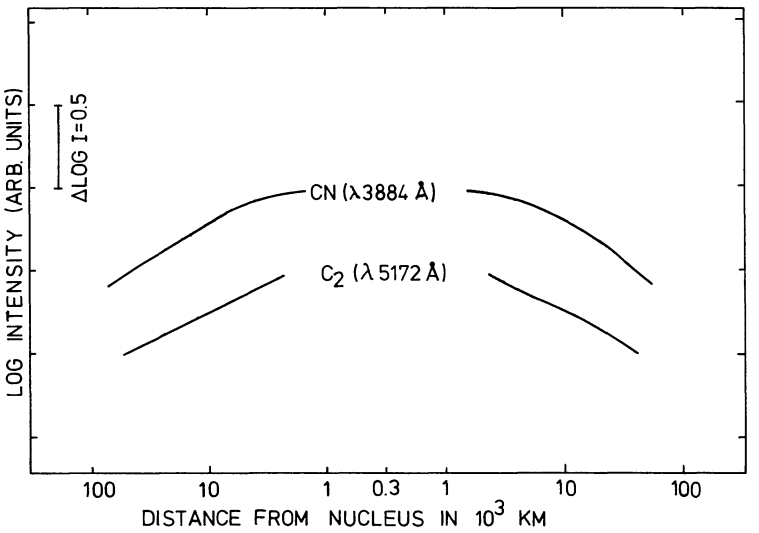

Figure 13 Intensity gradients along the sun-comet line (sun toward the left) for CN λ3884Å and C_2 λ5172Å, February 14 UT, 1970.