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SPECTROPHOTOMETRY OF COMET BENNETT

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Photoelectric spectrum scans of the head of comet Bennett (1969i) covering the range 352÷612 mμ are presented and the emission features of CN, CH, C_2 and Na have been identified. The scattered light becomes redder as the phase angle decreases and matches with the solar light scattered according to the λ^2 law at a particular phase angle, indicating that the size of the scattering particles is of the order of 0·5 μ.

Спектрофотометрия кометы Беннетта. Представлены фотоэлектрические сканирования спектра головы кометы Беннетта (1969i) покрывающего диапазон 352 ÷ 612 mμ и определены эмиссионые свойства CN, CH, C_2 и Na. Рассеянный свет становится более красным, если фазовый угол уменьшается и соответствует солнечному свету, рассеяному по λ^2-закону рассеяния для некоторого значения фазового угла, которое показывает, что размеры рассеивающих частиц порядка 0,5 μ.

1. Instrumentation and observations

A total of five scans of the central region of the head of Comet Bennett (1969i) were obtained with the photoelectric spectrum scanner described elsewhere (Babu, 1971) on 2,4 and 6 April 1970. The only modification of the instrumentation was that the grating of the monochromator was driven by a synchronous motor at a rate, corresponding to a spectral scan at the exit slit, of 25 mμ per minute. The entrance slit of the monochromator was set at 2·0 × 0·5 mm throughout the observations while the width of the exit slit was equivalent to a spectral window of 3·5 mμ. With the help of the reflected image formed off an inclined quartz plate placed just before the entrance slit, continuous guiding on the comet head could be done with a fair amount of accuracy. On the first two days the scanner was mounted at the Cassegrain focus of the 15-inch reflector, while on the last date it was mounted at the Nasmyth focus of the 20-inch reflector. A summary of the observations is given in Table I.

In addition, η Peg was observed on each night to serve as a comparison star. Though it is a multiple system (ADS 16211) and its light has been suspected of variability (Batten, 1967), it is not included in the latest General Catalogue of Variable Stars (Kukarkin et al., 1969). Hence for our purposes, we have taken it as a non-variable star.

After correcting for extinction by the usual graphical method, the observations (i.e., measurements at intervals of ~4 mμ on the tracings) were normalized so that at λ 479 mμ, $m(\lambda) = 0^m.00$. In order to get the normalized relative magnitudes of the comet at each λ, the values of (Comet − η Peg) were obtained, which are obviously independent of instrumental effects. These were finally converted into intensities in order to get the normalized relative fluxes of the comet at each λ, normalized to λ 479 mμ.

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Table I

Summary of observations of the head of comet Bennett

Date, UT 1970	Telescope (reflector)	Area of comet head admitted through the entrance slit. (in sq. km)	No. of scans	Wavelength limits	Δ (in a.u.)	r (in a.u.)
April 2·96^d	15-inch (f/15)	$3·75 \times 10^8$	2	λ 440 mμ to λ 612 mμ	0·746	0·627
April 4·94^d	15-inch (f/15)	$3·97 \times 10^8$	1	λ 440 mμ to λ 612 mμ	0·771	0·652
April 6·96^d	20-inch (f/13·1)	$3·41 \times 10^8$	2	λ 352 mμ to λ 612 mμ	0·812	0·677

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2. Relative flux distributions

Figure 1 shows the mean relative flux distributions of the head of comet Bennett on various dates, the curves (*a*), (*b*) and (*c*) being in increasing order of *r*, the distance between the sun and the comet. In these the emission features of CN, CH, the principal Swan band sequences of C_2 and Na have readily been identified. In order to obtain the band profiles of these emission features, the continuum in the spectrum scans was located by selecting wavelength regions free of emission lines, based on Table III of the Atlas of Representative Cometary Spectra (Swings and Haser, 1956). The relative fluxes obtained at these

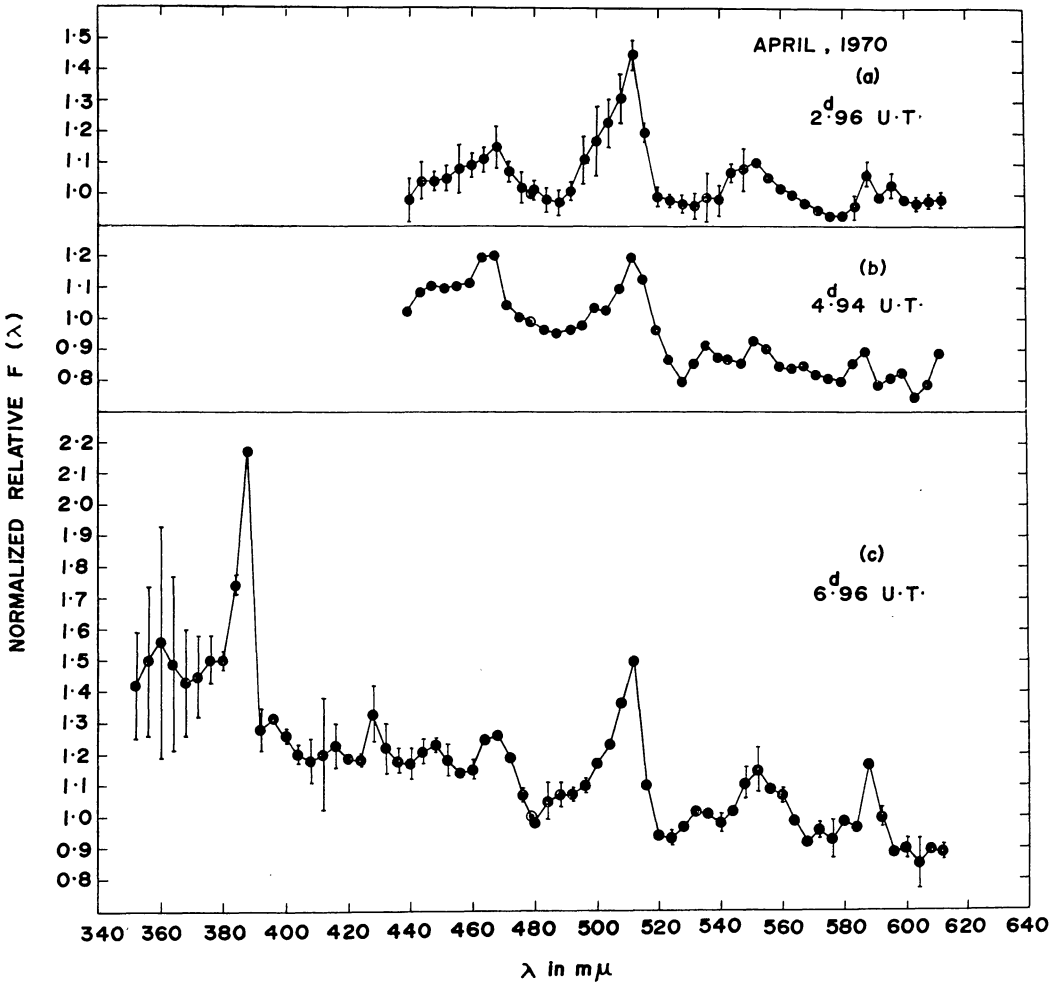

Fig. 1. Relative flux distributions of the head of comet Bennett on various dates, normalised to λ 479 mμ.

Table II

Relative fluxes of band-sequences in the head of comet Bennett

Date, UT 1970	$F/F(C_2, \Delta v = 0)$						$F(C_2, \Delta v = 0)$ (ergs cm^{-2} sec^{-1})	$\frac{F_{4790}}{F(C_2, \Delta v = 0)}$ (ergs cm^{-2} sec^{-1} Å^{-1})
	CN (λ 388 mμ)	CH (λ 428 mμ)	C_2 $\Delta v = +1$ (λ 468 mμ)	C_2 $\Delta v = 0$ (λ 512 mμ)	C_2 $\Delta v = -1$ (λ 552 mμ)	Na (λ 588 mμ)		
April 2·96^d	—	—	0·484	1·000	0·342	0·103	$0{\cdot}371 \times 10^7$	0·799
April 4·94^d	—	—	0·635	1·000	0·510	0·116	$0{\cdot}860 \times 10^7$	0·934
April 6·96^d	0·833	0·074	0·522	1·000	0·505	0·276	$1{\cdot}447 \times 10^7$	0·574

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wavelength regions are joined together to represent the approximate continuum. Then the areas of the emission band profiles were planimetered so as to obtain the total band intensities, which are given in Table II, relative to the (C_2, $\Delta v = 0$) band sequence at λ 512 mμ. It appears from this Table that the (C_2, $\Delta v = 0$) band was the strongest followed by the CN band emission at λ 388 mμ, the (C_2, $\Delta v = +1$) emission at λ 468 mμ, the (C_2, $\Delta v = -1$) emission at λ 552 mμ and the Na emission at λ 588 mμ, in that order. In the same Table continuum intensities at λ 479 mμ are also given relative to the (C_2, $\Delta v = 0$) band at λ 512 mμ. The absolute flux in the (C_2, $\Delta v = 0$) band sequence is also given in column 8.

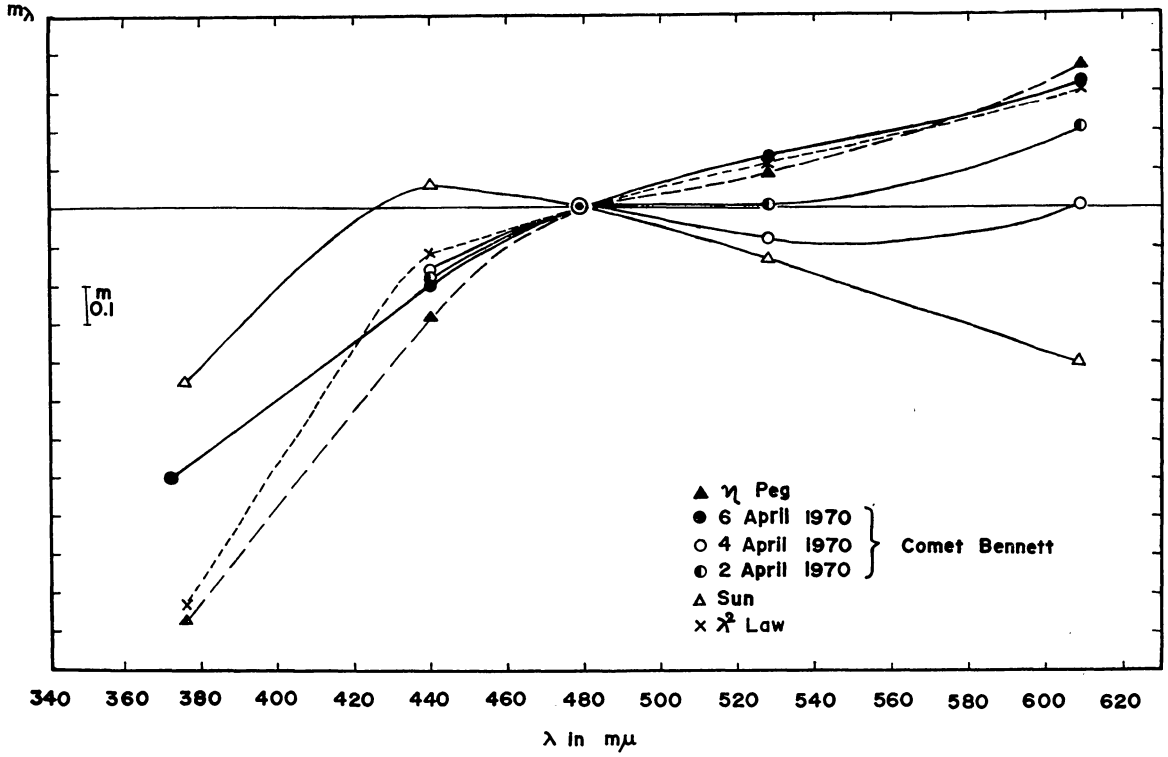

Fig. 2. Continuum energy distribution of the head of comet Bennett compared with those of η Peg, sun and the solar light scattered according to the λ^2 law. (All curves are normalized to λ 479 mμ and the Balmer discontinuity is smoothed out.)

Table III

Adopted monochromatic magnitudes of η Peg, head of comet Bennett, sun and solar light scattered according to the λ^2 law, normalized to λ 479 mμ

λ in mμ	$m(\lambda)$					
	η Peg	Comet Bennett			Sun	Solar light scattered according to λ^2 law
		6·96^d Apr 70	4·94^d Apr 70	2·96^d Apr 70		
372	—	+0·70 ± 0·160	—	—	—	—
376	+1·08 ± 0·090	—	—	—	+0·45	+1·03
440	+0·28 ± 0·087	+0·20 ± 0·051	+0·16	+0·19 ± 0·077	−0·06	+0·12
479	0·00	0·00	0·00	0·00	0·00	0·00
528	−0·09 ± 0·073	−0·13 ± 0·007	+0·08	−0·01 ± 0·015	+0·13	−0·12
609	−0·37 ± 0·085	−0·33 ± 0·027	−0·01	−0·21 ± 0·038	+0·40	−0·31

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3. Continuum energy distribution

The continuum energy distribution in the head of comet Bennett on different dates and of the comparison star η Peg (G8 II + F?)*) have been obtained independently by taking the same line-free regions as in the previous paragraphs, using α Lyr as the standard star. The latest calibration of α Lyr given by Oke and Schild (1970) has been used. The adopted monochromatic values relative to λ 479 mμ are given in Table III and are plotted in Figure 2. The energy distribution of the sun and of the solar light scattered according to the λ^2 law (Mie scattering), given by Arpigny (1965), are also plotted in the same figure.

It appears from this figure that the light, coming from the head of comet Bennett is 'redder' than that of the sun. The energy curve of the comet on 2 April 1970 appears to be tending towards that of η Peg, while on 6 April 1970 the curves of both the comet and η Peg are found to have almost the same shape. Previous studies (Walker, 1959; Vanýsek, 1960; Bappu and Sinvhal, 1960; Liller, 1961) of continuum-dominated comets show that the energy distribution and the colours of these comets closely match with those of a G8 star. This agrees with our study of comet Bennett but conflicts with the grey scattering found in comet Humason (1961e) (Arpigny, 1965), comets Ikeya-Seki (1967n), Thomas (1968b) and Honda (1968c) (See Gebel, 1970).

*) η Peg has been classified as a G2 II—III star in the MK system (1943) and as a G8 II + F? in Yerkes classification (Stebbins and Kron, 1956). Franklin (1959) has shown that, the energy curves of α Aur and η Peg are very much alike, whereas α Aur has been given as G8 III + F both in MK and Yerkes classifications. In addition, the energy curve of η Peg obtained by us differs from that of the sun just in the same way as the energy curve of ε Vir differs from that of the sun (Stebbins and Kron, 1964). This ε Vir has been classified as G8 III in the MK system and as G9 II—III in the Yerkes classification.

On the basis of these arguments, we consider that the Yerkes classification of η Peg is more accurate, which we adopted.

On 2 April 1970, the phase angle of the comet was 93° and on 6 April 1970, it was 84°. The reddening, as it is already seen, was more on the sixth than on the second, showing an increase in the reddening as the phase angle became smaller albeit by only 9°. It is interesting to note that the curve of the solar light scattered according to the λ^2 law matches very closely with that of the comet on the last date of observation indicating that at a particular phase angle (in this case 84°), Mie scattering became predominant. At this phase the size of the scattering particles is of the order of 0·5 μ (Arpigny, 1965), prior to which the reddening effect is comparatively less.

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