0.25 and 0.35, a filling factor $\mu_0 = 0.9$ of the optical star in its Roche lobe, and a limb-darkening coefficient of 0.4 for the star. If the minimum of depth ≈ $0^m.01$ measured by Bruevich et al. is real and is due to an occultation of the star by the disk, then noting that the largest possible size for the disk is $r_d = 0.3$, and using results we have given in an earlier letter,[10] we obtain constraints i ≈ 52-65° on the inclincation of the system and $\mu \approx 0.85$–0.95 on the proportion of the Roche lobe filled by the star.

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Photometry of V616 Monocerotis (A0620–00) during minimum light

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Photoelectric *U,B,V* observations of the nova V616 Mon (A0620 – 00) as well as photographic observations carried out in 1976–1978 are reported. The $U-B$, $B-V$ color indices correspond to spectral type GO. An ultraviolet excess $U-B = -0^m.7$ was maintained during the abrupt drop in brightness. All available observations of V616 Mon are compatible with a double-wave light curve having a $6^d.36$ period and a *V* amplitude of $0^m.4$.

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The x-ray and optical nova that appeared in Monoceros in 1975 has aroused the interest of many investigators. It has been observed both photographically[1–3] and photoelectrically.[4–6] However, all these observations were made soon after outburst of the nova, near maximum light. Photometry of the star at minimum light has been lacking, and there has been no information on its color indices at that phase. The only exception is one very uncertain estimate from the Palomar sky atlas,[7] indicating that at minimum light (B = $20^m.5$) the star was very red, with a color index B−R ≈ $3^m.6$ corresponding to spectral type M.

In this letter we present the results of photoelectric and photographic photometry of V616 Mon during minimum light in 1976-1978 (subsequent to the 1975 outburst), by which time the star had reverted practically to its original brightness before the flare.

1. Photoelectric observations. Photoelectric photometry of the nova V616 Mon (A0602−00) has been carried out with the 2.6-m telescope of the Crimean Astrophysical Observatory, Academy of Sciences of the USSR, and the 1.25-m telescope of the Shternberg Astronomical Institute's Southern Station in the Crimea. A photo-counting photometer was used. Measurements were made differentially with respect to comparison star[4] d. Table I gives the results.

In the U filter the star could be measured twice, in September 1976 and in October 1978. Both measurements give the same result: U−B ≈ $+0^m.5$ at minimum light. We notice at once that at minimum (B = $18^m.6$) the star is by no means as red as would appear from estimates on the Palomar Sky Survey prints.

2. Photographic observations. The star has been observed photographically with the 50-cm Maksutov telescope of the Shternberg's Southern Station. Kodak 103a-D plates were used in conjunction with a ZhS-17 filter, which corresponds approximately to the V system. The results of these observations are given in Table II. For calibration we have taken published photoelectric stnadards,[4,8] extended toward fainter magnitudes by means of a Racine wedge placed in front of the telescope objective. The photographic and photoelectric V magnitudes are in good agreement.

3. Light curve and color indices. Figure 1 displays the V light curve of V616 Mon as well as the B−V color-index curve, beginning at JD 2442720. Along with our own observations, Fig. 1 includes some observations

TABLE I

JD 24 . . .	V	B	U	Telescope
43046.570	17.60±0.10	18.61±0.15	19.1±0.3	2.6-m
399.566	17.66±0.20	18.64±0.20	–	2.6-m
519.413	17.50±0.35	19.00±0.40	–	1.25-m
521.375	18.05±0.35	19.25±0.40	–	1.25-m
785.570	18.19±0.10	19.46±0.13	20.0±0.5	2.6-m

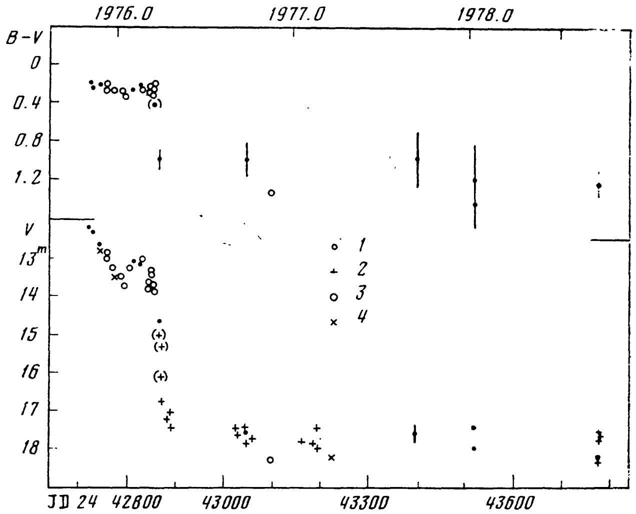

FIG. 1. The color and light curves of V616 Mon. Symbols: 1, 2) our photoelectric and photographic observations; 3, 4) photoelectric and photographic observations by other authors.

TABLE II

JD 24 . . .	V_{pg}	JD 24 . . .	V_{pg}
42873.309	16.8±0.6	43057.591	17.80±0.25
88.263	17.3±0.5	43164.366	17.85±0.25
90.259	17.1±0.5	84.258	17.90±0.25
92.256	17.5±0.3	88.273	17.9±0.3
43026.549	17.65±0.3	90.357	18.0±0.3
27.552	17.50±0.3	92.289	17.50±0.25
45.562	17.55±0.25	43429.585	17.95±0.2
49.584	18.0±0.4	785.556	18.4±0.3
50.535	17.95±0.25	86.592	17.60±0.2
55.579	17.75±0.25	89.561	17.70±0.25
56.589	17.55±0.25	95.579	17.86±0.25

by other authors.[6,9,10] A full list of all observations of V616 Mon has been compiled by Webbink,[11] from whom we have, in particular, adopted the dates of the observations by Ciatti and Vittone and certain other authors.

After V616 Mon had faded abruptly to $V \approx 17^m$ in the spring of 1976, the star apparently reached minimum light, and no further decline has been observed. Despite the fairly considerable errors of measurement at minimum (Tables I and II), the light fluctuations, amounting to as much as 1^m, may be considered real. At minimum light the B−V color index has remained constant, between $+1^m.0$ and $+1^m.4$, within the errors, although the index may have increased somewhat in January 1978. A color index U−B $+0^m.5$ has been measured twice, in September 1976 and in October 1978; after two years it has not changed (see Table I), so we may regard the U−B index, as well as B−V, as having reached its limiting value.

The color-index variations of V616 Mon are illustrated in the two-color diagram of Fig. 2 at maximum light (circle), at minimum, and at several intermediate stages on the decline. If we adopt an interstellar reddening[12] $E_{B-V} = 0^m.4$, then according to its color indices the star would correspond at minimum light approximately to spectral type G0, whereas a type of about M has been estimated from the color on the Palomar Sky Atlas prints. A spectral type of K8 for V616 Mon at minimum light has been determined by Ciatti and Vittone[9] from the B−V and V−R color indices, but they did not make simultaneous observations in B, V, and R. Thus, the R_{pg} magnitude of the star was recorded on JD 43151, B_{pg} on JD 43219, and V_{pg} on JD 43225. Since the star fluctuated in brightness by up to 1^m at minimum, as mentioned above, observations cannot give accurate information on the color unless they are simultaneous.

It is also worth noting that the star did not reach its maximum color indices simultaneously: while the B−V index had risen to $+1^m$ by April 1976 (JD 42869), U−B was then still the same as at maximum light. For lack of observations we cannot accurately determine the time when U−B rose to $+0^m.5$.

4. Possible periodicity. Lloyd et al.[3] find that their observations satisfy a $3^d.180$ period (the periods of $7^d.8$ or $3^d.92$ previously suggested by other authors have not been confirmed by subsequent observations); the periodic component has an amplitude of $0^m.1$. We have reduced all the observations of V616 Mon at minimum light using twice[1)] the period of Lloyd et al., $P = 6^d.36$ (Fig. 3).

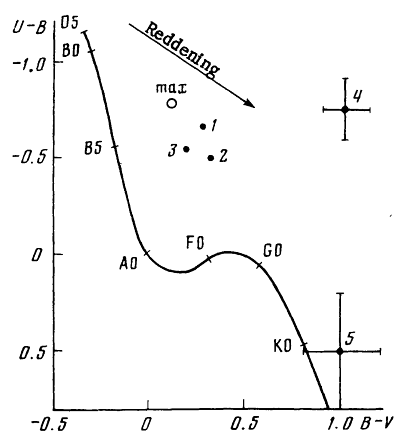

FIG. 2. Position of V616 Mon in the two-color diagram at various levels of brightness. 1) JD 2442792; 2) JD 42852; 3) JD 42857; 4) JD 42869; 5) JD 43046; max) at maximum light.

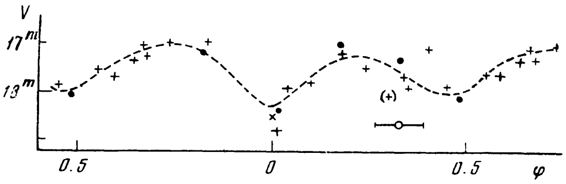

FIG. 3. The light curve of V616 Mon with a period P = $6^d.360$. Symbols as in Fig. 1.

The observations presently available satisfy this period quite well, giving a light curve in the form of a double wave of $0^m.4$ amplitude. The observations are of course inadequate for a definitive finding of the presence of a period; nevertheless, there is reason to believe that V616 Mon may be a binary star with P = $6^d.36$ and a certain amount of orbital eccentricity, as the distances between the minima are not the same.

Conclusions. Our photometry of the x-ray nova V616 Mon (A0620−00) at minimum light (after the outburst) has therefore yielded the following results.

a. The color indices of the star, corrected for interstellar reddening, correspond to spectral type G0, rather than K8-M, as previously believed.

b. As the brightness waned, the B−V index first increased, and then U−B; thus the star retained an ultraviolet excess for a time.

c. A period of $6^d.36$ might be present, with a light curve in the form of a double wave (from the ellipsoidality of the components). Periods of this order are found in other x-ray binaries.

[1)]Since the minima are placed asymmetrically, P = $3^d.180$ fits the observations somewhat less well than 2P = $6^d.36$.

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Do planetary-nebula nuclei form an evolutionary sequence?

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An analysis is made of how planetary-nebula nuclei whose spectrum has been classified are distributed with respect to the radio surface brightness of the nebula, and of how they are distributed in the Hertzsprung–Russell diagram. It is suggested that the spectrum of these stars may begin to evolve at type Of and WR in the youngest objects; after passing through the Cont and O VI stages, the evolution would conclude with type O spectra for the nuclei of the oldest and most rarefied planetaries.

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It has been maintained increasingly often in the past few years that planetary nebulae represent a family of objects belonging to different galactic population types.[1] From this point of view it is of interest to attempt to identify and trace the evolution of the nuclei of planetary nebulae. If the nuclei are indeed stars differing in age, mass, and chemical composition, then a unified evolutionary sequence cannot exist — and vice versa.

The spectra of planetary-nebula nuclei afford a complex characterization of their properties and evolutionary state, provided directly by the observations. As a rule the spectra are quite complicated, hindering their classification. Nevertheless, a definite system of criteria has recently been laid down, and the spectra of many nuclei have been systematized on this basis.

A survey by Aller,[2] supplemented by the work of Heap[3] and Lutz,[4] includes classifications of 80 "ordinary" nuclei and 13 nuclei considered peculiar because their spectra are too late for such a star to be capable of exciting the nebula. These nuclei evidently belong to binary systems, in which we observe the brighter and cooler components. Thus far there is no clear reason to believe that a nucleus