NOTES FROM OBSERVATORIES

AN UNUSUAL STELLAR SPECIES

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One of the densest portions of the large network of obscuring clouds in Taurus contains a faintly luminous nebula discovered by Barnard[1] in 1907 and included by him in his *Catalogue of 349 Dark Objects in the Sky*[2] under the designation B 10. This luminous nebula has a radius of at least 5 minutes of arc.[3] According to Struve[4] the nebula is illuminated by a star of photographic magnitude 15, as estimated with the help of the nearest Selected Area[5] which falls within the limits of Barnard's photograph No. 5 in the *Atlas*. It is evident that these values are not consistent with Hubble's expression[6]

$$m_* + 5 \log a = 11.$$

To satisfy the formula the star should have an apparent magnitude of 7.5. The discrepancy is so large that unusual conditions must prevail either in the nebula or in the star.

Photographic observations by Collins at the Yerkes Observatory[7] show that B 10 is distinctly blue. This is clearly shown by comparing it with the reddish nebulosity designated by him and by Hubble as IC 359?, which surrounds a star of photovisual magnitude 12.5 and of spectral class dK8. This star has probably no connection with the blue nebula B 10. Within the latter are two stars, one of photographic magnitude 15 which we shall designate as *A*, the other of photographic magnitude 16 which we shall designate as *B*. *B* is about 30″ north of *A*. The nebula, B 10, is located mostly to the east of *A* and *B*, its brightest portion being about 2′ distant.

[1] *Ap. J.*, **25**, 218, 1907.

[2] *A Photographic Atlas of Selected Regions of the Milky Way*, Carnegie Institution of Washington, 1927.

[3] Barnard considered it probable that B 10 forms only the brighter, central condensation in the southeast part of the large irregular obscuring nebulosity B 7.

[4] *Ap. J.*, **85**, 211, 1937.

[5] *Harv. Ann.*, **101**, 1917.

[6] See also O. Struve and Helen Story, *Ap. J.*, **84**, 208, 1936.

[7] *Ap. J.*, **86**, Plate XXII facing p. 543, 1937.

Several slit spectrograms of *A* obtained with dispersions of 150 A/mm and 300 A/mm at λ 3930 show that *A* has exceedingly strong emission lines of hydrogen, which can be seen to *H* 14. There are strong emission lines of *Ca* II and weaker ones of *He* I. The continuous spectrum is easily visible to λ 3300. It may be caused to a considerable extent by Paschen emission in the photographic region and is almost entirely caused by Balmer emission on the violet side of λ 3647, but there are no conspicuous absorption lines: those of *H, Ca* II, and *He* I, if present, would be covered by the emission lines. There are no distinct absorption lines or bands in the visual region as far to the red as *H*α.[8]

The Balmer continuum of star *A* is so strong that it cannot have been appreciably reddened by absorption. We estimate that any general photographic absorption must be less than one magnitude if the absorbing cloud in Taurus has the usual ratio of color excess to photographic absorption. Since the dark nebula is practically opaque, the star must be located on our side of the nebula. It seems safe to assume that the distance of star *A* is the same as that of the nebula B 10—about 100 parsecs. At 10 parsecs the photographic magnitude of *A* would be about +10. Such an object may bear some resemblance to the underluminous emission-line companions of certain double-star systems and perhaps to the T Tauri variables.

The spectrum of star *B* is K-type, with emission lines of *Ca* II, and with a strong absorption band of *CH*. This star presents nothing unusual. With its apparent magnitude of 16, it would have an absolute magnitude of +11, if it were located at the distance of the nebula. If it were a foreground star its

[8] Dr. A. H. Joy of the Mount Wilson Observatory has since informed us that he has observed the spectrum of this star and that on his spectrograms "the absorption lines of a late-type dwarf are faintly present." The spectrum may be variable, but it is more likely that we have here a combination of a normal dwarf spectrum with what Joy describes as "an overlying spectrum of numerous strong emission lines and continuous background which blots out most of the absorption lines of the star." It is this overlying spectrum which we find to be distinctly blue and which we believe to be only slightly if at all affected by interstellar or nebular reddening.

absolute magnitude would be even fainter. For a normal K5 main-sequence star the absolute photographic magnitude is about +10. The discrepancy may be easily accounted for by the uncertainty of the observed magnitude and spectral type.

The spectrum of the nebula B 10 was obtained with a seven-hour exposure which shows a very strong night-sky spectrum and a continuum which must in part belong to the nebula. The brightest portion of B 10 shows a very faint emission line of $H\beta$, but it is weaker in relation to the continuum than $H\beta$ is in the spectrum of star *A*. There is no trace of [*O* II] emission. Hence we are reasonably certain that at least a part of the nebular light is reflected radiation of *A* and that none is of gaseous character. The discrepancy in Hubble's relation is still unaccounted for. Since the star is not deeply involved in the nebula, and since the scattering function—being directed away from the observer—is unfavorable to the production of strong scattered radiation, we wonder whether there may not exist some other, as yet unknown, process whereby strong ultraviolet stellar radiation (perhaps from the Lyman region) is converted by the nebular particles into more or less continuous radiation of longer (and therefore visible) wave lengths.

In the laboratory many solids (as well as liquids and gases) show an intense continuous visible fluorescence when they are excited by far ultraviolet radiation, such a fluorescence being sometimes especially pronounced at low temperatures. The specific chemical composition and temperature of the solids and the specific exciting radiation required for an intense fluorescence may possibly be encountered occasionally in dust nebulae. Such a conversion of ultraviolet energy, in addition to scattering, may cause an occasional discrepancy in Hubble's relation.

The extraordinary nature of star *A* strongly suggests that we are concerned with a phenomenon which depends upon the interaction of cosmic dust and stars. Since star *A* is a member of Joy's group of forty emission objects in Taurus[9] it is probable that we are concerned with a phenomenon having a direct bear-

[9] *Pub. A.S.P.*, **58**, 244, 1946. See also J. L. Greenstein and L. H. Aller, *Pub. A.S.P.*, **59**, 139, 1947, and J. L. Greenstein, *Harvard Symposium on Interstellar Material,* December 1946, in press.

ing upon the problem of star formation or evolution. If star *A* is a late-type dwarf, in accordance with Joy's observation, then there must exist a conspicuous envelope radiating in continuous light as well as in discreet frequencies. This nebular halo would then account for the major portion of the violet and ultraviolet light of the object. On the other hand, if we should consider this blue continuous radiation as being representative of the star itself we would have to conclude that the latter is underluminous. In either case the light of the nebula is entirely too strong to be accounted for by pure reflection. The possibility, of course, exists that star *A* has nothing to do with the bright nebula, but in that case the explanation of the nebular radiation becomes even more difficult.

THE ORBITAL ELEMENTS OF ADS 16800 (β 1266)

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Although the visible components of ADS 16800 ($23^h\ 27^m\!.9$; +30° 34′, 1950.0; Mag., 8.0, 8.1; Sp F5) have completed one observed revolution only recently, several sets of orbital elements have been published, the last, in 1936, by S. Arend.[1] The elements presented here are based on data available in 1935 with the addition of the following measure by H. M. Jeffers of the Lick Observatory:

1946.619 50°.6 0″.16 3n

The pair is a difficult one—the apparent separation varying from 0″.11 to 0″.29.

The apparent ellipse was based on three-year means in which were included all known observations that did not depart from the mean by more than three times the rough probable error. Elements were derived from the apparent ellipse by the method of Zwiers and of Kowalsky. The average of these elements, together with those of two earlier orbits, are:

	a	e	i	☊	ω	P	T
Aitken (1923)	0″.22	0.33	48°.0	46°.0	133°.0	40ʸ.0	1909.8
Arend (1936)	0.20	0.43	32.0	83.4	173.0	49.4	1959.7
Russell (1947)	0.21	0.43	40.6	78.6	164.4	47.9	1957.8

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[1] *A.J.*, **45**, 71, 1936.

Aitken, who regarded his elements as provisional, stated that they would require revision after a full revolution of the system had been observed. The author's elements represent his three-year-mean places slightly better than do Arend's elements.

TABLE I

RESIDUALS FOR ADS 16800

Date	O − C	Arend	O − C	Russell
1892.84	+ 3°3	−0″01	− 0°4	−0″03
1896.78	− 2.8	+0.05	− 7.8	+0.03
1899.70	+ 5.0	+0.03	− 0.8	+0.02
1901.57	+ 1.3	+0.05	− 7.4	+0.04
1904.92	+10.2	+0.02	+ 6.8	+0.02
1907.61	−10.2	+0.02	− 5.5	+0.02
1911.26	− 3.6	+0.05	+ 0.4	+0.05
1913.63	+ 4.9	+0.03	+ 5.1	+0.02
1916.28	+10.2	+0.04	+10.4	+0.05
1919.90	− 1.8	+0.01	+ 0.8	+0.01
1923.11	− 2.6	−0.01	+ 0.3	−0.01
1926.70	− 0.6	−0.04	+ 2.3	−0.04
1929.07	− 2.8	−0.03	− 0.1	−0.03
1933.90	+ 0.0	−0.02	− 1.9	−0.03
1946.62	− 2.4	−0.07	− 1.1	−0.06
Mean deviations	4°1	0″032	3°4	0″031

Date	O − C	Arend	O − C	Russell
1890.0	−1°1	+0″00	−4°2	−0″01
1895.0	−1.3	+0.03	−5.7	+0.01
1900.0	+4.1	+0.04	−2.5	+0.04
1905.0	−2.4	+0.02	−7.0	+0.03
1910.0	−1.6	+0.02	+4.3	+0.01
1915.0	+2.8	+0.01	+4.0	+0.01
1920.0	−0.6	−0.02	+2.3	−0.02
1925.0	−1.5	−0.03	+2.0	−0.04
1930.0	+0.7	−0.04	+1.5	−0.05
1935.0	+0.2	−0.02	+2.0	−0.04
Mean deviations	1°6	0″023	3°6	0″026

Arend's empirically adjusted elements, on the other hand, represent his five-year, interpolated places materially better than do the author's. This seeming paradox results from the inevitable discordances in measures of close pairs and from the manner of combination and the basis for the rejection of observational data. It is not implied that the 1947 elements are an improvement over Arend's; indeed, his small residuals would indicate that the reverse is true. It should be noted, however, that adjusted elements may represent smoothed mean places with smaller residuals than those obtained with unadjusted elements and unsmoothed mean places.

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LIGHT-CURVES OF AC HERCULIS

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AC Herculis is a variable star of the RV Tauri type. In some respects the variation of RV Tauri stars resembles that of the Cepheids. It is characterized by regularly spaced minima with deep secondary minima halfway between them. The second maximum might be regarded as an exaggeration of the hump often found after maximum in the Cepheids. The spectrum of AC Herculis[1] varies from F8 near maximum to K5 at primary minimum.

The light-characteristics of AC Herculis were studied from photographs taken over the period 1898 to 1926 by W. F. H. Waterfield.[1] He gives

$$\text{Min} = \text{JD (GMT)}2414461.1 + 75^{d}.4E - 6^{d}.1 \sin (157^{\circ}.5 + 2^{\circ}.045E), \quad (1)$$

the cyclical term accounting for a variation averaging 6.1 days during 44 periods, or 9 years. Formulae have been derived from intensive measures over shorter periods. G. Zacharov,[2] for example, derives

$$\text{Min} = \text{JD } 2423591.19 + 75^{d}.46E \quad (2)$$

from light-curves showing 8 minima between 1923 and 1926. The cyclical term in equation (1) has questionable value, since like similar terms used to represent the sunspot curve, it improves the representation of the observations from which it was derived, but not necessarily those of earlier or later dates.

The present investigation was undertaken to implement

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[1] *Harvard Bulletin,* No. 845. [2] *Pub. Tashkent Obs.,* **I**, 67, 1928.