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NOTES

A HIGH-LATITUDE PLANETARY NEBULA

ABSTRACT

A blue star imbedded in faint nebulosity has been discovered at high galactic latitude. Spectra, photoelectric photometry, and interference-filter photography show that it is a member of the class of old planetary nebulae. Radial velocities and proper motions enable a distance to be estimated.

An extremely faint nebulosity has been detected on a high-latitude, blue-sensitive *Palomar Sky Survey* print. Even though the nebulosity is slightly stronger on the red-sensitive *Sky Survey* print, it was apparently still too faint to have been discovered in previous surveys of old planetary nebulae with low surface-brightness envelopes (Abell 1966). The unwidened spectrum shown in Figure 1 (Plate 7) demonstrates the nebulosity is in emission with strong 3727 and a trace of Hα. In the spectrum, the [O II] line is registered out to about 35″ on either side of the central star.

The central star is blue, and turns out to have been designated No. 932 in the Haro-Luyten Palomar catalogue (1962). Two spectra of this central star were obtained at 195 Å/mm, and one of them is shown in Figure 2 (Plate 7). The widened spectra show the Balmer lines Hγ through H9, He I $\lambda\lambda$4471, 4026, and possibly λ4144 and λ5015. The number of Balmer lines visible indicates that the star is subluminous (J. L. Greenstein, private communication). The spectral type is early B (R. Schild, private communication). The hydrogen lines are similar to those in Abell 36 (which is another high-latitude planetary with similar colors), but the presence of strong He I seems to be unique (Greenstein and Minkowski 1964). The heliocentric radial velocity of the star from hydrogen lines measured on two spectra is $v_R = +15$ km/sec $\pm$ 20 km/sec.

We are grateful to Dr. Willem Luyten for furnishing us with a proper motion for the star. That motion is quite accurate because the star is in the Bordeaux *Carte du Ciel* (+15° zone, plate 347, star No. 88, 1897.97) as well as on three 48-inch plates taken between 1951 and 1965.

The colors of the star are consistent with the hypothesis that the nebula is a planetary. The measured *UBV* data for the star, which are listed in Table 1, have been corrected for the slight contribution from the nebula, as determined by measures through different diaphragms. The present object has not been corrected for reddening, but, because of its high galactic latitude, the correction would be expected to be small and, therefore, the blue color as measured is not surprising. The place of the present object in the $U - B$, $B - V$ diagram indicates about as blue a color temperature as possible (Arp 1961), and therefore implies an effective temperature greater than 25000° K. The measured colors of Abell's planetaries range from $B - V = -0.35$ to $+0.51$, but most of the scatter is due to various degrees of reddening. Using Abell's approximate values for $\Delta m_{\rm pr}$, we deredden his $B - V$ values, and of the twenty-nine stars for which the data exist, all but two lie in the range -0.41 to -0.12 mag. The average is $(B - V)_0 = -0.28$ mag. Because of the crudeness of this reddening correction, the true scatter may be much smaller, but the coincidence of the mean unreddened color with that of our present object supports its identification as a member of the class of old planetaries.

The average M_V for Abell's old planetaries is $+6$, but with a large scatter about this value. If $M_V = 6$ for the present star (which is consistent with the subluminous nature suggested by the spectra), the distance would be 160 pc. The same distance was estimated independently by Luyten (private communication), based on the proper motion alone. The radial velocity and proper motion provide another independent estimate of

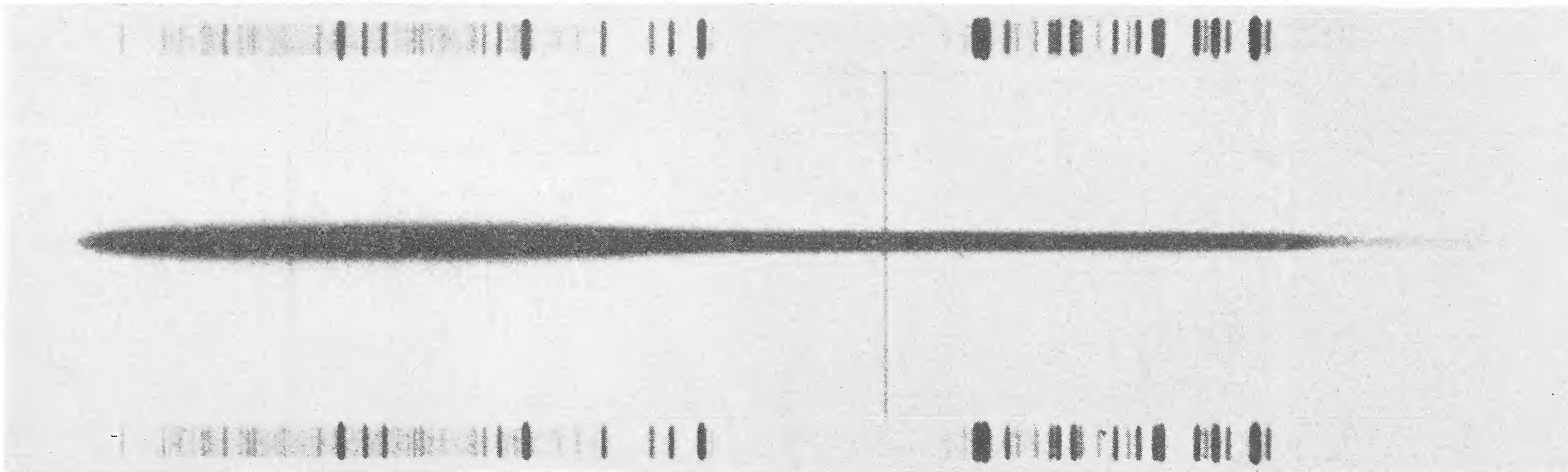

FIG. 1.—Spectrum of nebulosity around central star. Original dispersion, 400 Å/mm on 103aF plate. Window, 92″ wide. Emission at λ3727 [O II] strong; Hα barely detectable.

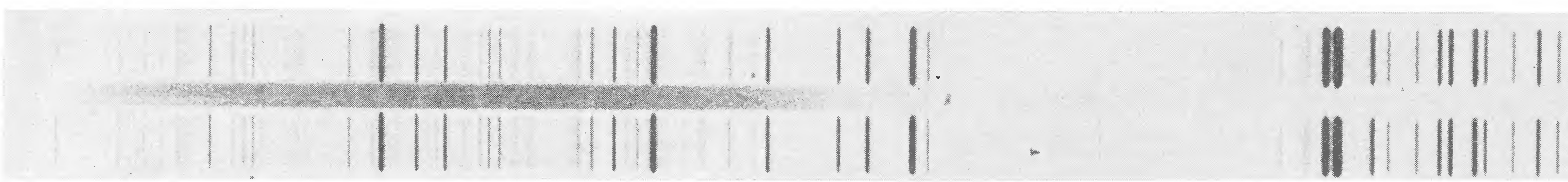

FIG. 2.—Spectrum of central star widened to 33″. Original dispersion 195 Å/mm. Eastman 103aF emulsion

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the distance: with the observed values and errors, an *upper limit* of about 150 pc is set if the tangential and radial velocities are equal. At latitude 47° the nebula would be out of the disk of the Galaxy if the distance were much greater than 150 pc, whereas planetaries generally occur in the disk or near the galactic center. Also, the comet shape of the nebulosity (see Fig. 4, Pl. 8) suggests interaction with the interstellar medium, which can be significant only within the disk. Thus four independent methods suggest 150 pc or less as the distance to the planetary. We could also use Abell's (1966) version of Shklovsky's method, which gives 700 pc, if the mass of ionized hydrogen of the present nebula is typical of those in Abell's list. This distance is probably within the range allowed by the errors in any one of the distance estimates, but a more reasonable possibility is that the ionized mass is much less than typical (by a factor of 16 if the actual distance were 150 pc).

We have seen, therefore, that in luminosity and temperature the central star of the present object resembles those in the class of old planetaries. The surface brightness of the nebulosity is very low. Only ten of the eighty-six planetaries in Abell's (1966) list have fainter surface brightnesses. But its galactic latitude is higher than any of the old planetary nebulae previously discovered, and much higher than the galactic latitude for normal planetary nebulae (Minkowski and Abell 1963).

TABLE 1

OBSERVATIONAL DATA

Name......	PHL 932
Position	$0^h57^m19^s$, $+15°28'$ (1950) $l^{II}=125\overset{\circ}{.}9$, $b^{II}=-47\overset{\circ}{.}1$
Photometry:	
(Star)........	$V=12.14$, $B-V=-0.31$, $U-B=-1.10$ (hence $P=11.5$, $R=12.4$)
(Nebula).. ...	Surface brightness: 23.1 m_{pr}/sq. sec of arc Integrated brightness: $m_{pr}=12.8$
Motion..	Right ascension: $+0\overset{''}{.}049$/yr $\pm 0\overset{''}{.}007$/yr Declination: $+0$ 014/yr $\pm 0\overset{''}{.}007$/yr Radial velocity: +15 km/sec ± 20 km/sec

The shape of this nebulosity also seems to be unusual, as shown in Figures 3 and 4 (Plate 8). The inner ring form as shown in the Hα photograph is perhaps not unexpected, but the outer nebulosity in the photograph extends to the northwest, asymmetrically away from the central star. On the isodensitometer tracing of this same photograph, which is shown just below in Figure 4 (Plate 8), even fainter nebulosity can be detected. This outermost nebulosity has a very clear comet shape. Surprisingly enough, however, the tail now points away to the southwest. The shape of the outermost isophote could conceivably be due to an interaction with some property of the surrounding medium. But, if an interstellar wind, for example, was responsible for the outer isophotal shape of the nebulosity, it does not seem likely that it could account for the differently-oriented axis of the inner asymmetric material.

We would like to thank W. Krzeminski for photoelectric measures of the central star, W. Luyten for proper motions, and J. L. Greenstein and R. Schild for comments on the spectra. J. D. S. is a National Science Foundation Graduate Fellow.

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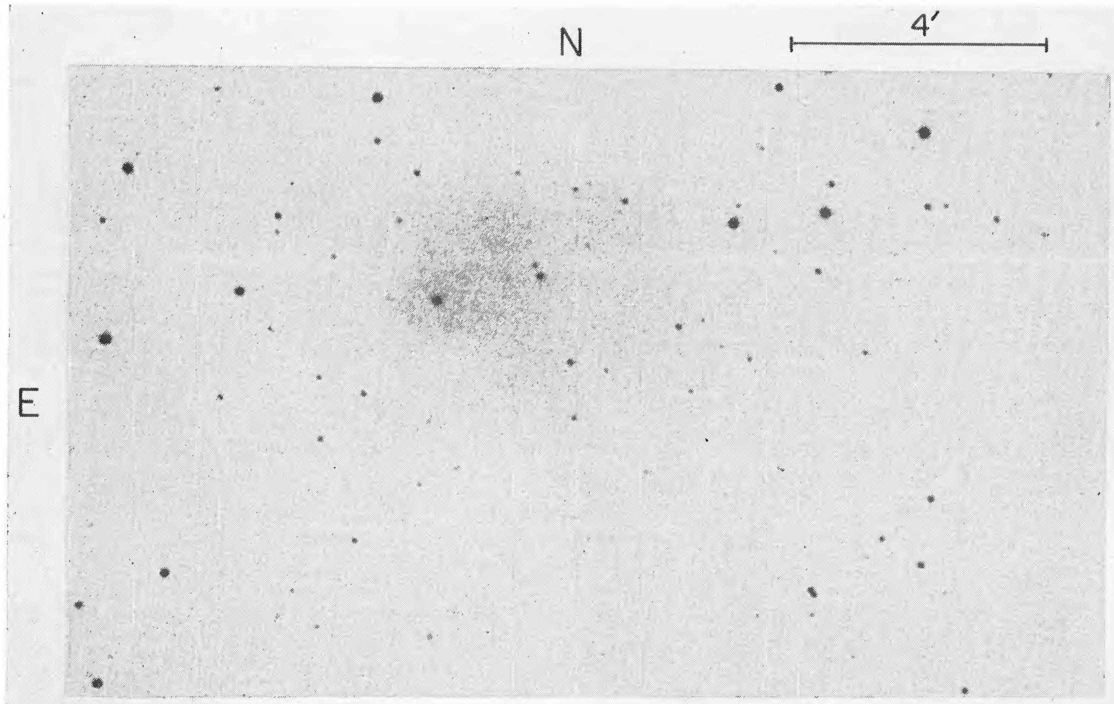

FIG. 3.—A 4-hour exposure with the 48-inch Schmidt telescope using a 100-Å band pass, Hα interference filter in order to make visible the extent of the emission nebulosity. Stars as faint as the central star do not have diffraction rings; therefore, inner nebular ring is concluded to be real.

FIG. 4.—Isodensitometer tracing of plate shown in Fig. 1 on same scale. Cometic shape of faintest outermost material is emphasized.

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