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BY

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The star H.D. 142926, R.A. (1900) $15^h\ 52^m.2$, dec. (1900) 42° 51′, vis. mag. 5.61, H.D. type B8, was announced as a spectroscopic binary by Plaskett[1] from eight Victoria spectrograms of 1919-20, the total range being from −3.2 to −34.9 km./sec. Plaskett remarked that "broad and diffuse hydrogen and broad faint magnesium are the only lines measurable in this spectrum".

From spectrograms taken here between 1936 and 1940 the velocity variation of this star has been confirmed[2] and emission lines in the spectrum have been detected.[3] The purpose of the present paper is further to describe peculiarities in the spectrum, to discuss the velocity variation, and to indicate a possible connection between the two.

The Spectrum

Forty spectrograms taken with the one-prism spectrograph fitted with the 25-inch camera lens (dispersion 33 A/mm. at $H\gamma$) have been used in this investigation. Most of these are on Astra II plates, a few on Eastman 40 and one (J.D. 2429659.9) on Eastman Process. As well, there are several Astra VIII plates showing $H\alpha$ fairly strong in emission. No spectrum variations have been detected on these plates which cover the period 1936-40. The Process plate shows greater detail than the others; on this plate the hydrogen lines appear as broad-winged absorption lines of total width about 30 Angstrom units with distinct sharp central absorption cores; the helium lines 4026 and 4471 are fairly prominent and are very broad and diffuse, other helium lines are faint, broad and indistinct; Mg^+4481 is slightly stronger than 4471 and not quite so broad; Ca^+3933 compares in intensity with 4026 but is, by comparison, much sharper; less prominent are many

[1] Pub. D.A.O. vol. 1, p. 287.

[2] Pub. D.D.O. vol. 1, no. 3, p. 71.

[3] Jour. R.A.S.C. vol. 33, p. 384, 1939 (Comm. D.D.O. no. 4).

fine lines due to Fe^{+}, ten of which are easily measurable and all of which are strikingly sharp by comparison with the helium lines. On the Astra II plates the broad wings and sharp cores of the hydrogen lines are evident, the broad 4026, 4471 and 4481 and the sharper 3933 are usually seen, and, of the sharp Fe^{+} lines, only a few of the stronger, particularly 4233, are occasionally seen, depending on the quality of the plate.

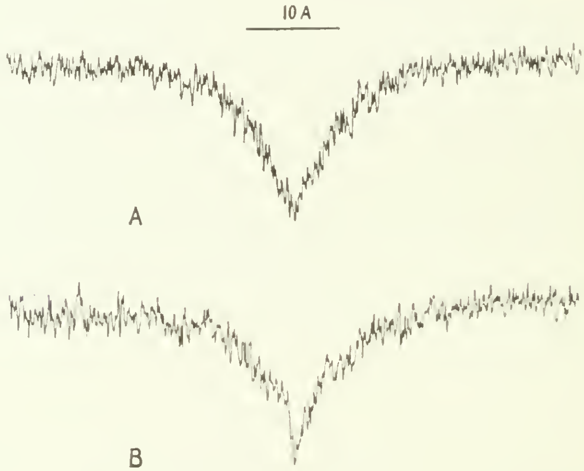

Figure 1—Microphotometer tracings of H_γ for H.D. 142926.
A—Victoria, J.D. 2422085.839.
B—Toronto, J.D. 2428304.651.

Struve and Swings[4] have called attention to the existence of a small group of B-type stars of peculiar spectrum characterized by hydrogen emission, sharp absorption cores of hydrogen with broad wings, sharp lines of ionized metals and broad diffuse lines of helium. They have interpreted the broad hydrogen wings and helium lines as arising from the reversing layer of the star, rotation accounting for the broadening of the helium lines, and the hydrogen cores and the sharp ionized metal lines as arising from an extensive atmosphere with less rapid rotation. This view found support in the anomalous sharpness of He 3964 in the spectrum of several of these stars.

The composite nature of the spectrum would seem to put H.D.

[4]Ap. J. vol. 88, p. 84, 1938.

142926 in this class of stars, with the broad helium lines and hydrogen wings originating in the reversing layer and the hydrogen cores and sharp Fe^+ lines originating in the shell. Ca^+ 3933 and Mg^+ 4481 which are of intermediate width may originate partly in the reversing layer and partly in the shell. He 3964 might be expected to be sharp as it is for some other stars of this class, but its region is obscured by the wide wing of $H\epsilon$.

Plaskett's failure to remark on the hydrogen cores led to the suspicion that these had become accentuated since 1920. Through the kindness of Dr. J. A. Pearce the Victoria plates have been made available here. These plates do show spectral characteristics similar to those described above, but the cores of the hydrogen lines are decidedly less pronounced. Figure 1 reproduces microphotometer tracings of $H\gamma$ from two plates of comparable density, one from Victoria, one of ours. The tracing of the Victoria plate has been reduced photographically in one coordinate to make the scales of dispersion the same.

The Velocity Variation

The forty plates mentioned above have been measured for radial velocity. The hydrogen cores are easily measured and give accordant results. Other lines measured on some plates seemed to be much less reliable. Accordingly, in attempts to determine a period, the mean velocities from $H\beta$, $H\gamma$ and $H\delta$ only were used. These velocities are given in Table I.

A period of 0.97625 day fits the observations. Longer and shorter periods are ruled out by several series of observations made during single nights. This period results in the velocity curve shown in Figure 2. If this be interpreted on the binary hypothesis the approximate elements of the orbit derived by the graphical method of R. K. Young are as follows:

$$P = 0^{d}97625$$
$$e = 0.5$$
$$\omega = 0^\circ$$
$$K = 15 \text{ km./sec.}$$
$$\gamma = -18 \text{ km./sec.}$$
$$T = \text{J.D. } 2428207.176$$
$$a \sin i = 174000 \text{ km.}$$
$$f(M) = 0.00022 \odot.$$

The eight Victoria observations have not been used in determining the period and, indeed, they do not fit well with this period. The fit, however, is not so poor as to rule out the period for the 1919-20 interval, especially in view of the poorer character of the lines at that time.

TABLE 1

J.D. 242	Velocity (km. sec.)				J.D. 242	Velocity (km. sec.)			
	H cores	He 4026 and 4471	Ca^+ 3933	Mg^+ 4481		H cores	He 4026 and 4471	Ca^+ 3933	Mg^+ 4481
8206.977	−20.8		−35.9		8342.606	−29.4	−51.5	−57.7	
8220.952	−15.4		−31.2	−68.8	8344.608	−16.1	−78.2	−28.1	+1.2
8221.940	−9.3	−23.2	−34.6		8348.594	−19.9	−56.3	−22.0	−1.9
8228.949	−21.9		−43.9		8357.626	−8.2	−13.9	−27.3	−114.8
8262.854	+5.7		−40.2	−11.2	8359.584	−8.7		−26.5	
8280.753	−20.9		−27.0	−64.2	8616.758	−28.6	−19.1		−42.3
8281.747	−25.4		−55.6	−65.9	8616.917	−26.1	−46.7	−0.5	−87.7
8281.859	−21.1	−82.8	−43.3		8682.655	−3.4	−56.1	−9.2	−50.0
8281.901	−28.6	−31.2	−32.8	+17.7	8682.794	−16.3	−39.9	−22.6	−103.2
8282.760	−15.8	+2.3	−62.5	−36.0	8723.638	+11.2		−39.3	−18.3
8283.788	−24.6	−28.4		+2.6	8723.681	−1.0			
8285.783	−17.5	−31.1	−45.7	−50.5	8764.572	−8.0	−38.1		+6.6
8294.751	−18.7	−36.1	−19.7	−103.5	9424.675	−13.0	−54.5		−34.0
8296.744	−33.7	−47.5	−31.8	−15.6	9436.653	−32.3	−34.3	−48.4	−47.2
8297.648	−17.7		−10.3	−74.5	9438.619	−33.8	−62.7	−26.3	−15.0
8297.810	−23.7		−18.9		9455.598	−23.2	−35.8	−20.0	+24.4
8303.658	−13.1	−54.8	−10.2		9455.760	−7.9	−40.7		−17.2
8303.760	+0.9	−35.9	−1.1	−38.6	9659.913	−18.3	−68.3	−28.0	−28.8
8304.651	−17.5	−42.4	−22.8		9745.722	+0.3	−29.2		+13.8
8305.778	−4.2	−92.2	−28.9		9745.819	−0.4	−60.0		−49.9

It is immediately apparent that the combination of early spectral class, short period, small range and high eccentricity make this orbit improbable, to say the least. We must, therefore, consider the possibility of the velocity variation arising from some cause other than orbital motion. Some sort of pulsation of the shell is suggested by the fact that the velocities refer to the hydrogen cores which have originated in the shell rather than in the reversing layer.

This pulsation hypothesis would find support if the velocities from lines originating wholly in the reversing layer of the star failed to show variation similar to that from the hydrogen cores. Accordingly the broad helium lines 4026 and 4471 were measured whenever they appeared with sufficient distinctness; these velocities are shown in Table 1. At best these lines are difficult to set on, and no great reliance may be placed on any of the measures. However, unless some blending or other systematic effect has

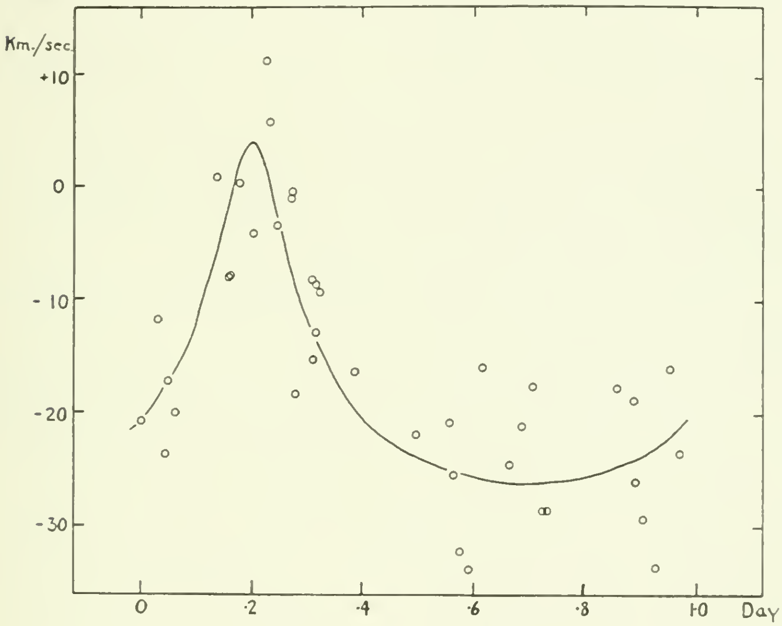

Figure 2—Velocity Curve for H.D. 142926.

affected the measures, it does appear certain that the helium velocities are distinctly more negative than those from the hydrogen cores, the average of the 29 helium velocities being −44.4 km./sec. compared with −16.8 km./sec. for the average of the corresponding hydrogen core velocities. With regard to the question of variation of the helium velocities the following test may have some significance: ten of the helium velocities are from observations with phases between $0^d.10$ and $0^d.35$, namely on the "high" part of the velocity curve; the average of these is −48.9 km./sec.; the average of the others is −42.1 km./sec.; the corresponding averages from the hydrogen core velocities are −6.2 and −22.4 km./sec. respectively. Although the evidence is inconclusive because of the poor quality of the helium lines, this does suggest that the helium lines fail to show velocity variation similar to that shown by the hydrogen cores.

In like manner Ca^+ 3933 and Mg^+ 4481 have been measured where possible. The results, which show very large scatter especially for the broader 4481, are given in Table 1. For the 32 calcium velocities the mean is −29.8 km./sec., for the 29 magnesium velocities it is −37.0 km./sec., the corresponding hydrogen core velocity means being −17.0 and −15.6 km./sec. respectively. So it appears that the calcium and magnesium lines, which have breadths intermediate between the sharpest and broadest lines, have velocities which are intermediate between the hydrogen core velocities and the helium velocities. Tested with reference to phase neither the calcium nor magnesium velocities show any tendency to vary with the 0.97625-day period.

The sharp Fe^+ lines are too weak to measure on most plates; from the Process plate of J.D. 2429659.9 the mean velocity from ten Fe^+ lines is −31.0 km./sec.

The observation of greater negative velocity from the broad helium lines than from the sharp hydrogen cores is of particular interest aside from the question of variation in either. This, on the shell hypothesis, means that material of the reversing layer and material of the shell are approaching each other. Cherrington[5] has recently investigated velocities from sharp and nebulous lines for 13 super-shell stars and has found that in each case the opposite is true—velocities from sharp lines originating in the shells are more negative than velocities from broad lines originating in the reversing layers. He puts this down to expansion of the shells and points to a relation between these stars and novae. H.D. 142926, therefore, would appear to constitute an exception to Cherrington's rule.[6] For this star either the shell is suffering a net contraction or material of the reversing layer is being driven outwards towards the shell.

[5]P.A.S.P. vol. 52, p. 116, 1940.

[6]Another super-shell star being investigated by the writer, namely H.D. 12302, exhibits a similar effect to a greater degree. From five plates the average hydrogen core velocity is +39.2 km./sec. while the average helium velocity is −55.1 km./sec.

Although H.D. 142926 had not been recorded as a variable, the possibility of minor variations with the 0.97625-day period was considered. Dr. C. M. Huffer of the Washburn Observatory kindly made a series of observations with the photoelectric photometer in the summer of 1938 and reported the star as constant in light.

In view of Beals' recent suggestion[7] that α Cygni and P Cygni stars develop from stars with spectra showing both broad and narrow lines it will be of interest eventually to observe whether the sharpening of the hydrogen cores recorded here be periodic or secular.

Summary

Super-shell characteristics have been detected in the spectrum of H.D. 142926 and are found to be present to a greater degree now than in 1919-20. The velocity variation from the hydrogen cores has a 0.97625-day period, but the velocity curve leads to an improbable orbit. Failure to detect similar velocity variation from the broad lines suggests that the variation arises from the shell alone. Mean velocities from the broad lines are more negative than those from the hydrogen cores, indicating that materials from reversing layer and shell are approaching each other.

[7]P.A.S.P. vol. 52, p. 278, 1940.