3. Les résultats sont indépendants du choix de g_e et de θ'_e. Par suite, on peut leur accorder une certaine valeur malgré les critiques que l'on pourrait faire concernant le calcul ou l'utilisation des modèles.

4. Les résultats peuvent se résumer comme suit (nous nous abstiendrons, pour l'instant de les interpréter).

La variation du rayon est en phase avec celle de la magnitude ultra-violette: ceci est incompatible avec l'interprétation classique des vitesses radiales en terme de rayon. De plus, alors que cette interprétation fournit la valeur

$$\frac{R_{\max}}{R_{\min}} = 1{\cdot}1, \text{ nous obtenons } \frac{R_{\max}}{R_{\min}} = 1{\cdot}2.$$

Le maximum de rayon se situe à $\phi \sim 0{\cdot}55$; le minimum de la température à $\phi \sim 0{\cdot}65$. Le maximum de température effective (comme le minimum du rayon) se situe à $\phi = 0$.

6. THE WIDENING OR DOUBLING OF LINES IN THE SPECTRA OF VARIABLE STARS

By Roscoe F. Sanford. (*Presented by* M. Schwarzschild)

Certain absorption lines in the spectrum of W Virginis have been found to be double during a short phase interval centred approximately at light maximum.* They behave as if a sequence of velocity variation starts abruptly with the appearance of lines showing high velocity of approach, just before light-maximum and while the lines of the preceding sequence showing high velocity of recession are still present. As the sequence continues, the lines, which at first showed high velocity of approach, move longward until they in turn show high velocity of recession. They do not disappear until the next light-maximum, by which time another velocity sequence is well advanced. The duration of a velocity sequence is thus from shortly before one light-maximum until shortly after the next.

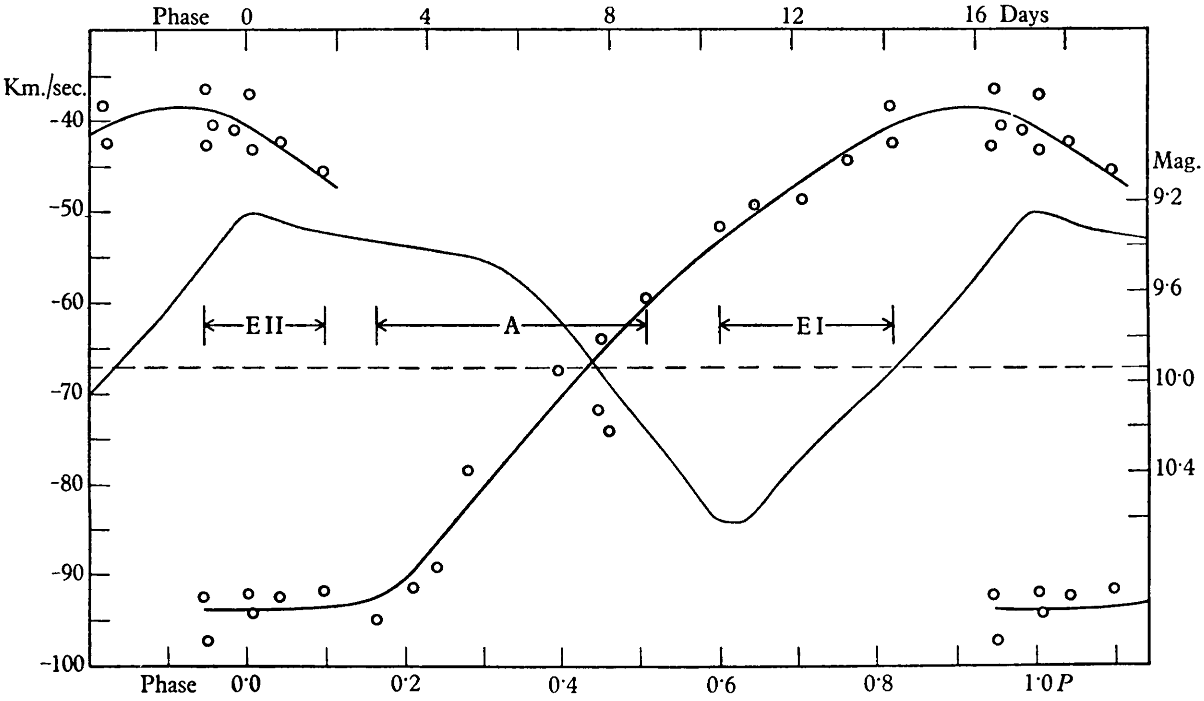

Fig. 1. Radial velocity curve of W Virginis from the absorption lines. The lighter line is the light curve by Gordon and Kron. A represents the interval with single absorption and no emission lines, E I the interval with single absorption lines and the hydrogen lines in emission, and E II the interval with double absorption lines and hydrogen emission lines.

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* R. F. Sanford: *Ap. J.*, **116**, 331, 1952.

It is perhaps significant that the two Sr II lines λ4077 and 4215 and the strong Ti II lines which are most conspicuously double in the spectrum of W Vir are also the lines that widen and have velocity displacements in certain other cepheids* at or near light-maximum. The doubling of these lines in W Vir raises the question whether in other cepheids their width and displacement may not result from the blending of components belonging to an old and a new cycle of velocity change co-existing for a short interval near maximum light. Perhaps the wide lines would be resolved into two components, if still higher dispersion were used. The best cepheids for such a test would be those that are bright enough for high dispersion and that have long periods and large amplitudes of velocity and light. Table 1 lists six cepheids satisfying these conditions.

The writer has studied the spectrum of T Mon and SV Vul with a dispersion of 10 A./mm. Sr II and Ti II lines are widened and displaced near light-maximum in both variables. Furthermore, one spectrogram of SV Vul shows some Ti II lines not only widened but apparently about to be resolved into two components. High dispersion spectrograms of these cepheids in the phase interval of 0·90P to 0·10P may reveal results of significance for interpreting cepheid variation.

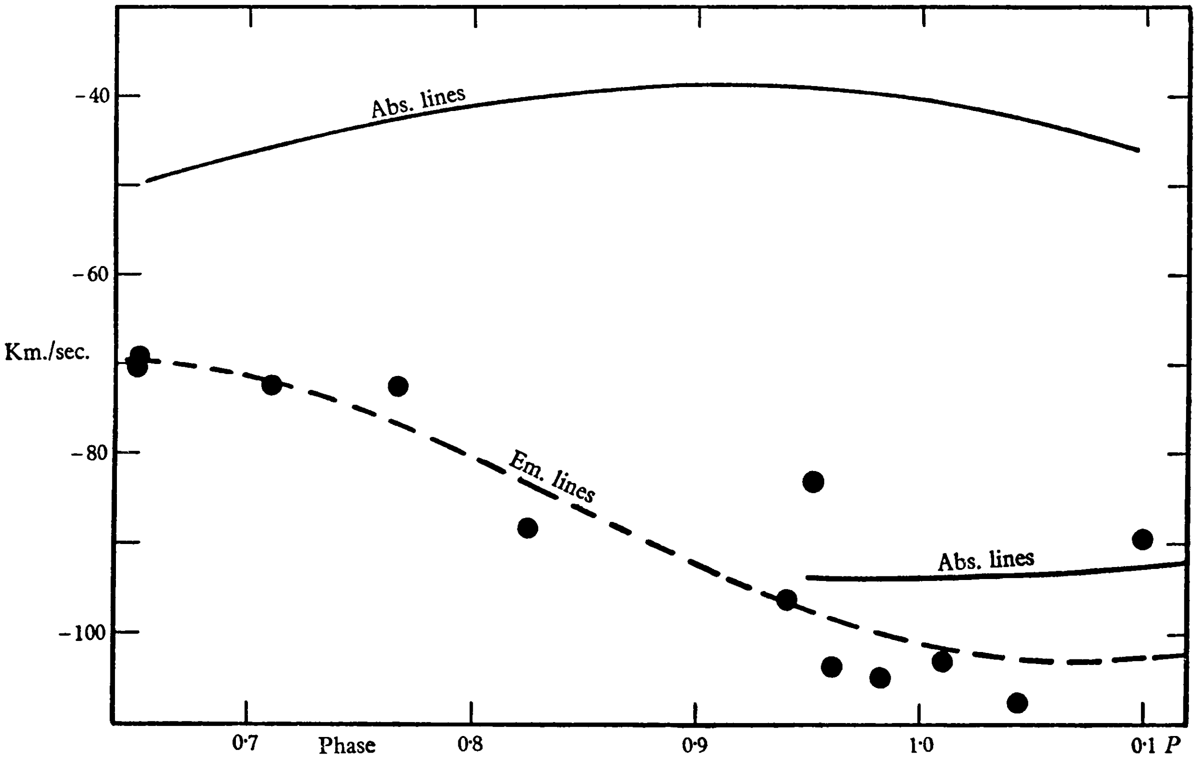

Fig. 2. Radial velocity curve of W Virginis from the emission lines.

Table 1

Cepheids with large ranges of velocity and light

Star	Period	Velocity range	Light range	Median mag. *pg*
TT Aquilae	13·75 days	52 km./sec.	1·7 mag. *pg*	8·3
X Cygni	16·39	56	1·4	7·4
T Monocerotis	27·01	50	1·6	7·3
X Puppis	25·96	71	1·8	9·4
WZ Sagittarii	21·85	62	2·2	9·0
SV Vulpeculae	45·21	44	1·6	8·8

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* D. W Lee: *Publ. Obs. Univ. Mich.* **4**, 109, 1926. R. W. Petrie: *Publ. Obs. Univ. Mich.* **5**, 9, 1933. T. S. Jacobsen: *Publ. A.S.P.* **61**, 156, 1949.

In this connexion it is interesting to consider the doubling of the absorption lines H and K and H_α in the spectrum of RR Lyrae* and the doubling of many absorption lines on a spectrogram of AC Herculis obtained 10 July 1949.

A spectrogram of T Mon at phase 0·00*P* was obtained on 25 March 1951 with a dispersion of 2·3 A./mm. and one of SV Vul at phase 0·94*P* on 30 May 1952 with a dispersion of 4·4 A./mm. The lines of Sr II, Sc II and Ti II were not resolved into two components on these spectrograms but both showed wide lines not only of these elements but of other elements as well. However, optimum resolution was not realized on either of these spectrograms.

7. SHOCK WAVES IN THE ATMOSPHERES OF PULSATING STARS

By Martin Schwarzschild

The profiles of the absorption lines in cepheids (their width, asymmetry, and doubling) have to be interpreted in terms of the motions throughout the reversing layer. To cover the entire volume of the reversing layer one has to integrate both over the surface of the visible hemisphere and throughout the depth of the reversing layer. The effect of the surface integration has already been discussed in this symposium by Dr Savedoff. Here will be discussed the effects of the depth integration.

In the case when the pulsations in the atmosphere are synchronous, i.e. have the character of a standing wave, the depth integration will not add sensibly to the line profile since at any one moment the pulsational velocity will differ little from point to point in the reversing layer. If, however, the atmospheric pulsation has the character of a progressive wave, the phase delay from the bottom to the top of the reversing layer will introduce velocity differences which may appreciably affect the appearance of the lines. Let us consider a shock wave as an extreme case of a progressive wave.

Fig. 1 shows schematically the motions of the top, the middle, and the bottom of the reversing layer as a periodic function of time.

To start with, at phases 0·1 to 0·3 all strata move outwards, more or less with the same velocities. Next, the strata reach successively their largest distances from the centre and their motions turn inwards until the entire reversing layer is in a more or less uniform downwards motion during the phases 0·7 to 0·9. At phase 0·9 suddenly the shock front enters from below the bottom of the reversing layer and reverses the velocity of the lowest strata from a fast downwards motion into a fast upwards motion. Subsequently the shock front moves upwards through the whole reversing layer, reversing successively the direction of the velocity of all strata and finally leaving the top of the reversing layer at phase 0·1. Now, again, the reversing layer is in an essentially uniform upwards motion and the cycle can begin again.

The density variations in this type of atmospheric pulsation can be read directly from Fig. 1 by considering the vertical distances between the three curves. For the low reversing layer which presumably is responsible for the light variations, one finds that highest compression occurs about at phase 0·0, at which time therefore one should expect light-maximum.

Let us now consider the effect of this type of motion on the appearance of the absorption lines. At any time between phases 0·1 and 0·9 the velocity difference between top and bottom of the reversing layer is not very large and hence no radical effects on the line profiles could be expected. However, at any time between phases 0·9 to 0·1 the reversing layer is sharply divided into a lower portion with a fast upwards motion and an upper portion with a fast downwards motion, thus, for example, at phase 0·95 about one-quarter of the reversing layer has already been passed by the shock front while the upper three-quarters of the reversing layer are still falling down undisturbed, similarly at phase 0·05 the lower three-quarters of the reversing layer have been hit by the shock front and

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* R. F. Sanford: *Mt Wilson Contr.* No. 757; *Ap. J.* **109**, 208, 1949.