2. PHOTOMETRIC MEASUREMENTS OF MAGNETIC-FIELD AND SPECTRUM VARIABLES

By G. R. MICZAIKA

In Heidelberg photo-electric measurements have been made on the spectrum variables ι Cassiopeiae, 73 Draconis, γ Equulei, χ Serpentis, ϵ Ursae Majoris, BD + 33° 1008 and others. According to our results all of these stars are variable with an amplitude of 0·01 magnitude and period equal to that of the spectral variability. Mr Bahner has carried out some further spectrophotometrical measurements of the line intensities in the spectra of ι Cassiopeiae, χ Serpentis and ϵ Ursae Majoris. These measurements have enabled him to determine the phase relationship between the total light and line variations. The magnetic-field variable HD 133129 is likewise variable in magnitude with a small amplitude. The period, which might be several days long, could not as yet be determined with certainty.

3. THE SPECTRA OF VARIABLE STARS OF THE RW AURIGAE TYPE

By GEORGE H. HERBIG. (*Presented by* C. D. Shane)

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The RW Aurigae stars form a class of variables that has recently been recognized, notably through the work of C. Hoffmeister.* Members are assigned to this class solely on the basis of their type of light variation; specifically, through the possession of rapid, non-periodic fluctuations in brightness. The spectral type and luminosity play no part in the classification. Since the prototype, RW Aurigae, is itself a 'T Tauri star', some misunderstanding has arisen as to the relationship between the RW Aurigae variables on one hand, and the T Tauri stars on the other. It is important to note that assignment to the T Tauri class is based entirely upon spectral criteria, in particular, the possession of a characteristic emission-line spectrum; the nature of the light variation (because the great majority, if not all, of the T Tauri stars are variable) is not considered in making the assignment.

It should be mentioned that the T Tauri stars are but one variety of the emission-line stars found in association with nebular material, although the other types occur much less frequently.† Furthermore, there are many irregular variables whose association with nebular matter cannot be questioned but that definitely show no bright lines. In the Orion Nebula, for example, only 47 % of the known variables exhibit emission at H_α. It is not known if the emission and non-emission stars differ in the nature of their light variations.

It is clear, first, that the RW Aurigae class is not identical with the T Tauri stars. This is demonstrated by the fact that a large fraction of the RW Aurigae variables are not associated with nebular material, while, as far as is known at the present time, the T Tauri stars and allied objects occur exclusively in regions of bright or dark nebulosity. At best, then, the RW Aurigae class must be a considerably diluted sample of bright-line nebular variables.

It might then be asked if the T Tauri stars may not be just a sub-group of the RW Aurigae variables which, as Hoffmeister has suggested, may include all of the intrinsic variable stars lying on the main sequence. This does not seem likely, for the T Tauri variables are known to exhibit a wide diversity in their photometric behaviour. It would seem to be difficult, therefore, to find photometric criteria that are adequate to distinguish, in every case, T Tauri-type variables from irregular variables of other types.

Obviously, the best way to test the ability of the photometric observers to pick out T Tauri variables and related objects is to investigate those variables that have been assigned to the RW Aurigae class without knowledge of their spectra. Spectroscopic

* *A.N.* **278**, 24, 1949.

† For a brief discussion of the types of bright-line objects found in nebulae, see G. H. Herbig. *J. Roy. Astr. Soc. Canada*, **46**, 222, 1952.

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observations also make it possible to judge something of the physical significance of the RW Aurigae class of variable stars. In order to shed light on these matters, spectroscopic observations were made of a large sample of the RW Aurigae variables that are accessible from Mt Hamilton.

The material upon which this report is based consists of from one to four slit spectrograms, with dispersions of 75, 130 or 430 A./mm., of each of thirty-four variables, mostly of unknown spectral type, that have been assigned to the RW Aurigae class, principally by Hoffmeister. The results can be summarized as follows.

Of the thirty-four stars examined, twenty-two fell in the sub-groups called 'typical RW Aurigae stars' or 'RW Aurigae stars with small amplitude' or 'RW Aurigae-like stars'. Of these twenty-two, only three (V 536 Aquilae, SU Aurigae, and T Orionis) were found to have the spectroscopic characteristics of bright-line nebular variables, while only the first was a typical T Tauri star. If eight additional stars of other RW Aurigae sub-groups, and of unknown sub-groups, are added to these twenty-two more or less typical objects, then a total of five stars out of the thirty are found to have the spectra of bright-line nebular variables. Therefore, the photometric characteristics not only fail to distinguish bright-line nebular variables in any consistent way, but the criteria bring together with the bright-line variables objects of widely different spectral characteristics; among the thirty objects examined, the spectral types range from B5 to M4, and the luminosity classes from Ib (supergiant) to V (dwarf). This sample indicates that the probability is small (0·1 or 0·2) that a variable assigned to the RW Aurigae group solely on the basis of its photometric behaviour will turn out to be a bright-line nebular variable of a type recognized as such at the present time. If an RW Aurigae variable lies in a nebulous region, then the chances are much larger that that star will be a bright-line nebular variable, but it is still not at all certain.

These considerations demonstrate the looseness of the association between the RW Aurigae stars and the bright-line nebular variables. It may now be asked if the spectroscopic evidence supports the idea that the RW Aurigae variables are a physically homogeneous group. The wide range in spectral class and luminosity already mentioned does not support this conclusion. To be sure, a comparatively wide range in physical properties is present in the eclipsing variables, for example, but in that case the light variation results from the duplicity. It is not easy to find another such general phenomenon, capable of overriding wide differences in physical characteristics, that might be operative in the RW Aurigae variables.

The present spectroscopic material does not substantiate the proposal that the RW Aurigae variables are all main-sequence stars.

Of the twenty-two most typical RW Aurigae objects, eight stars that are reasonably free from the suspicion of being nebular variables can be assigned spectroscopic luminosities. Of these eight, only three are dwarfs.

In view of the foregoing results, it is seen that the name 'RW Aurigae variables' for this group is not a happy one, because of the implied association with the bright-line nebular variables. A designation such as 'rapidly irregular variables' would be more free from objection. However, it would be unwise to confuse the situation still more by changing names at this time, because the problem of nomenclature may vanish if the doubts expressed here as to the physical reality of the RW Aurigae class are borne out by future work.

Appendix

Spectral types of RW Aurigae-type variables

1. Typical RW Aurigae stars

RY Ori	F6		V 426 Oph	Pec.	(Note 2)
T Ori	A3eα		WW Vul	A3eα	
BN Ori	A5–A7		V 536 Aql	Pec.	(Note 3)
RR Tau	A2, II–III	(Note 1)	V Sge	Pec.	(Note 4)
RY Lup	Go, V:		Z Mic	F0–F5	

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2. RW Aurigae stars with small amplitude, and RW Aurigae-like stars

XY Per	A (western), A 2, II; B (eastern), B 6 (Note 5)	AK Sco	F 5, V
SU Aur	G 2e, III (Note 6)	BQ Ser	F 5, III
Y Lep	M 4, III (Note 7)	V 733 Aql	G o, I b
CT Tau	B 5:n	RY Boo	F 5, III or IV
CY Ori	G o, V	V 517 Cyg	A o–A 5
DO Mon	M 4–M 5		
V 553 Cen	G 5*p*, I–III (Note 8)		

3. Transition types to 'Algol-like' stars

BE Cas	F 2 (Note 9)	CQ Tau	F 2
VX Cas	A o (Note 10)	BH Cep	F 5

4. Typical 'Algol-like' stars

BO Cep	F o–F 5

5. Special cases

GG Cas	B 5–B 8 + G (Note 11)

6. Unknown sub-types

BM And	F 8eα
VV CrA	Pec. (Note 12)

7. Possibly RW Aur variables

HK Aql	K 5, III	V 395 Cyg	F 8, I b
Y Boo	K o, III	120 1943 Pup	F 1, V

Notes to Appendix

Note 1. *RR Tau.* There is no certain emission in the photographic region; the red has not been observed. The variable lies in a dark cloud and illuminates a small bright nebula.

Note 2. *V* 426 *Oph.* Somewhat diffuse emission lines are present at H_β, H_γ, H_δ.

Note 3. *V* 536 *Aql.* A typical T Tauri star; the H lines are strong in emission from H_α at least as far as H_δ. H and K are bright, as is a weak He I λ4471.

Note 4. *V Sge.* The spectrum has been described by Joy and by Elvey and Babcock; it is unlike any other star in this list. The most conspicuous features are broad emission bands of H and He II (λ4685 is very strong; $\lambda\lambda$4199 and 4541 are probably weakly present). There are no absorption features other than weak absorption edges at H_β.

Note 5. *XY Per* = ADS 2788. The separation is 1″.4; the Harvard observations indicate that both stars must be variable (Miss Boyd, *H.B.* **904**, 18, 1936). Separate spectrograms of each component, both in the photographic region and in the red, have been obtained. No emission has been observed in either star. The pair lies in a dark cloud and illuminates a rather large bright nebula. The variations are probably connected with the presence of the nebular material.

Note 6. *SU Aur.* A type of gG2 was also assigned at Mt Wilson (*Ap. J.* **81**, 187, 1935). Weak emission is present at H_β and in H and K.

Note 7. *Y Lep.* A spectral type of M 1 was assigned by Mrs Mayall (*H.A.*, **115**, 217).

Note 8. *V* 553 *Cen.* CH and CN are strong, and C_2 is weakly present. The lines of Fe I are unusually weak. It may be a carbon star. A more precise luminosity classification is difficult because of the peculiarities of the spectrum.

Note 9. *BE Cas.* The classification is approximate since it is based on only one low-dispersion plate. A companion about 25 inches distant in p.a. 260° is of spectral type G.

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Note 10. *VX Cas*. There is some confusion as to the identification of this star; the object observed here is that observed by A. V. Nielsen (*Aarhus Medd.* No. 10, p. 150, 1937) and D. Martynov (*Izvestia Astr. Obs. Engelhardt, Univ. Kasan*, No. 26, 1951). The type of M2 given by C. F. Rust (*Ap. J.* **88**, 526, 1938) must refer to another star. No emission has been found at H_α.

Note 11. *GG Cas*. The spectrum is composite. The G-type star is probably a giant.

Note 12. *VV CrA*. Undoubtedly a T Tauri star. H_α is very intense in emission, and H_β and H_γ are bright as well as a few Fe II lines.

4. THE SPECTRA OF THE β CANIS MAJORIS VARIABLES

By O. Struve

(The results presented at the symposium will be published in the near future.)

5. LES VARIATIONS DE LA TEMPERATURE EFFECTIVE ET DU RAYON D'UNE CEPHEIDE

By R. Canavaggia et J. C. Pecker

1. Le but des recherches actuellement en cours est l'interprétation, aussi complète que possible, du spectre des céphéides. A chaque phase de sa pulsation, l'atmosphère d'une céphéide peut être représentée par l'atmosphère d'une certaine étoile, de température effective et de gravité à déterminer de façon que son spectre soit identique à celui de la céphéide. Pour déterminer, dans chaque phase, les valeurs de T_e et g, nous avons calculé un certain nombre de modèles d'étoiles de types F et G, géantes et supergéantes, correspondant aux valeurs suivantes de T_e et g:

$\theta_e = \dfrac{5040}{T_e} = 0{\cdot}65$	$0{\cdot}75$	$0{\cdot}85$	$0{\cdot}95$
$\log g = 1{\cdot}3$	$1{\cdot}8$	$2{\cdot}3$	$2{\cdot}8$

Nous avons ensuite calculé les spectres des étoiles correspondant à ces modèles d'atmosphère.

2. Nous avons l'intention de calculer, d'une part, les caractéristiques du spectre *continu*; d'autre part, celles du spectre de *raies* pour chacun de nos modèles.

La présente communication qui a déjà fait l'objet d'une publication* à laquelle on voudra lieu de reporter, ne concerne que les résultats obtenus à partir du fond continu.

Si on utilise la relation bien connue:

$$0{\cdot}4\,(m'-m) = \log \frac{F_\nu(\theta_e)}{F_\nu(\theta'_e)} - 2\log \frac{R'}{R}$$

ou les grandeurs affectées d'un 'exposant prime' désignent une phase initiale, d'ailleurs arbitraire, on constate que, dans le cas de δ Céphéi, que nous prendrons comme exemple:

$m'-m$ est fourni par les *mesures* de Stebbins et Whitford, pour différentes couleurs.

$\dfrac{F_\nu(\theta_e)}{F_\nu(\theta'_e)}$ est obtenu à partie des modèles calculés.

Si on affecte à la phase initiale une température θ'_e, choisie, θ_e est obtenu par la condition que, pour une même valeur de $\dfrac{R'}{R}$, la coincidence entre les deux termes de l'équation à dessus ait lieu pour toutes les couleurs de Stebbins et Whitford. La grandeur $\dfrac{R'}{R}$ est obtenue par surcroît.

* *C.R. Acad. Sci.* **234**, 1739 (1952) (contr. I.A.P. A, No. 109); *Annales d'Astrophysique*, **15**, 260, 1952.

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