EQUIVALENT WIDTH OF H-ALPHA IN LATE-TYPE STARS

DONNA WEISTROP
Mount Wilson and Palomar Observatories
Carnegie Institution of Washington
California Institute of Technology

Received August 8, 1967

The use of the equivalent width of Hα as a luminosity criterion for late-type stars is investigated. The method is found to be no more accurate than MK luminosity classifications. Two spectrograms are presented which indicate a change in the Hα equivalent width in 22 Vul over a three-year period.

Among absolute magnitude criteria for late-type stars more accurate than MK luminosity classifications, one of the most successful has been the Wilson-Bappu effect. The use of the Ca II emission line to determine absolute magnitudes has some disadvantages, however. Its location near λ 3900 is a major drawback in stars that have relatively weak fluxes in the ultraviolet. Measurement of the width of the emission against the central portion of a strong absorption line requires spectrograms of high spectral resolution and long exposure times. Hα, on the other hand, is located in the red, where a large fraction of the flux of late-type stars is found, and, in addition, appears in absorption against this strong background. For the above, and other, reasons, the use of Hα as a luminosity criterion was investigated by Kraft, Preston, and Wolff (1964). It was found that there indeed exists a relation between the ultraviolet absolute magnitude, M_U, and the half-width of Hα.

In order to use giants and supergiants for galactic structure studies, absolute magnitudes for stars of apparent magnitude 10 or 11 must be obtained. Since dispersions of 5 to 10 Å/mm are necessary to measure the half-width of Hα, the exposure time needed is prohibitively long. Therefore, an investigation was initiated to determine whether the equivalent width of Hα, which can be determined from plates of smaller dispersion, might also be useful as a luminosity criterion.

The spectrograms used in this study were taken with the 16-inch camera of the Mount Wilson 60-inch Cassegrain spectrograph; the dispersion is approximately 30 Å/mm, and Kodak IIa-E plates were used throughout. Values of the equivalent width of Hα, h, were obtained from tracings made on the Caltech microphotometer.

The results of this study are given in Table I where M_U is taken from Kraft *et al.* (1964). For those stars for which more than one spectrogram has been obtained, a mean value of log h is listed. The probable error of an equivalent width determined from one plate is 0.29 Å. Our results do not agree with those of Peat (1964), but considerable doubt has been cast on the individual equivalent widths he derives, owing to the width of his passband (Price 1966). It was impossible to compare the present results with those of Price (1966), owing to the small number of high-luminosity stars considered in his work.

Figure 1 illustrates the relationship between ultraviolet absolute magnitude and log h. In spite of the scatter, a definite correlation between M_U and log h is found. A least-squares solution gives for the straight line the relation

$$M_U = \underset{\pm 0.61}{2.38} - \underset{\pm 2.89}{17.45} \log h. \quad \text{(m.e.)}$$

The probable error in M_U determined from one observation is ± 1.17 mag., considerably larger than the ± 0.5 magnitude precision available from half-width measurements by Kraft *et al.* The size of the uncertainty indicates that the use of Hα equivalent widths as a luminosity criterion is no more accurate than MK luminosity classifications, and half-widths must be used to obtain improved absolute magnitudes, thus effectively eliminating this method from use in galactic structure studies.

There are indications from the data that the equivalent width of Hα changes in some stars. One of the most prominent cases is that of 22 Vulpeculae, which shows a change of about 30% in equivalent width over a three-year period. Plate I reproduces two spectrograms of 22 Vul, one taken in 1963, the other in 1966, which clearly illustrate the change in the hydrogen line. There is evidence that some other stars also show this effect, but the photometry is not accurate enough to provide definite proof. Further investigations should be undertaken to determine the extent of the Hα variations and the types of stars that display this phenomenon, since the possi-

TABLE I

Equivalent Widths in Late-Type Stars

G-Type Stars					K-Type Stars				
HD	Name	Sp. Type	log h(Å)	M_U	HD	Name	Sp. Type	log h(Å)	M_U
4362	HR 207	G0 I*b*	0.340	—4.8	5286	36 And	K1	0.061	—
9270	η Psc	G8 III	0.137	+1.5	12533	γ And A	K3 II	0.076	+1.3
16901	14 Per	G0 I*b*	0.233	—3.8	12929	α Ari	K2 III	0.025	+3.5
20123	HR 969	G5 II	0.248	—3.0	17506	η Per	K3 I*b*	0.233	—1.5
146791	ϵ Oph	G9 III	0.170	+3.5	20644	HR 999	K3 II–III	0.124	—
148856	β Her	G8 III	—0.023	+1.6	150275	HR 6191	K1 III	0.215	—
159181	β Dra	G2 II	0.364	—	156283	π Her	K3 II	0.140	+1.9
170820	M25, #150	G6 II	0.255	—0.5	161096	β Oph	K2 III	0.093	+3.4
173764	β Sct	G5 II	0.312	—2.7	163588	ξ Dra	K2 III	0.009	—
185758	α Sge	G0 II	0.225	—1.0	163770	θ Her	K1 II	0.173	—0.2
192713	22 Vul	G0 I*b*	0.297	—3.8	167042	HR 6817	K1 III	0.121	—
192876	α^1 Cap	G2 I*b*	0.199	—3.8	171443	α Sct	K3 III	0.013	—
192947	α^2 Cap	G9 III	0.025	+2.9	176411	ϵ Aql	K0	0.017	—
202109	ζ Cyg	G8 II	0.061	+2.9	176670	λ Lyr	K3 II	0.049	—
204867	β Aqr	G3 I*b*	0.371	—3.8	180809	θ Lyr	K0 II	0.228	—0.2
206859	9 Peg	G5 I*b*	0.320	—1.8	184406	μ Aql	K3 III	0.013	—
208606	HR 8374	G8 I*b*	0.324	—2.8	186791	γ Aql	K3 II	0.009	+0.9
215182	η Peg	G2 II–III	0.117	+0.3	192004	HR 7718	K3 II–III	0.199	—
216206	HR 8692	G4 I*b*	0.265	—	192577	31 Cyg	K3 I*b* + B4	0.308	—
217476	HR 8752	G0 I*a*	—0.201	—	192909	32 Cyg	K5 I + B3 V	0.053	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	K5 II	[illegible]	

200905	ξ Cyg	K5 I*b*	0.143	—0.6
201251	63 Cyg	K4 II	0.201	—
205349	HR 8248	K1 I*b*	0.161	—
207089	12 Peg	K0 I*ab*	0.318	—4.2
210745	ζ Cep	K1 I*b*	0.053	—2.3
216946	HR 8726	K5 I*b*	0.161	—1.3
218356	56 Peg	K0 IIp	0.093	—1.2
221246	HR 8925	K5 III	0.121	—
225212	3 Cet	K3 I*b*	0.228	—

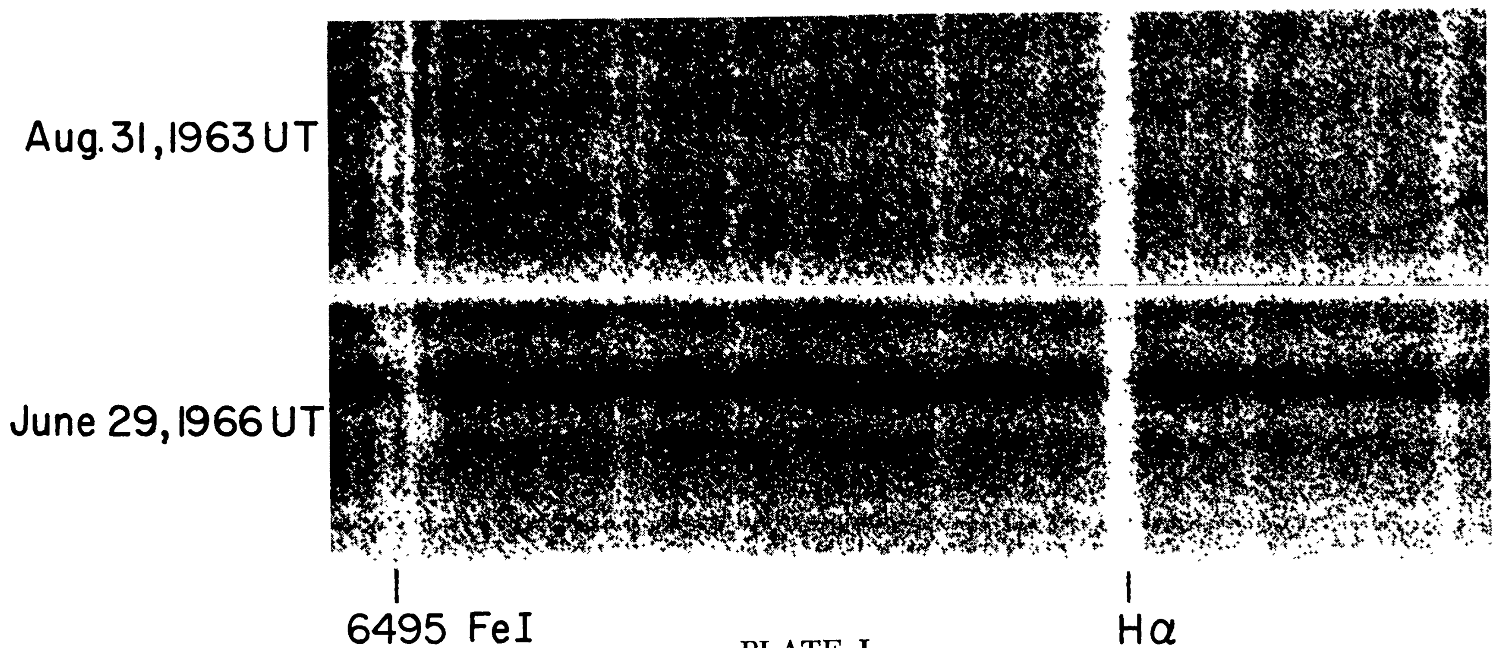

PLATE I

Spectrograms of 22 Vulpeculae showing the change in the appearance of Hα over a three-year period.

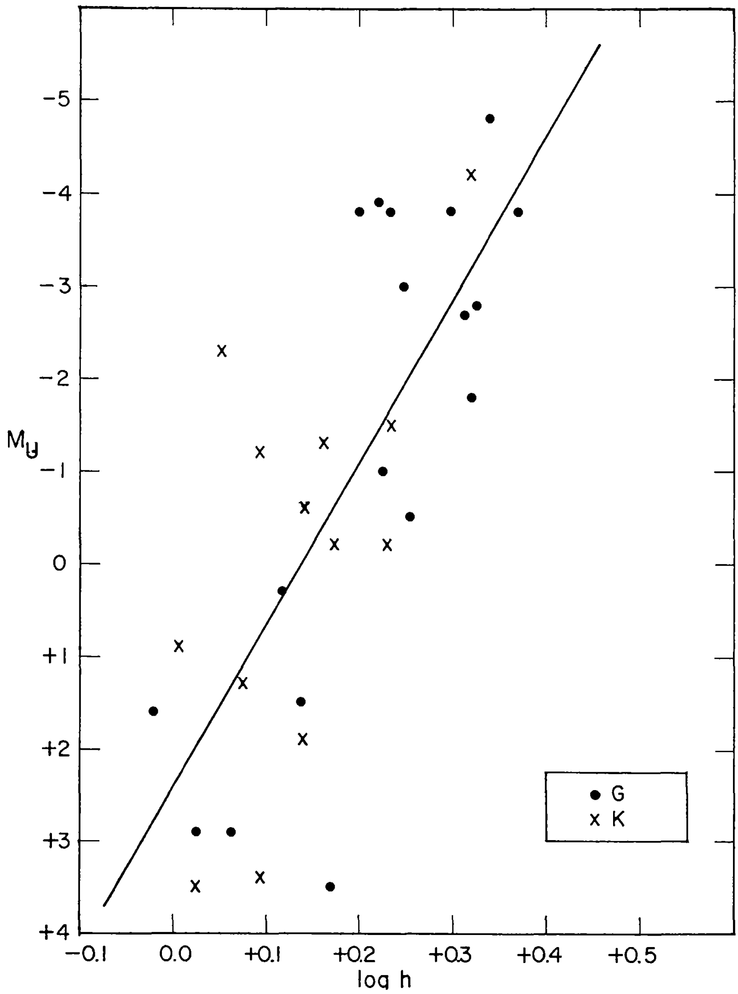

FIG. 1 — Correlation between M_U and log h for the observed stars of known M_U. As noted, G-type stars are represented by dots and K-type stars by crosses.

bility of changes in the width of Hα casts considerable doubt on the use of Hα as a luminosity criterion.

I am indebted to Dr. R. P. Kraft for the use of the spectrograms taken by him in 1963.

REFERENCES

Kraft, R. P., Preston, G. W., and Wolff, S. C. 1964, *Ap. J.* **140**, 235.
Peat, D. W. 1964, *M.N.R.A.S.* **128**, 435.
Price, M. J. 1966, *M.N.R.A.S.* **133**, 449.