EXTENSIONS OF THE WILSON-BAPPU EFFECT AMONG VERY LUMINOUS STARS

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Twenty years ago, Wilson and Bappu (1957) published their observational correlation of M_V and the logarithm of the full width at half maximum of the CaII K-line central emission for G, K and M stars. The technique was stated to have $\pm$ 0^m.5 accuracy, while a tabulation of M_V(K) by Wilson (1976) suggests the error may only be $\pm$ 0^m.3. This accuracy makes the approach valuable for late-type supergiants since other methods suffer from comparable errors. However, for F through M supergiants (Ia, O), circumstellar absorption obscures the chromospheric K-line core emission and excludes such objects from the Wilson-Bappu correlation. I report here on a new class of emission lines in late-type giant and supergiant spectra that exhibit M_V correlated widths, yet are detectable among the brightest stars.

Fosbury (1971) reported a solar-like emission line at 3935 Å in Arcturus. After finding several solar-like emission lines in the Ca II H-K wings in cool giant spectra, I examined spectra across the cooler portion of the HR diagram to delineate the empirical properties of these "H-K wing emission lines." Coude´ plates for 220 bright MK standards between F0 and M8, from dwarf to supergiant, from the collections of Hale Observatories were examined. A description of the plates and the analysis can be found in published work (Stencel, 1977a, b). Several moderate strength lines, attributable to iron-peak elements, occurring between 1 - 7 Å from the H-K line centers appear in absorption in cool dwarfs, but fill-in and vanish among giants, and are present in emission lateward of K giants, G bright-giants and F supergiants (cf. Fig. 1, Stencel 1977a). Comparable lines are found in Mira and some Cepheids. The luminosity effect described can be seen

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in Figs. 9 and 10 of the original Wilson and Bappu work (1957), and in Fig. 3 of Deutsch's (1960) work, notably just redward of the K-core emission. In summary, 24 H-K wing emission lines between 3925 - 3974 A were found which exhibit this luminosity effect (Stencel, 1977a, b).

Empirically, the H-K wing emission lines show an M_V - log FWHM correlation, although the slope of the correlation for individual H-K wing emission lines seems to depend on the square of their wavelength displacement from the CaII line centers, just as the resonance line wing opacity does. Thus, it appears that these lines arise from differing layers in the stellar atmosphere and may allow direct measure of non-thermal broadening velocity with height gradients (cf. Stencel, 1977a, b).

With this in mind, we look at the superluminous F, G, K and M stars. As a group, they show evidence for circumstellar matter and mass-loss. K-core emission is absent due to circumstellar self-absorption, but several H-K wing emission lines are unaffected due to their displacement from the line center. The wing emission at 3936 Å is a good example of this. Consider HR 2061 (α Ori, M2 Iab) and HR 8316 (μ Cep, M2 Ia). HR 2061 shows K core emission and $M_V(K) = -5\overset{m}{.}5$, while HR 8316 shows no K core emission and thus has no $M_V(K)$. Based on an M_V - width relation for the 3936 Å line, HR 8316 has $M_V(3936) = -6\overset{m}{.}9 \pm 0\overset{m}{.}9$, in agreement with other estimates. For HR 8752 (G5V Ia0), again with no K-core emission, we find $M_V(3936) = -8\overset{m}{.}2 \pm 0\overset{m}{.}7$, near Sargent's (1965) value of $-9\overset{m}{.}0$. For HR 9045 (ϱ Cas, F8 Iap), Sandage and Tammann (1974) give $M_V = -9\overset{m}{.}5$, based on uncertain membership in Cas OB5 association. I find no K-core emission, but derive $M_V(3936) = -6\overset{m}{.}1 \pm 0\overset{m}{.}5$. The discrepancy arises from non-membership or shell-episode spectral effects (Sargent, 1961). The point is: there seems to be a useful M_V -width effect which makes the H-K wing emission lines possible extensions of the Wilson-Bappu effect. With the use of low-light level spectral scanners at 1 Å resolution, these features may now be detectable in the brightest late-type stars of the Magellanic Clouds or of nearby galaxies.

In a slightly different spectral region, we find promise of additional M_V - width relations, and I am pleased to present the current state of this effect for the 2800 Å Mg II resonance line cores. This work is due to Y. Kondo and others with the SRL/NASA BUSS experiment. Earlier versions of Fig. 1 have been published (Kondo, et al. 1976a, b). Since the emission cores are clearly present in F stars, including the supergiants, there is some hope that the Mg II resonance lines in extremely luminous stars may reveal M_V information otherwise not available with the CaII resonance lines. Dr. Kondo and I are planning further UV observations along these lines.

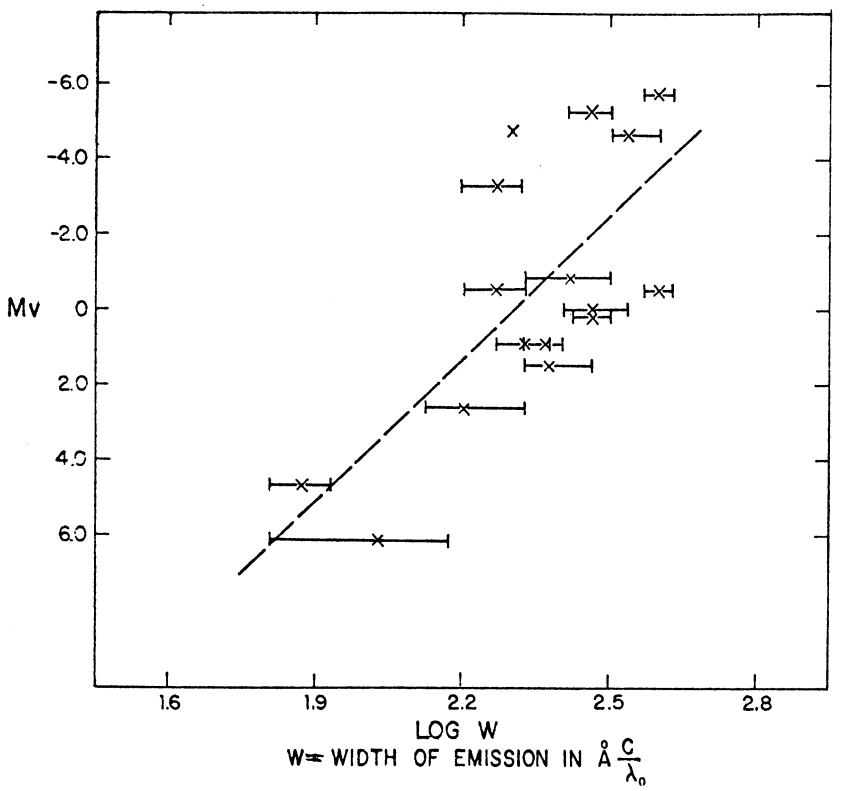

Fig. 1. Mg II core emission width versus M_V. (Kondo, Morgan and Modisette, to be published.)

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DISCUSSION

BUSCOMBE: Do you take any account of the suspected effect of stellar age on the correlation of luminosity with the shape of the H and K emission?

STENCEL: The age effect demonstrated by Wilson for the H and K emission arose from comparison of emission strengths of main-sequence stars in clusters of differing age. This age effect is not established for giants and supergiants due to the small sample. Since the H-K wing emission lines appear in giant and supergiant spectra, any age effect is not clearly delineated. However, this would be interesting to investigate. Incidentally, there may also be an abundance effect, e.g. in the Ba II stars, which can alter the strengths of these emission lines. R.A. Fesen and I are looking into these age and abundance effects.

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