Wilson-Bappu Effect: Extended to Surface Gravity

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ABSTRACT

Wilson and Bappu found a tight correlation between the stellar absolute visual magnitude (M_V) and the width of the Ca II K emission line for late-type stars in 1957. Here, we revisit the Wilson-Bappu relation (hereafter, WBR) to claim that WBR can be an excellent indicator of stellar surface gravity of late-type stars as well as a distance indicator. We have measured the width of the Ca II K emission line (log W) in high resolution spectra of 125 late-type stars, which were obtained with the BoHyunsan Optical Echelle Spectrograph (BOES) and adopted from the UVES archive. Based on our measurement of the emission line width (log W), we have obtained a WBR of M_V = 23.76 – 18.08 log W. In order to extend the WBR to be a surface gravity indicator, the stellar atmospheric parameters such as effective temperature (T_eff), surface gravity (log g), metallicity ([Fe/H]), and micro-turbulence (ξ) have been derived from the self-consistent detailed analysis using the Kurucz stellar atmospheric model and the abundance analysis code, MOOG. Using these stellar parameters and log W, we found that log g = 5.85 log W + 9.32 log T_eff - 23.48 for late-type stars.

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DATA ANALYSIS & RESULT

★ Wilson – Bappu Relation (WBR): Wilson and Bappu (1957) found a strong relationship between the absolute visual magnitude (M_V) and the width of the Ca II K emission line (log W) for late-type stars.
★ There are many precedent studies about WBR. Lutz and Pagel (1982) mentioned that there is a dependence of the WBR on stellar atmospheric parameters. Pace et al. (2003) used high resolution spectra and Hipparcos data to obtain a WBR, and they applied the WBR to estimate the distance to M67. However, WBR has not been examined explicitly to obtain stellar surface gravity.
★ In this study, we extend WBR to be an indicator of the surface gravities of late-type stars, including M-type stars.

Wilson-Bappu Relation (WBR)

Star: Bappu & Wilson (1957) introduced the WBR to late-type stars. The WBR is given as:

\[ M_V = 23.76 - 18.08 \log W \]

where M_V is the absolute visual magnitude and log W is the width of the Ca II K emission line.

The WBR was derived from the observations of 33 late-type stars. The WBR was found to be a good indicator of the stellar surface gravity.

Application of WBR to the Distance

We applied the WBR to M67 to calculate its distance modulus using the spectra from Dupree et al. (1999). Our mean distance modulus from 5 stars agrees well with previous results.

- Measure the absolute magnitude using WBR
- Calculate the distance modulus of M67
- Previous studies: 1.95 ± 0.2 mag, 9.55 ± 0.25 mag
- Mean distance modulus of 5 stars: (m-M)_0 = 9.88

Emission Width as a Surface Gravity Indicator

log W has a tight relation (WBR) with M_V, which is associated with effective temperature and stellar radius:

\[ M_V \propto \log L \propto \log T_{\text{eff}} \propto \log g \]

Because \( L \propto M_V \)
\[ M_V \propto \log W \propto \log L \propto \log g + \log T_{\text{eff}} \]

As expected, log W varies with temperature at a given gravity, as seen for log \( g_{\text{model}} \) in Fig. 6. Therefore, we take into account the relationship between log \( g_{\text{model}} \) and log W.

Application to M type stars

The surface gravities calculated with the above equation for 4 M type stars agree well with those values derived in previous studies within the standard deviation of log \( g_{\text{var}} \) (0.21 dex). Therefore, this relation can provide a simple way to calculate the surface gravity of late-type stars without using stellar atmospheric models.

REFERENCES

Lutz, T. E. & Pagel, B. E. J. 1982, MNRA, 205, 31