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Photometric and Spectroscopic Investigation of the Blazhko Star DR And: Inherent Limits of the Applicability of the Baade-Wesselink Method on Blazhko Stars

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Abstract. Utilizing photometric and spectroscopic data, we attempted to perform Baade-Wesselink analysis of a large modulation amplitude Blazhko star, DR And. The application of the method has failed because of the divergent behavior of the photometric and spectroscopic radius variations. The spectroscopic radius variation follows the observed phase modulation of the light curve, but the amplitude and phase of the photometric radius changes are marginally, if at all, affected by the modulation.

1. Data

BVI_C photometric data of DR And were collected with the 24" telescope in the course of the Konkoly Blazhko Survey in 2012. Spectra were taken with the FIES spectrograph attached to the 2.5-m Nordic Optical Telescope, at the small-amplitude phase of the modulation in 2012 and at around the predicted Blazhko maximum in 2013.

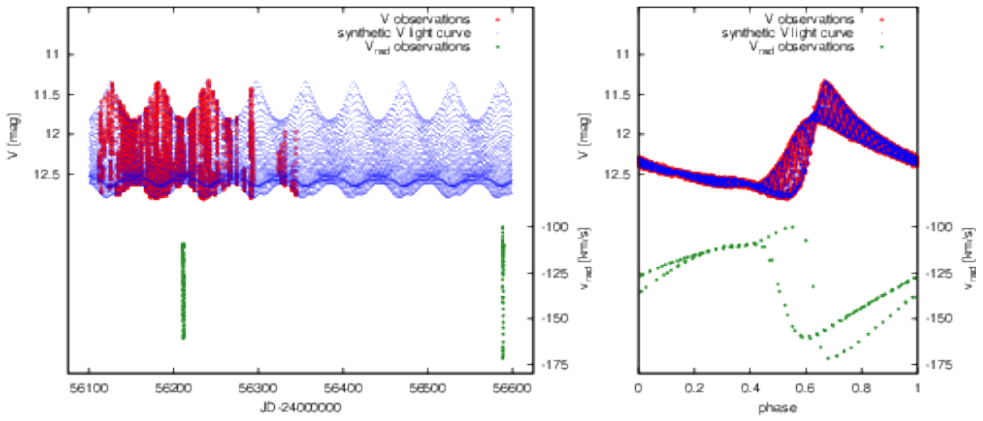

Figure 1. Time distribution of the photometric and the radial velocity observations of DR And (left) and the phased V and $V_{\rm rad}$ curves (right). The spectroscopic observations were obtained at the Blazhko minimum and the predicted maximum. The modulation of DR And is very stable, so the timing of the second spectroscopic run fits Blazhko maximum very well as the large amplitude and the phase of the $V_{\rm rad}$ observations around JD 2 456 590 indicate.

2. Results

The Baade-Wesselink method aims to determine the distance by assuming that the radius changes derived from the spectroscopic data ($R_{\rm sp}$) are equivalent to the appropriately scaled angular diameter changes measured from the photometry ($R_{\rm phot}$).

However, this assumption is not valid for Blazhko stars; the amplitudes and the phases of their $R_{\rm phot}$ and $R_{\rm sp}$ variations are different in most, but especially in the small-amplitude phases of the modulation. To resolve the amplitude differences of $R_{\rm phot}$ and $R_{\rm sp}$, different distance values should be used in different Blazhko phases, which, naturally, cannot be the case. Moreover, there is no way in the method to resolve the phase differences of the derived radius variations. Although $R_{\rm sp}$ and $R_{\rm phot}$ seems to match each other better at the large-amplitude phase of the modulation than in the small-amplitude phase, this is not true for all Blazhko stars (e.g. V130 in M3, Jurcsik & Hajdu 2017)

The stability of the photometric radius changes indicates that the observed light curve modulation of Blazhko stars is induced, primarily, by changes in the temperature variations of the pulsation. The analysis of Blazhko stars in the M3 globular cluster has led to a similar conclusion (Jurcsik & Hajdu 2017).

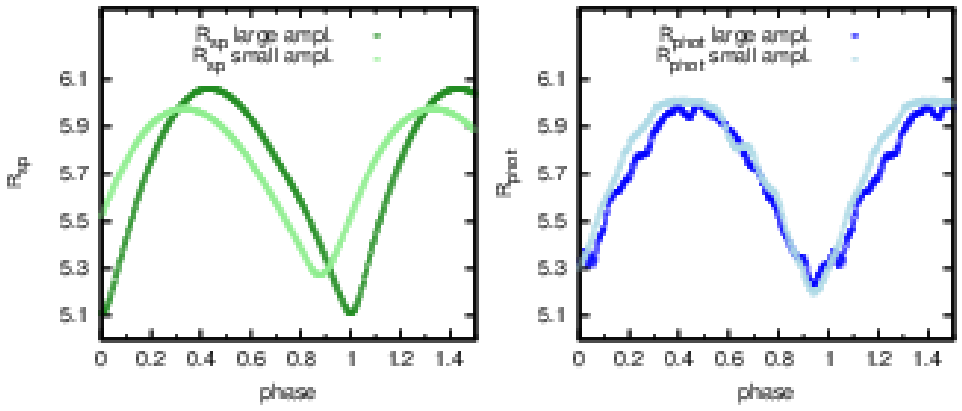

Figure 2. Comparison of the spectroscopic (left) and photometric (right) radius variations of DR And in the large- and small-amplitude phases of the modulation.

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References

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