Connection between the period and the amplitude of the Blazhko effect

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Abstract. We found a possible relationship between the modulation period and the amplitude of the Blazhko RR Lyrae stars: long modulation period generally implies high modulation amplitude while the short modulation period results in small amplitude. Although this effect is much more a tendency than a strict rule, it can be detected easily in the space-born time series data produced by Kepler and CoRoT. Good quality ground-based data show this relation, too. This phenomenon could give us constraints for the physics of the Blazhko effect.

1 Introduction

By investigating the Kepler Blazhko RR Lyrae light curves [3] we found a possible connection between the Blazhko period \(P_B\) and the Fourier amplitude of the modulation frequency \(A(f_B)\) \(P_B \propto A(f_B)\); see Fig. 9 in [3]). The literature was reviewed searching for this effect, but nothing specific was found. Two papers were published which implicitly suggest such a relation. (i) Jurcsik, Sódor & Váradi [6] found a correlation between the pulsation period \(P_0\) and the modulation amplitude of RR Lyrae stars \(P_0 \propto A_2\). Here the modulation amplitude \(A_2\) was defined as the sum of the Fourier amplitudes of the first four modulation components: \(A_2 = A(f_0 + f_B) + A(f_0 - f_B) + A(2f_0 + f_B) + A(2f_0 - f_B)\). (ii) Jurcsik et al. [7] found a correlation between \(P_0\) and the Blazhko period \(P_B\), as well \(P_0 \propto P_B\).

On the basis of these works we could deduce a possible relation between the Blazhko period and the modulation strength: viz. if \(P_0 \propto A_2\) and \(P_0 \propto P_B\) then \(P_B \propto A_2\). What is the connection between the parameter \(A_2\) and \(A(f_B)\)? As we showed in a simplified mathematical framework [2], the modulation component amplitudes in \(A_2\) depend on the strength of the frequency modulation (FM), while \(A(f_B)\) depends on the amplitude modulation (AM) only. Therefore, using \(A(f_B)\) is clearly superior in characterizing AM. There is, however, a drawback. The number of stars of known \(A(f_B)\) is small, because \(f_B\) can be detected only in space-born and the best quality ground-based data.

2 Sample and Method

We collected stars where \(A(f_B)\) are known. These stars were observed from space by Kepler [3], by CoRoT [4], [11], [5], and from the ground by the Konkoly Blazhko Survey (KBS, [8]). These different observations were obtained in different color bands (e.g. \(V, R, I, K_p\)), hampering their uniform handling. The spectral response function of the CoRoT and Kepler detectors are similar, but the CoRoT band is a bit wider than Kepler’s one [1], [12], therefore, we have to scale the CoRoT amplitudes. Nemec et al. [10] found empirical transformations between amplitudes (e.g. \(A_{tot}, A_1\)) in bands \(K_p\) and \(V\). The transformed KBS data, however, do not show a clear correlation. There is an alternate parameter for characterizing the strength of AM: the amplitude of the envelope curve \(A_{max}\). This parameter can be determined easily, but it depends also on the pulsation amplitude. We checked the ratio on KBS data

\[ A_{max} = \frac{A_{tot}}{A_{env}} \]

\[ A_{env} = \frac{A_1}{A_2} \]

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using this $A_{\text{max}}$ values and found a tight correlation between $P_B$ and $A(V)_{\text{max}}$ (see blue symbols in Fig. 1). We applied the empirical transformation formula of [10] between the total amplitude in bands $K_p$ and $V$. If we plot the result in Fig. 1. (red circles), Kepler stars show similar correlation than KBS stars. This $P_B \propto A_{\text{max}}$ ratio could be tested in the future by using massive photometric data basis (e.g. MACHO, OGLE).

3 Interpretation

Similar effect is common in hydrodynamical systems: e.g. weakly dissipating systems forced to show high amplitude by long time-scale perturbing forces only [9]. We call the reader’s attention to the deviating stars (CZ Lac, MW Lyr, BD Her and KIC 7257008 in Fig. 1 and V355 Lyr in Fig. 9 of [3]). These may represent a separate group within Blazhko RR Lyrae stars. The existence of this group can also be tested by using large data bases.

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