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Comprehensive study of changes in the pulsation period of Galactic Cepheid variables

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Investigating period changes of classical Cepheids through the framework of $O-C$ diagrams provides a unique insight to the evolution and nature of these variable stars. In this work, we carried out the $O-C$ diagram calculation of 148 Galactic Cepheids with century long coverage. In multiple cases we observed peculiar $O-C$ behaviours that indicated the possible presence of a formerly undetected companion star, either through phase jumps or slips, or through light-time effect. Some Cepheids show large amplitude period fluctuations, that cannot be explained by the current stellar evolutionary models. By estimating the pulsation period change rates we found that the number of Cepheids exhibiting decreasing period is significantly lower than those of showing increasing period, which cannot be explained solely by the difference in the number of the crossing modes. By compiling the colour-magnitude diagrams of the investigated Cepheids using the recently published \emph{Gaia} EDR3 data we found that the period change rate varies notably between the two edges of the instability strip for short period Cepheids, which indicates that the rate of period change can also provide valuable information for the determination of physical parameters. We also found that 49 Cepheids in our sample showed period fluctuations. By quantifying the strength of fluctuations we found that for long period ($P > 18$ days) Cepheids they scale linearly with the logarithm of the pulsation period, while for short period stars the fluctuation strength is seemingly independent of the pulsation period. Most notably, we found fluctuations for every pulsation period length with a clear exception for bump Cepheids, which can only be explained through a quenching mechanism, which is in agreement with the current models of radial pulsation of Cepheids.

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