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Light curve analysis of Kepler-observed eclipsing binary star systems: KIC3858884, KIC8504570, and KIC6629588

L. V. A. N. Perera,* J. Adassuriya, and K. P. S. C. Jayaratne

Astronomy and Space Science Unit, Department of Physics, Faculty of Science, University of Colombo

This investigation analysed three Kepler targets, KIC3858884, KIC8504570, and KIC6629588, which are eclipsing binaries containing Delta Scuti stars, allowing the analysis of both extrinsic and intrinsic characteristics. The main objective was to probe the g-modes of these and understand essential interior stellar parameters such as overshooting, mixing length, and chemical composition. The light curves of the star systems were analysed using Kepler's photometric data. Binary signatures in these light curves were eliminated by disentangling eclipses from pulsations using the PYWD2015 binary light curve modelling tool. The process of eliminating binary characteristics involved selecting the most accurate binary parameters through iterative differential corrections, aiming to minimize the differences between observed light curve data and the modelled binary light curve. The residual data were subjected to Discrete Fourier Transform, allowing them to be decomposed into their constituent frequency components. Only frequencies with a signal-to-noise ratio (S/N) ≥ 4 were considered for analysis. Prior to probing the g-modes, dominant radial and non-radial pressure modes and their combinations and harmonics were removed. The g-modes for each star system were identified within the frequency range of 0.3 to 3.0 cycles per day. This study confirmed seven g-modes for KIC 8504570, fourteen g-modes for KIC 3858884, and nine g-modes for KIC 6629588. After identifying the g-modes of these star systems, evolutionary tracks representing the life cycle of each star were modelled using MESA code. The best-fitted track for each star in the binary star systems was selected as the one spending most of its lifetime within the observed temperature and luminosity region. According to the best-fitted evolutionary tracks, the primary star and the secondary star of KIC 8504570 possess stellar masses of 1.65 ± 0.05 $M_\odot$ and 0.95 ± 0.05 $M_\odot$ respectively. For KIC 3858884, findings indicate stellar masses of 1.95 ± 0.05 $M_\odot$ and 1.90 ± 0.05 $M_\odot$ for its binary components. In the case of KIC 6629588, the analysis points to stellar masses of 1.60 ± 0.05 $M_\odot$ for the primary star and 0.45 ± 0.05 for the secondary star. The evolutionary tracks indicate that the primary stars of KIC 8504570 and KIC 6629588, both binary components of KIC 3858884, are Delta Scuti stars, as they reside within the instability region on the H-R diagram. The secondary stars of KIC 8504570 and KIC 6629588 are non-variable and do not contribute to brightness variations through pulsations. The study has the potential to further computational simulations of the g-modes exhibited by these stars and explore their interior properties.

Keywords: g-modes, eclipsing binaries, Delta Scuti stars, evolutionary tracks

E-mail: nathaliperera16@gmail.com