Comm. in Asteroseismology,
Vol. 159, 2009, JENAM 2008 Symposium № 4: Asteroseismology and Stellar Evolution
S. Schuh & G. Handler

Mapping pulsations on rapidly rotating components of eclipsing binaries

B. I. Bíró [1] and O. Latković [2]

[1] Baja Astronomical Observatory, H-6500, Szegedi út, P.O. Box 766, Baja, Hungary
[2] Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia

Abstract

We report on the progress in the development of an eclipse mapping method for reconstruction of non-radial pulsation patterns on components of eclipsing binaries. In this paper we present our attempts to use the method on distorted modes caused by rapid rotation, and we estimate that it can properly detect this phenomenon.

Introduction

In previous publications (Bíró & Nuspl 2005, Latković & Bíró 2008) we have presented the development of the eclipse-mapping method for reconstruction of surface patterns of non-radial oscillations on pulsating stars in eclipsing binaries. So far, the method was tested on artificial light curves computed for a simple model: spherical stars, circular orbit and monochromatic radiation. It was proven that, in principle, many simultaneous non-radial oscillation modes can be reconstructed to a degree that allows mode identification, provided that enough and precise observational data are available. The goal of our most recent work is to prepare the method for application to real data. As a first step in this direction, we have tested whether the method can detect the mode distortion effect, which is expected in rapidly rotating stars.

Binarity, pulsation and rapid rotation

The effects of rapid rotation on stellar pulsations have recently been reconsidered by Ligniéres et al. (2006). Their scheme applies especially to p modes of δ Scuti stars, the most frequent type of pulsators found in eclipsing binaries. They show that the validity of the perturbative approach to analysis of pulsations becomes questionable already at modest rotational velocities of 50 km/s. δ Scuti stars generally rotate even faster, up to 200 km/s (Rodríguez et al. 2000). In addition, tidal synchronization in eclipsing binary systems also enforces large rotation on the components of any type – therefore the need to account for rotationally distorted modes.

As shown by Ligniéres et al. (2006), the most important effect of rapid rotation on a pulsation mode is the concentration of the amplitude towards the equator. This effect increases with the frequency of the mode and drastically changes its visibility in integrated light. This is good news for eclipse mapping, since modes with degrees up to $l = 4$ become photometrically detectable, and thus can be reconstructed.

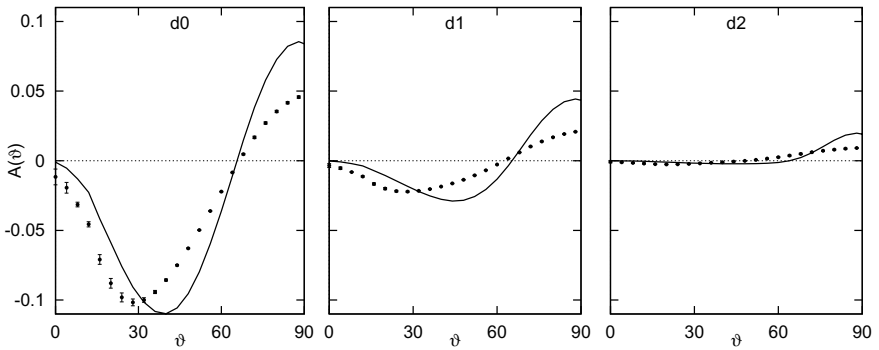

Figure 1: Reconstructed amplitude profiles of an $l = 4$, $m = 2$ mode as a function of co-latitude, for three levels of distortion (d_0 being the "no distortion" case). The model profiles are plotted with solid lines, and the reconstructed profiles with dots. Note how the response factor increases with the distortion: the three cases yield the same out-of eclipse oscillation amplitude in the light curve.

Results

We have tested the method on a number of artificial eclipsing binary systems, with different pulsation modes. For demonstration here we chose a model with stellar radii $r_1 = 0.14$ and $r_2 = 0.36$ (in units of separation), inclination of 80^o, and one single mode with $l = 4$ and $m = 2$. Since the mode distortion becomes significant even at relatively low rotational velocities, we did not alter the spherical shape of the pulsator. Having no analytical expression for the mode distortion, we used an empirical approach that roughly reproduces the equatorial amplitude concentration, since the main purpose of this study is only to check whether such a kind of deviation from spherical harmonics can be detected by the eclipse-mapping method.

Figure 1 shows the amplitude profiles on the northern hemisphere for three levels of distortion. The phase profiles (omitted for brevity), show no difference in the three cases, and are properly restored (as expected given the good longitudinal resolution of the eclipse's surface sampling), yielding the correct $m = 2$ order.

Conclusions

Our investigation shows that for all modes for which the rotational distortion produces sensible changes in the modulation of the pulsations during the eclipses, the distortion of the modes can be detected and, in principle, properly restored by the Eclipse Mapping method.

Acknowledgments. This work was supported by Hungarian OTKA Grant No. F-69039 and by the Ministry of Science and Technological Development of Serbia through project no. 146003, "Stellar and Solar Physics".

References

Bíró, I. B., & Nuspl, J. 2005, ASP Conf. Ser., 333, 221

Latković, O., & Bíró, I. B. 2008, CoAst, 157, 330

Ligniéres, F., Rieutord, M., & Reese, D. 2006, A&A, 455, 607

Rodríguez, E., López-González, M. J., & López de Coca, P. 2000, A&AS, 144, 469