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Hunt for Binaries with Pulsating Components

Olivera Latković

Astronomical Observatory, Belgrade, Serbia
email: olatkovic@aob.bg.ac.yu

Abstract. In the frame of the collaboration of several Southern European observatories, we are examining a number of eclipsing binary systems in search for evidence of pulsating phenomena. We hope our candidate systems will be suitable for subsequent astroseismological studies. As a first step towards this end, we are analyzing spectroscopic observations of several such binary stars; these observations have been made at the National Astronomical Observatory Rozhen, Bulgaria, in the period from 2002 to 2005, and the reduction was done at the Astronomical Observatory of Belgrade, Serbia. The measurements of radial velocities and RV curve analysis are in preparation.

Keywords. stars: binaries: eclipsing, stars: oscillations

1. Introduction

The aim of the collaboration of some Southern European astronomical institutions (see appendix A for the list of host institutions) is to bring together as many scientists as possible to join their effort and exchange experience, as well as to create opportunities for students to visit their neighboring countries either to carry out observations, or to discuss their scientific problems with experts. Each of the scientific teams has rich experience in the field of eclipsing binaries, but every team has experts in different specific subjects (theory, observations, data reduction, modeling etc), so this cooperation is aimed to open possibilities for research on a greater scale than any of the individual institutes could carry out on their own.

This international effort will be realized trough the "Eclipsing Binary and Pulsating Stars" project. While the goals set for this project are many and as diverse as its name suggests, they can be condensed in three broad categories that will be introduced in the first part of this paper: search for pulsating variability, determination of physical parameters, and astroseismological study of pulsating stars in eclipsing binary systems. The second part of the paper presents the results that have been obtained so far.

2. The "Eclipsing Binary and Pulsating Stars" project

Pulsating variability in stars that are members of eclipsing binary systems, can be directly discovered by detection of low amplitude quasi-periodical variations in the system's light-curve. Potential targets can also be selected based on the location of their components on the HR diagram. Among many systems with these properties the primary targets will be those systems that are bright enough for successful spectroscopy with available 1- to 2-m telescopes.

Acquiring a sample of systems that are known or suspected to have a pulsating component, will be followed by an effort to find physical parameters of these systems and

their components. Determination of absolute parameters requires a combination of spectrometric and photometric measurements; photometric observations can be taken on the smaller instruments available in the region, while the spectroscopy has so far been done with the Bulgarian 2-m telescope at Rozhen.

The study of stellar oscillations is virtually the only reliable tool for "getting inside stars", that is, obtaining knowledge of stellar interiors. However, this methodology requires precise identification of the oscillation modes which has been done in only a few cases (one example is the Sun, whose proximity allows direct observation of the surface distribution of each mode). Having a pulsating star in an eclipsing binary system is an opportunity to solve the mode identification problem. The mutual eclipses of components provide effective sampling of their surfaces and an estimation of the original brightness distributions can be made using eclipse mapping technique. Surface brightness distribution of the pulsating component can then be used to identify oscilation modes (Bíró & Nuspl 2005).

3. Work done so far

3.1. *Observations*

Spectroscopic observations of the following objects were made at NAO Rozhen from 2002 to 2005: HS Her, RX Her, V994 Her, AS Cam, and EK Cep. The observations were made in following spectral regions: around the Na D1/D2 (5889.95/5895.92 Å) lines, and around the Mg II (4481.15 Å) line.

Reduction of data was done at the Astronomical Observatory in Belgrade. We used IRAF software for standard CCD reduction, including wavelength callibration, continuum normalization and corrections for radial velocity of Earth's motion. The reduction was carefully standardized and hopefully in the future it will turn into a semi-automated pipeline.

Identification of lines has already been done by the team at the Astronomical Observatory in Belgrade (Lalović *et al.* 2006), but even so, few lines proved to be suitable for taking RV measurements. We used prominent lines of neutral helium (5875.62 Å) and ionized silicon (5957.56 Å) in the Na D1/D2 region, and the lines of neutral helium (4471.48 Å) and unresolved ionized magnesium lines (4481.13 Åand 4481.32 Å) in the Mg II region.

3.2. *Measurements*

We have begun measurements of radial velocities by calculating shifts of spectral lines. However, the results of these measurements are not yet ready for publication. Because of the small number of available lines and inherent uncertainty of line identification, we estimate that the accuracy of thus obtained radial velocities will not be very high. But preparations are underway to measure radial velocities using cross-correlation, which is expected to yield more reliable results. After obtaining radial velocity curves, determinations of mass ratios and orbital parameters will be made trough modeling.

4. Summary

The study of pulsating components in eclipsing binaries will contribute profoundly to the development of astroseismology. Binary systems have two main advantages:

a) absolute stellar parameters can be readilly determined for their components, and

b) the eclipse phenomenon allows a detailed analysis of the pulsations, increasing possibility of mode identification.

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Determination of stellar parameters requires both photometric and spectroscopic measurements, and the first steps in that direction are being made in the form of image reduction and radial velocity measurements for target objects.

Appendix A. Astronomical institutions hosting the project

(1.) Dept. Astrophysics, Astronomy & Mechanics, Faculty of Physics, Athens Univ.
Panepistimiopolis, Zografos 157 84, Athens, Greece

(2.) Astronomical Institute, Romanian Academy of Sciences
Str. Cutitul d'Argint 5, 75212 Bucharest 28, Romania

(3.) Baja Astronomical Observatory
6500 Baja, Pf: 766, Hungary

(4.) Astronomical Institute of the Bulgarian Academy of Sciences
72 Tsarigradsko chaussee, 1784 Sofia, Bulgaria

(5.) Astronomical Observatory
Volgina 7, 11000 Belgrade, Serbia

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