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A study of a spot migration in two contact binaries: KIC 2159783 and KIC 6118779

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Abstract. Data of contact binaries, provided by the Kepler spacecraft, can be successfully applied to estimate the parameters of a binary system only if its light curve has a flat-bottom secondary minimum. The derived system parameters are accurate enough to search for a spot migration using the Wilson-Devinney code. For binaries with a regular activity (e.g. KIC 6118779) the numerical spot modeling is consistent with a model-independent light curve morphology analysis. Finally, we proved that spot migration cycles established by the Wilson-Devinney modeling correspond to the O'Connell effect and maxima separation methods.

Key words: stars – contact binaries – star spots

1. Introduction

A presence of a stellar spot complicates an orbital solution by adding four extra parameters (temperature, size, longitude and latitude). We can greatly improve our determination of system parameters, if some of them (e.g. mass ratio q) can be independently obtained. Terrell and Wilson (2005) showed that a mass ratio can be determined if there is a flat bottom minimum in the light curve. Our aim was to establish a reliable solution of system parameters and search for a possible spot migration in two binaries showing total eclipses. For this purpose we chose KIC 2159783 and KIC 6118779, both exhibiting intrinsic light curve variations. Besides the numerical modeling, we have performed a new, model-independent analysis based on the light curve morphology. We have analyzed the evolution of the O'Connell effect and the evolution of maxima separation, which are connected with the spot migration in a straightforward way.

2. Data

The Kepler spacecraft has continuously probed several hundred contact binaries over the last four years. In this work we used long cadence (30 min sampling) Kepler data collected during Q1-16. First, we stitched and de-trended Q1-Q16 data of our two targets. Then, we divided them into bins of eight orbits wide. Finally, we phased the data. Such data chunks (epochs) are sampled dense enough to perform the modeling by means of the Wilson-Devinney (W-D) code (Wilson, Devinney 1971, Zola, Kolonko, Szczech 1997).

3. Results

3.1. KIC 2159783

Our numerical modeling of Q1-Q12 data clearly showed a spot migration between epochs 180-200, leaving the other epochs with irregular spot behavior. The O'Connell effect has a slow rising trend on a time scale of years with short time scale variations of a quasi-periodic nature. Maxima separation becomes regular shortly between epochs 170-240.

3.2. KIC 6118779

The second binary could be considered as a benchmark of the systems with migrating regular spots. Our W-D modeling showed a steady, monotonic migration of a spot along the stellar longitude with a period between 40 and 50 epochs. Simultaneously, the O'Connell effect evolves regularly with a period of about 45 days. The maxima separation have cyclic variation with a period of 44 days. Apparently, the spot undergoes transitions around epochs 120 and 400. These events may be explained by spots re-emergence.

4. Summary

Our analysis proved that using Kepler data, it is possible to reliably determine system parameters of contact binaries which show flat-bottom minima in their light curves. Such parameters are accurate enough to perform a further numerical modeling of the spot migration with the W-D code. In contact binaries with regular activity, a spot migration can also be found using model-independent methods. These results are fully consistent with a numerical modeling. Since a migration of a spot may be an indication of stellar activity, analyses of contact binaries observed with the Kepler spacecraft are highly encouraged.

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