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V421 Pegasi: a detached eclipsing binary with a possible γ Doradus component

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HIGHLIGHTS

- We present first detailed analysis of eclipsing binary V421 Pegasi.
- The system is a detached EB, formed by F1 V + F2 V components.
- We estimated reddening, absolute dimension and distance of the system.
- Primary component is a gamma doradus variable candidate.

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ABSTRACT

We present spectroscopic and photometric study of V421 Peg. This eclipsing binary displays lines from both components that are well separated. This allowed us to classify the primary and secondary component as F(1 ± 0.5) *V* and F(2 ± 0.5) *V*, respectively. We use our radial velocity measurements together with *Hipparcos* and ASAS photometry and apply simultaneous analysis, which yields masses and radii of the primary and secondary components as $M_1 = 1.594 \pm 0.029$ $M_\odot$, $M_2 = 1.356 \pm 0.029$ $M_\odot$ and $R_1 = 1.584 \pm 0.028$ $R_\odot$, $R_2 = 1.328 \pm 0.029$ $R_\odot$, respectively. Positions of the components in HR diagram suggest that the primary component is a γ Doradus variable candidate. Spectroscopic and photometric properties of the system indicates reddening value of $E(B-V) = 0^m.021$ which puts the system to the distance of 158 ± 4 pc.

1. Introduction

V421 Peg (ASAS 000702+2250.7, BD+22° 4955, Tycho 1729-206-1, $V = 8^m.28$, $(B-V) = 0.370$) was discovered to be an eclipsing binary of F spectral type, with a variability period of 1.54 d by the *Hipparcos* satellite (ESA, 1997). Since then, V421 Peg was the subject of several extensive studies based on ground-based photometric surveys, such as ASAS-3 (Pojmanski, 2002), NSVS (Woźniak, 2004), and SuperWASP.[1] Otero (2007) first displayed ASAS and *Hipparcos* light curves and listed new light elements of the system. In the plotted light curves, eclipses occur in 0.0 and 0.5 orbital phase indicating circular orbit. Its components do not show intrinsic variability, they are well separated and well within their Roche lobes, which values them proper tests for stellar models.

Several times of minima for V421 Peg have appeared in the literature, but no radial velocity measurements and related analysis have been published. The aim of this work is to obtain the absolute parameters of the system. Along the next section we first present our spectroscopic data and the set of light curves. The spectra allowed us to construct the radial velocity curve and derive the orbital parameters, as well as to estimate the spectral types for both components. Then, using the results from the spectroscopy together with the photometric data, we could determine the rest of the parameters of the system.

2. Spectroscopic observations and data reductions

Spectroscopic observations were performed with the FRESCO échelle spectrograph at the 91-cm telescope of Catania Astrophysical Observatory. The spectrograph was fed by the telescope through an optical fiber (UVNIR, 100 µm core diameter) and was located in a stable position in the room below the dome level. Spectra were recorded on a CCD camera equipped with a thinned back-illuminated SITe CCD of 1024 × 1024 pixels (size 24 × 24 µm^2). The resolution is 24,000, as deduced from the full width at half-maximum of the lines of the Th–Ar calibration lamp. The spectra cover the wavelength range from 4300 to 6650 Å, split into 19 orders. In this spectral region there are several lines useful

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[1] http://wasp.cerit-sc.cz/ .

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1384-1076/

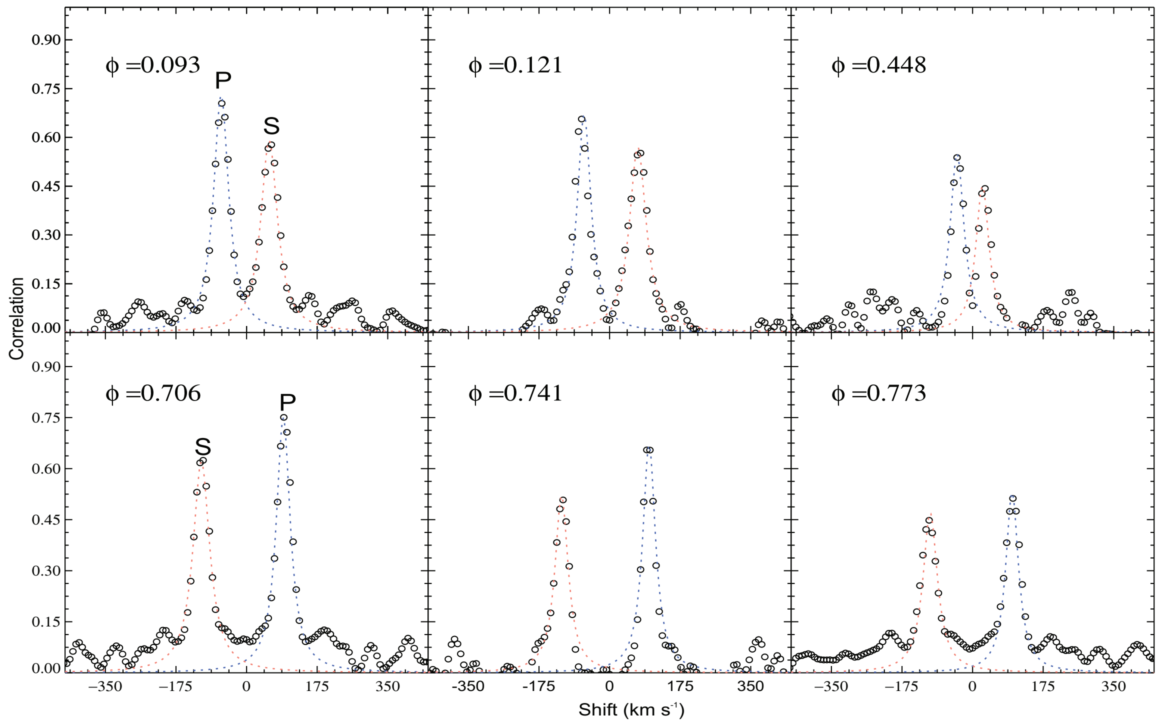

Fig. 1. Sample of CCFs between V421 Peg and the radial velocity template spectrum around the first and second quadrature. Dotted lines show the resulting fit of Gaussians to the line profile with letters indicating each component.

for measuring radial velocity and for the star classification, mainly located in the blue portion of the spectrum.

Eleven spectra of V421 Peg were collected during the 22 observing nights in the observational season in 2008. Typical exposure times were between 2400 and 3600 s. The signal-to-noise ratio (S/N) achieved was between 80 and 130, depending on the atmospheric conditions. α Lyr (A0V), 59 Her (A3IV), 50 Ser (F0V) and ι Psc (F7V) were observed during each run as radial velocity standard stars. The slowly-rotating star HD 27962 (A2IV) was observed as a template for the measurements of rotational velocity. The average S/N at continuum in the spectral region of interest was 170–350 for the standard stars.

The data reduction was performed using the echelle task of IRAF[2] ECHELLE PACKAGE (Simkin, 1974) following the standard steps: background subtraction, division by a flat-field spectrum given by a halogen lamp, wavelength calibration using the emission lines of a Th–Ar lamp, and normalization to the continuum through a polynomial fit. Heliocentric corrections were computed using the IRAF RVSAO.BCVCORR routine and were taken into account in the subsequent radial velocity determination.

2.1. Radial velocity analysis

To derive the radial velocities of the components, the 9 FRESCO spectra of the eclipsing binary were cross-correlated against the spectrum of ι Psc, a single-lined F6V star, on an order-by-order basis using the FXCOR package in IRAF (Tonry and Davis, 1979). The majority of the spectra showed two distinct cross-correlation peaks in the quadrature, one for each component of the binary. Thus, both peaks were fitted independently in the quadrature with a *Gaussian* profile to measure the velocity and errors of the individual components. If the two peaks appear blended, a double Gaussian was applied to the combined profile using *de-blend* function in the task. For each of the nine observations we then determined a weighted-average radial velocity for each star from all orders without significant contamination by telluric absorption features. Here we used as weights the inverse of the variance of the radial velocity measurements in each order, as reported by FXCOR.

We adopted a *two-Gaussian* fit algorithm to resolve cross-correlation peaks near the first and second quadratures when spectral lines are visible separately. Fig. 1 shows examples of cross-correlations obtained by using the largest *FWHM* at nearly first and second quadratures. The two peaks correspond to each component of the system. The stronger peaks in each CCF correspond to the more luminous component which has a larger weight into the observed spectrum.

The heliocentric radial velocities for the primary (V_p) and the secondary (V_s) components are listed in Table 1, along with the dates of observations and the corresponding orbital phases computed with the new ephemeris given in previous section. The

Table 1
Heliocentric radial velocities of V421 Peg. The columns give the heliocentric Julian date, orbital phase and the radial velocities of the two components with the corresponding standard deviations (in km s^{-1}).

HJD 2400000+	Phase	Primary		Secondary	
		V_p	σ	V_s	σ
54639.5768	0.1205	−71	1	75	2
54640.5866	0.4475	−31	1	34	2
54641.5911	0.7728	92	1	−113	1
54642.5803	0.0932	−55	1	61	3
54644.5808	0.7411	92	1	−115	1
54647.5593	0.7058	89	1	−111	2
54649.5758	0.3589	−76	2	85	3
54651.5610	0.0019	−5	2	–	–
54661.5501	0.2371	−100	1	110	1

[2] IRAF is distributed by the *National˜Optical˜Astronomy* Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under cooperative agreement with the National Science Foundation.