THE FIRST LIGHT CURVE ANALYSIS OF MARGINALLY ECLIPSED BINARY KZ Vir USING TESS DATA

Binary and Multiple Stars in the Era of Big Sky Surveys
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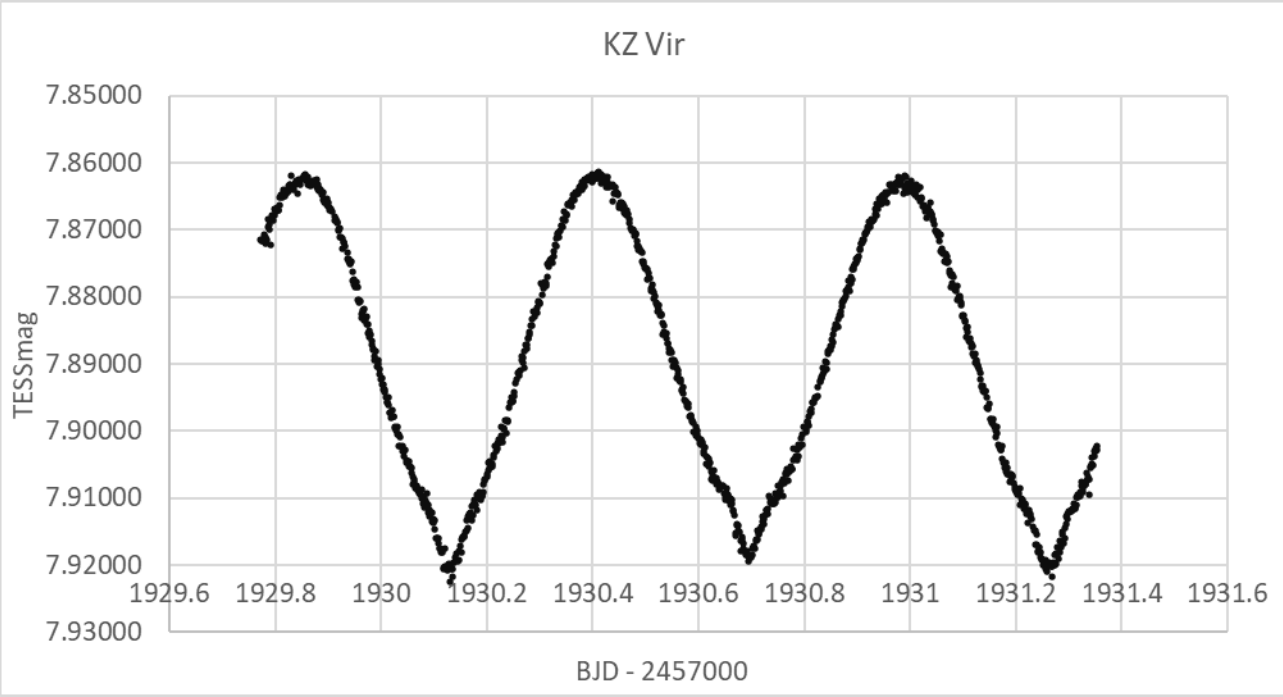
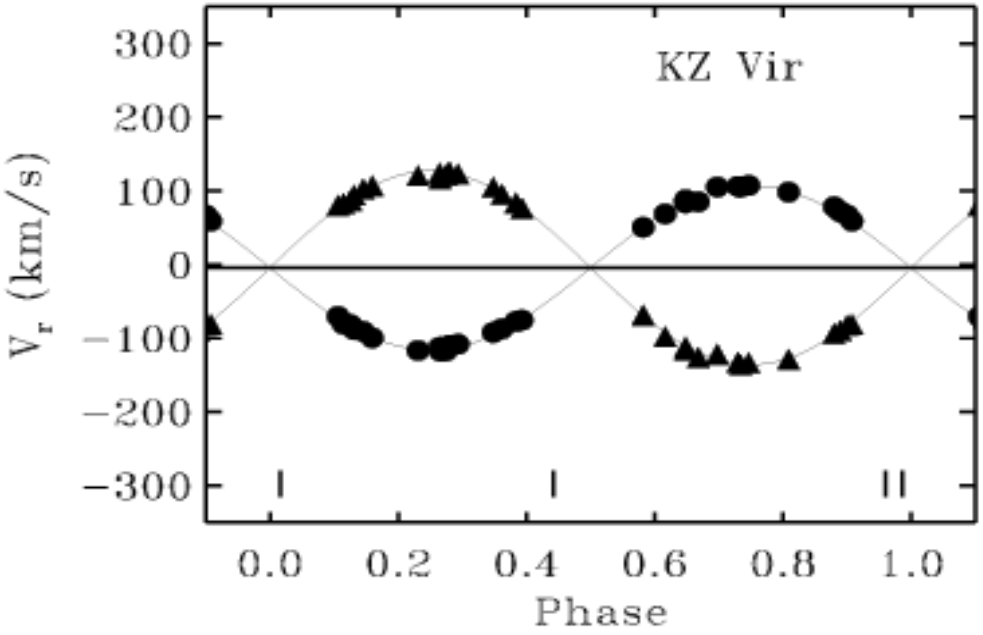
The KZ Vir binary system exhibits a low-amplitude light variation (~$0^m.06$).

So there is no ground-based light curve.

Thanks to TESS data as the light curve was observed for the first time (2020).

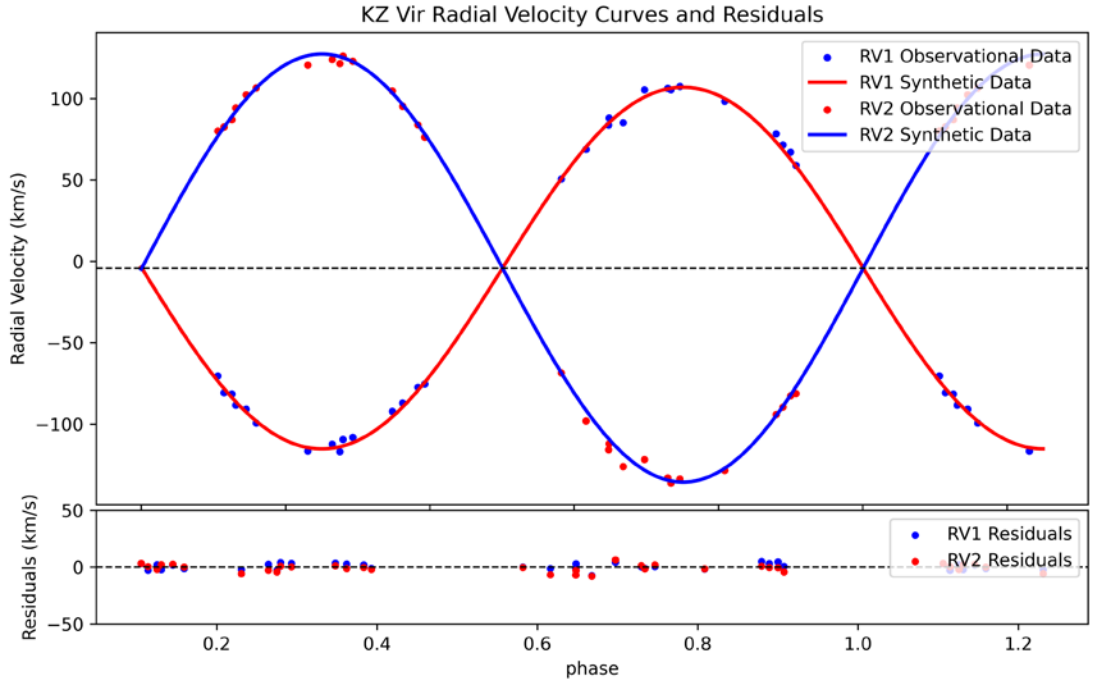


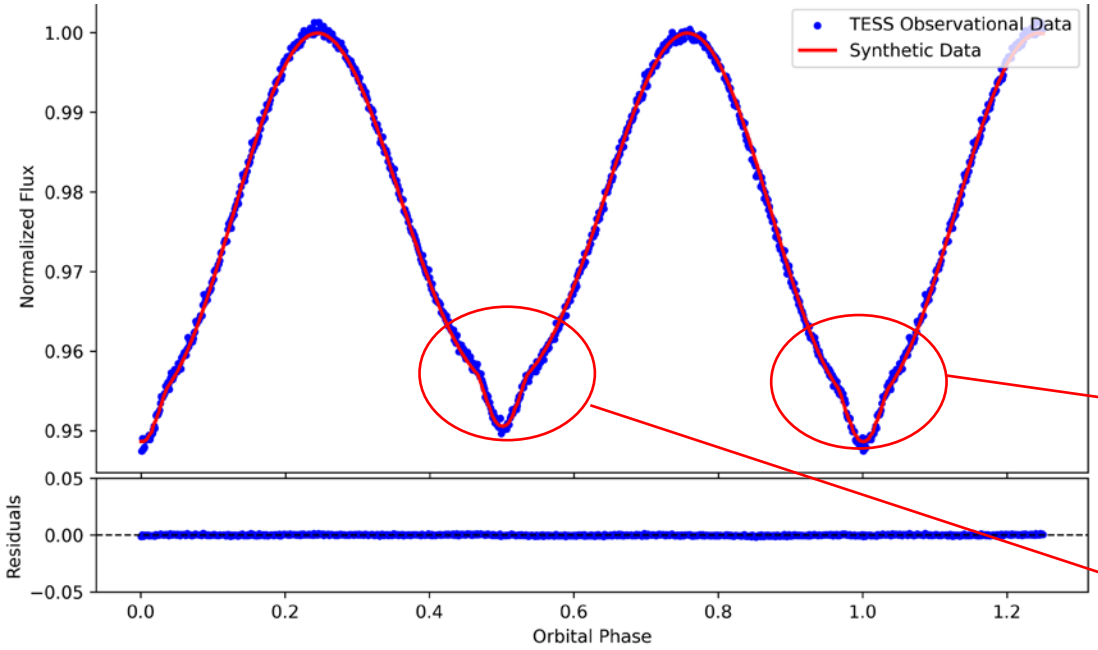
KZ Vir's radial velocity data was already available (Rucinski et al. 2001).



"So, we combined these two data sets and performed a simultaneous light curve analysis.

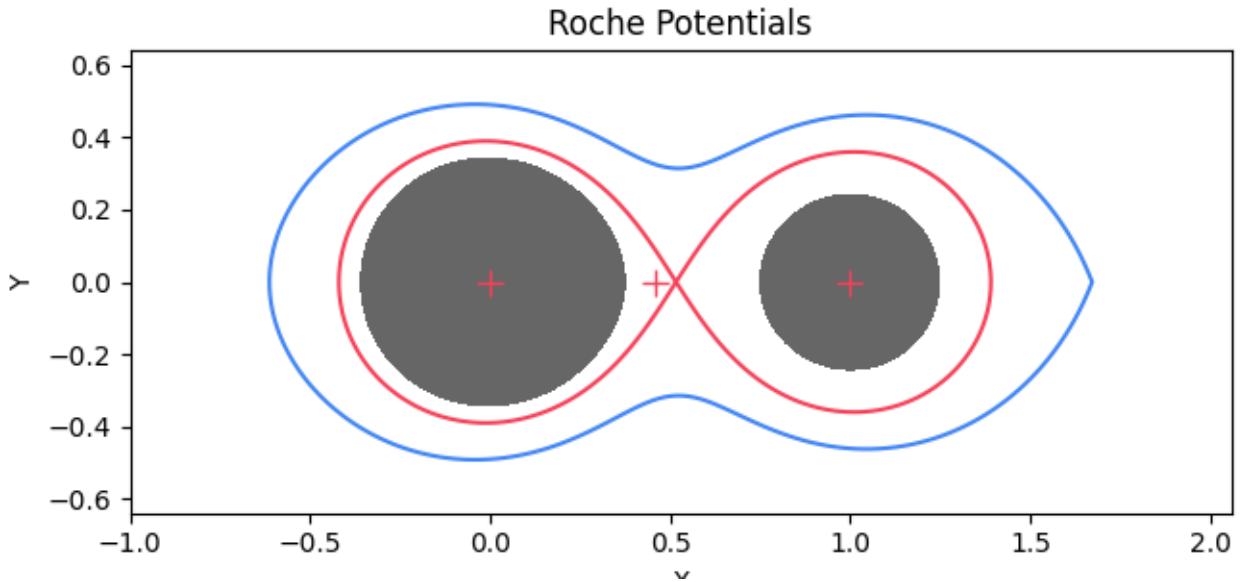
We performed analysis PyWD2015 (O. Güzel and O. Özdarcan, 2020)



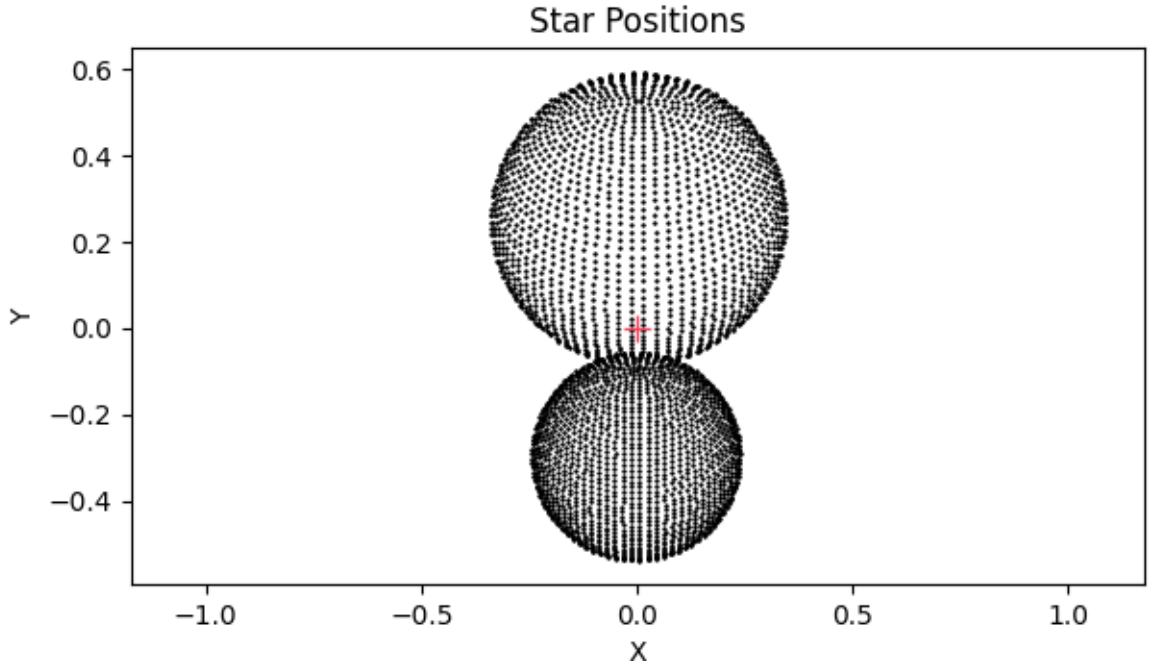


The large light variation due to the distortion of the star(s).

The effect of the eclipse



The out off eclipse variation is also supported by the Roche geometry of primary



The 3D representation of the stars obtained from the analysis

The absolute parameters of KZ Vir

Parameter	Value	Parameter	Value
i [°]	56.69 ± 0.78	M_1 $[M_\odot]$	1.59 ± 0.03
$a[R_\odot]$	6.537 ± 0.028	M_2 $[M_\odot]$	1.35 ± 0.04
V_γ [km/s]	-4.18 ± 0.41	R_1 $[R_\odot]$	2.24 ± 0.01
$q = M_2/M_1$	0.850 ± 0.003	R_2 $[R_\odot]$	1.58 ± 0.02
T_1 [K]	6436	$L_1[L_\odot]$	7.72 ± 0.09
T_2 [K]	6471 ± 10	$L_2[L_\odot]$	3.94 ± 0.11
Ω_1	3.840 ± 0.006	$\log g_1$ [cgs]	3.938 ± 0.003
Ω_2	4.620 ± 0.017	$\log g_2$ [cgs]	4.168 ± 0.004

… for more details in our poster. Thanks for attention

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The First Light Curve Analysis of Marginally Eclipsed Binary KZ Vir Using TESS Data

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What is this study about?

In this study, we simultaneously analyzed the light curve and radial velocity curves of the KZ Vir binary system for the first time to determine the absolute parameters of its component stars. Additionally, we discuss the evolutionary status of these stars based on the parameters we obtained.

Keywords: Binaries: close, Binaries: eclipsing, Stars: individual (KZ Vir), Stars: fundamental parameters.

Why did we do this study?

Binary stars play a crucial role in stellar astrophysics. Through simultaneous analysis of light and radial velocity curves, key parameters (e.g., orbital inclination, masses, radii, and temperatures of the component stars) can be determined. These parameters are essential for providing reliable data for statistical studies of both single and binary stars, enabling more accurate predictions about stellar structure and evolution. KZ Vir (HD 114726) was first noticed by [4] to exhibit light variation; however, due to its low light variation amplitude (0.05 magnitudes), its period and light curve could not be determined. The spectral type of the system was identified as F3V [5], and it was classified as a suspected eclipsing binary based on Hipparcos observations [6]. The first radial velocity study in the literature was performed by [1] and the spectroscopic mass ratio of the system was determined as 0.848[8]. This study also emphasized that the system is unlikely to be a contact binary and that both components may be distorted detached stars. They attributed the low light variation amplitude to the system's low orbital inclination. Finally, a statistical study using the light curve characteristics and spectral types [7] suggested that the system is likely a detached system with main-sequence components. Although it is a relatively bright system, there is no ground-based light curve in the literature. Finally, thanks to the TESS space telescope observations, a light curve was obtained for the first time. Thus, this enabled us to analyze the system using both the light curve and the radial velocity simultaneously.

Data and Methods

The TESS light curves used in this study were obtained from the MAST database, and the radial velocity data were taken from [1]. We conducted a simultaneous analysis of KZ Vir's light and radial velocity curves using the PyWD2015 code [2], which was developed in Python and is based on the 2015 version of the Wilson-Devinney (WD) code [3] with a graphical user interface (GUI).

Analysis

During the analyses with PyWD2015, Mode-2 for detached systems was used, as suggested by [1] and [7]. The effective temperature of the primary component was fixed to $T_1 = 6436K$, as provided by [8]. The gravity darkening and the albedo coefficients were set to 0.32 and 0.5, respectively. The limb darkening coefficients were interpolated automatically from the van Hamme tables under the linear-cosine law assumption. We adjusted the effective temperature of the secondary component (T_2), orbital inclination (i), surface potential of components (Ω_1, Ω_2), the system mass ratio (q), the luminosity of the primary component (L_1), semi-major axis (a), and the gamma velocity (V_γ) during the simultaneous analysis.

Due to the time difference between the radial velocity data (2000) and the light curve data (2020), both datasets were phased using different light elements, as given in equations 1 [1] and equations 2 [9], respectively.

$$HJD_{Mid} = 2451414.7848(11) + 1^d.131820(6) \times E. \quad (1)$$

$$HJD_{Mid} = 2458930.13012(5) + 1^d.13178(6) \times E. \quad (2)$$

The radial velocity curve and light curve analyses are presented in Figures 1 and 2, respectively. Figure 3 shows the graphic representation of the model, and Figure 4 illustrates the evolutionary status of the components. The obtained parameters are listed in Table 1 in the Results section.

Results

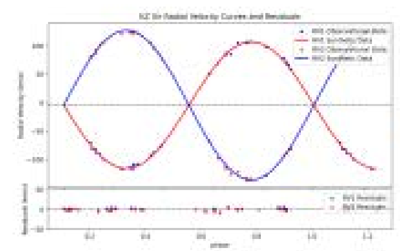

Figure 1: The upper panel shows RV curves from [1] of the KZ Vir system (red and blue dots) and RV fits with PyWD2015 (red and blue lines). The bottom panel shows the the residuals of the data from the model.

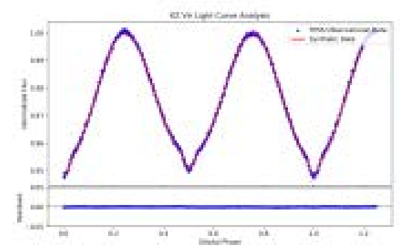

Figure 2: The upper panel shows LC curves from TESS of the KZ Vir system (blue dots) and LC fits with PyWD2015 (red line). The bottom panel shows the the residuals of the data from the model.

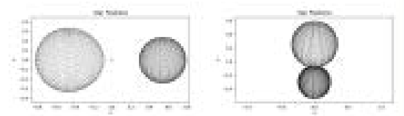

Figure 3: The graphic representation of the model at orbital phase 0.25 (left panel) and phase 0.0 (right panel) is shown.

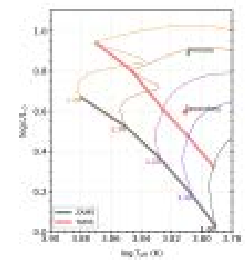

Figure 4: The positions of the components of KZ Vir on H-R diagram ($\log T_{eff}$ - $\log L/L_\odot$). The green star shape and red dot represent the primary and secondary components, respectively.

Table 1: Results from the light curve analysis (with formal errors from the WD code) and the absolute parameters of KZ Vir.

Parameter	Value	Parameter	Value
i [°]	56.09 ± 0.78	M_1 [$M_\odot$]	1.59 ± 0.03
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References

[1] [illegible]
[2] [illegible]
[3] [illegible]
[4] [illegible]
[5] [illegible]
[6] [illegible]
[7] [illegible]
[8] [illegible]
[9] [illegible]

Conclusion

In this study, the absolute parameters of the KZ Vir system, which has a low orbital inclination and is marginally eclipsing, were obtained for the first time by analyzing the system with PyWD2015 using RV data and TESS light curves available in the literature.
Both components are a small amount of evolved but the primary component is more evolved. This situation explains the low light variation outside of eclipses, which is attributed to the distortion of the primary component.

Contact Information