



Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture  
Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

# Eclipsing binary systems

**A fancy way to study stars**

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Departamento de Astrofísica, Universidad de La Laguna

April 14, 2023

## Observations in Astrophysics

### Eclipsing Binary Systems

Binary Systems  
Image Formation  
Differential Aperture  
Photometry

### Eclipsing binary ASAS J052919-1617.3

Ephemeris  
Temperature  
Orbit  
Radial Velocities  
System Parameters

### References



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### Eclipsing Binary Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

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J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

### References

## Stars

- $< 50\%$  single elements
- $\approx 70\%$   $M < 1M_{\odot}$





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Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

## What are they?

- **Stellar system of two stars**
- Orbiting each other around a common center of mass.



# Binary Systems

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

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# Eclipsing Binary Systems

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

## Eclipsing Systems

- **Orbital plane oriented towards the earth**
- Light Curves
  - Periodic variation of the brightness
  - Eclipses

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

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Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

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- Light Curves
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Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

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- Orbital plane oriented towards the earth
- Light Curves
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Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

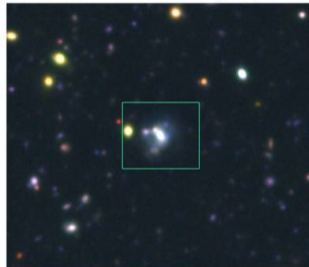
Orbit

Radial Velocities

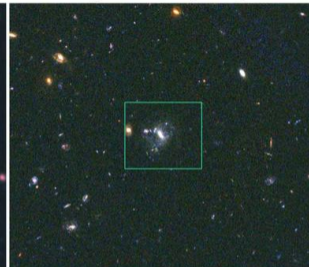
System Parameters

References

Ground: Subaru (8m)



Space: *HST* (2.4m)





# Atmosphere Turbulence

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

**Image Formation**

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture  
Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

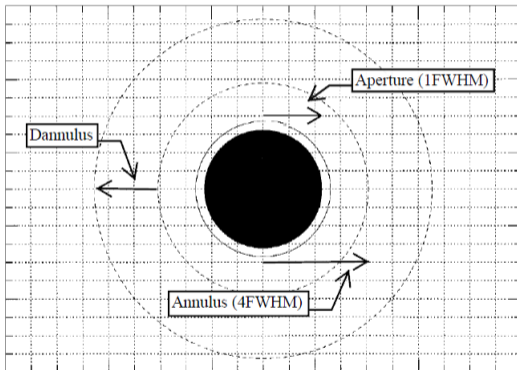
Temperature

Orbit

Radial Velocities

System Parameters

References



## Flux Measurement

- **Aperture**
- Sky ring

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture  
Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

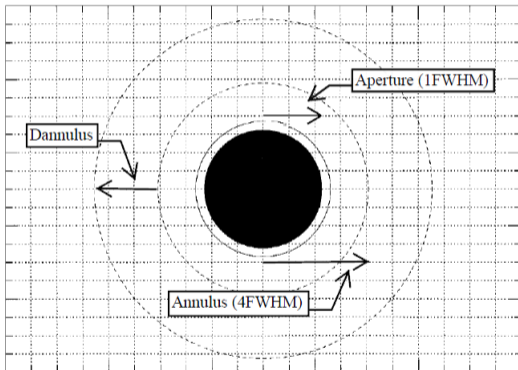
Temperature

Orbit

Radial Velocities

System Parameters

References



## Flux Measurement

- Aperture
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Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture  
Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

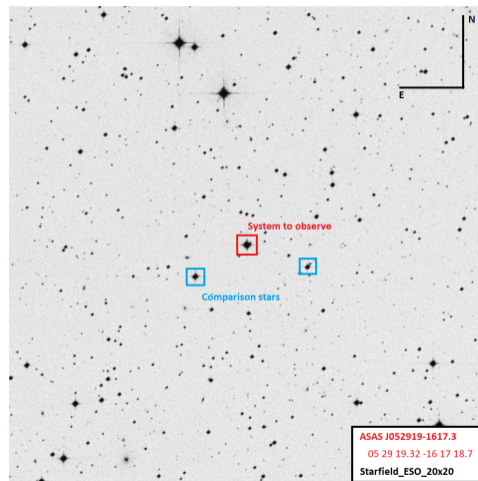
References

## Light Curve

- Brightness difference:
  - Binary system
  - Comparison stars

## Removing atmosphere effects

- Seeing
- Atmosphere air mass
- Clouds

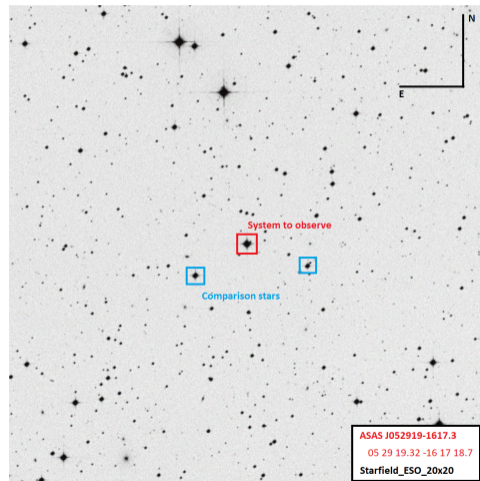


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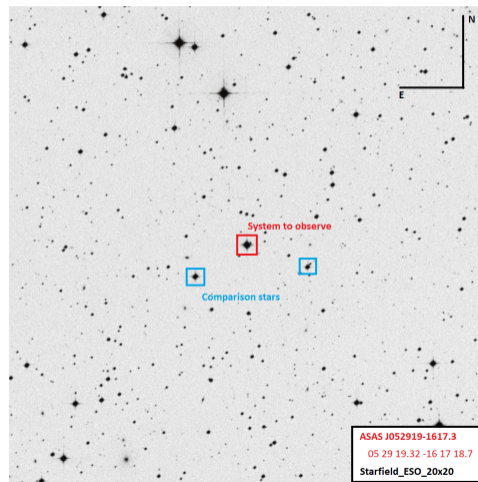


## Light Curve

- Brightness difference:
  - Binary system
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## Removing atmosphere effects

- Seeing
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ASAS J052919-1617.3 observed primary eclipses instants.

Observation Night	Filter	HJD <sub>min</sub>
2020/11/01	V	2459155.643993 ± 0.000099
	R	2459155.64390 ± 0.00020
	I	2459155.64474 ± 0.00029
2020/11/03	V	2459157.62664 ± 0.00059
	R	2459157.62628 ± 0.00042
	I	2459157.62645 ± 0.00021
2020/12/28	V	2459212.47705 ± 0.00044
	R	2459212.47658 ± 0.00021
	I	2459212.47670 ± 0.00034
2022/12/15	V	2459929.50073 ± 0.00030
	R	2459929.50039 ± 0.00034
	I	2459929.50032 ± 0.00044



# ASAS J052919-1617.3: Ephemeris

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

**Ephemeris**

Temperature

Orbit

Radial Velocities

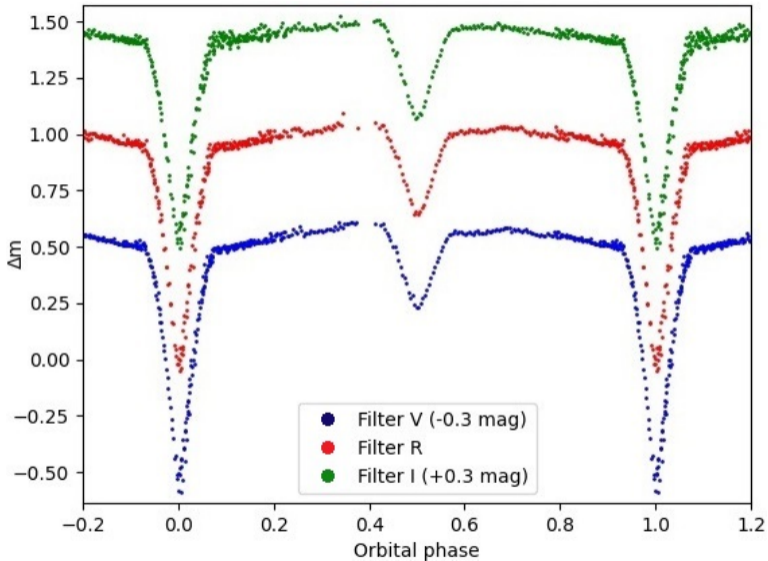
System Parameters

References

Ephemeris equation parameters of ASAS J052919-1617.3.

<b>Reference</b>	<b>P [d]</b>	<b>HJD<sub>0</sub> [HJD]</b>
AAVSO	$0.660855 \pm 0.000010$	$2451868.720 \pm 0.010$
Own data	$0.66085103 \pm 0.00000018$	$2459929.50048 \pm 0.00021$

# ASAS J052919-1617.3: light curve



Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

Calibrated observed magnitudes and color indices for ASAS J052919-1617.3 in phase 0.13.

<b>Band</b>	<b>Magnitude</b>	<b>Dereddened magnitude</b>
V	$11.748 \pm 0.048$	$11.676 \pm 0.048$
R	$11.282 \pm 0.047$	$11.225 \pm 0.047$
I	$10.837 \pm 0.042$	$10.798 \pm 0.042$
V-R	$0.466 \pm 0.067$	$0.451 \pm 0.067$
V-I	$0.911 \pm 0.064$	$0.878 \pm 0.064$
R-I	$0.445 \pm 0.063$	$0.427 \pm 0.063$

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture  
Photometry

Eclipsing binary  
ASAS  
J052919-1617.3

Ephemeris

**Temperature**

Orbit

Radial Velocities

System Parameters

References

ASAS J052919-1617.3 mean effective temperature estimations.

<b>Index</b>	<b>Index value</b>	<b>T<sub>eff</sub> [K]</b>
V-R	$0.451 \pm 0.067$	$6028 \pm 382$
V-I	$0.878 \pm 0.064$	$5640 \pm 225$
R-I	$0.427 \pm 0.063$	$5197 \pm 343$
Mean value (adopted)		$5621 \pm 280$

ASAS J052919-1617.3 observed secondary eclipses instants.

Observation Night	Filter	HJD <sub>sec</sub>	Phase
	V	2459156.63419 ± 0.00064	0.4985 ± 0.0011
2020/11/02	R	2459156.63546 ± 0.00056	0.50039 ± 0.00096
	I	2459156.63495 ± 0.00094	0.49961 ± 0.0015

# ASAS J052919-1617.3: Radial Velocities

Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

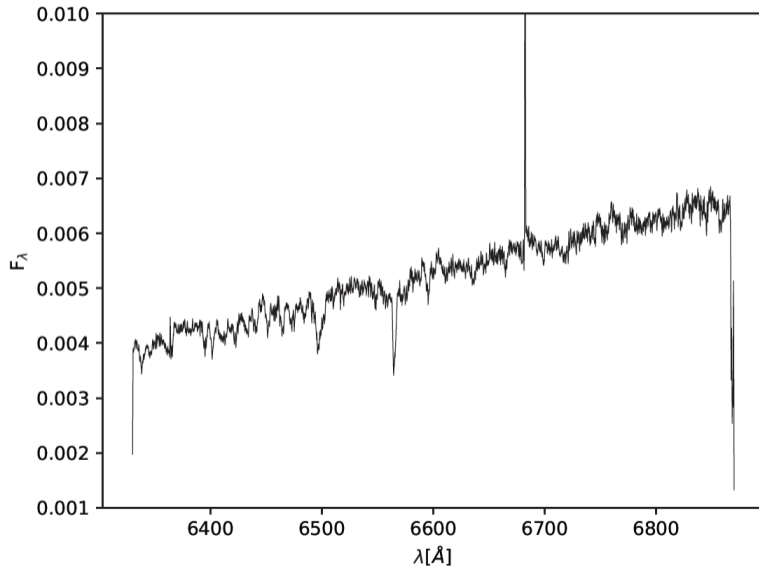
Temperature

Orbit

**Radial Velocities**

System Parameters

References



Parameter	Primary	Secondary	Parameter	Primary	Secondary
<i>Geometric and orbital parameters</i>					
$P$ (d)	0.5607222 <sup>(a)</sup>		$x_1, y_1$ (R band)	0.457, 0.330	0.351, 0.450
$T_0$ (HJD)	2 453 274.1705 <sup>(a)</sup>		$x_1, y_1$ (I band)	0.249, 0.455	0.157, 0.555
$\Delta\phi$	0.000219 $\pm$ 0.000051		$x_1, y_1$ (J band)	0.094, 0.544	0.037, 0.586
$q$	1.0170 <sup>(a)</sup>		$x_1, y_1$ (K band)	-0.156, 0.711	-0.147, 0.673
$\gamma$ (km s <sup>-1</sup> )	-16.31 <sup>(a)</sup>		<i>Spot 1 parameters (primary star)</i>		
$i$ (deg)	86.465 $\pm$ 0.083		Colatitude (deg)	31.4 $\pm$ 3.3	-
$e$	0.0 <sup>(a)</sup>		Longitude (deg)	101.014 $\pm$ 0.040	-
$a$ ( $R_\odot$ )	3.1139 $\pm$ 0.0076		Radius (deg)	37.0 $\pm$ 2.0	-
$\omega$ (deg)	90.0 <sup>(a)</sup>		$T_{\text{spot}}/T_{\text{surf}}$	0.884 $\pm$ 0.020	-
$\Omega$	5.559 $\pm$ 0.021	5.745 $\pm$ 0.023	<i>Spot 2 parameters (primary star)</i>		
$F$	1.0 <sup>(a)</sup>	1.0 <sup>(a)</sup>	Colatitude (deg)	57.2 $\pm$ 2.0	-
<i>Radiative parameters</i>					
$T_{\text{eff}}$ (K)	4240 <sup>(a)</sup>	4120 $\pm$ 100	Longitude (deg)	355.145 $\pm$ 0.044	-
<i>Albedo</i>	0.5 <sup>(a)</sup>	0.5 <sup>(a)</sup>	Radius (deg)	21.4 $\pm$ 1.5	-
$\beta$	0.32 <sup>(a)</sup>	0.32 <sup>(a)</sup>	$T_{\text{spot}}/T_{\text{surf}}$	0.703 $\pm$ 0.039	-
$l_3$ (for all bands)	0.0 <sup>(a)</sup>		<i>Spot 3 parameters (secondary star)</i>		
<i>Fractional radii</i>					
$r_{\text{pole}}$	0.2190 $\pm$ 0.0010	0.2130 $\pm$ 0.0010	Colatitude (deg)	-	36.1 $\pm$ 6.0
$r_{\text{point}}$	0.2261 $\pm$ 0.0011	0.2190 $\pm$ 0.0012	Longitude (deg)	-	0.0 $\pm$ 2.4
$r_{\text{side}}$	0.2214 $\pm$ 0.0010	0.2151 $\pm$ 0.0011	Radius (deg)	-	29.00 $\pm$ 5.3
$r_{\text{back}}$	0.2247 $\pm$ 0.0011	0.2179 $\pm$ 0.0011	$T_{\text{spot}}/T_{\text{surf}}$	-	0.940 $\pm$ 0.021
$r_{\text{vol}}$	0.2218 $\pm$ 0.0011	0.2154 $\pm$ 0.0014	<i>Parameters computed from MCMC</i>		
<i>Luminosities</i>					
$L/(L_1 + L_2)$ (V)	0.5659 $\pm$ 0.0022	0.4341 $\pm$ 0.0022	$\Delta\phi$	0.00010 <sup>+0.00045</sup> <sub>-0.00049</sub>	-
$L/(L_1 + L_2)$ (R)	0.5567 $\pm$ 0.0023	0.4433 $\pm$ 0.0023	$i$ (deg)	86.22 <sup>+0.61</sup> <sub>-0.61</sub>	-
$L/(L_1 + L_2)$ (I)	0.5446 $\pm$ 0.0024	0.4554 $\pm$ 0.0024	$\Omega$	5.59 <sup>+0.12</sup> <sub>-0.14</sub>	5.71 <sup>+0.15</sup> <sub>-0.12</sub>
$L/(L_1 + L_2)$ (J)	0.5371 $\pm$ 0.0027	0.4629 $\pm$ 0.0027	$T_{\text{eff}}$ <sup>(b)</sup> (K)	-	4104 <sup>+39</sup> <sub>-55</sub>
$L/(L_1 + L_2)$ (K)	0.5305 $\pm$ 0.0028	0.4695 $\pm$ 0.0028	<i>Fractional volumetric radii from MCMC</i>		
<i>Limb-darkening coefficients (square-root law)</i>					
$x_1, y_1$ (bol)	0.227, 0.446	0.140, 0.521	$r_{\text{vol}}$	0.2205 <sup>+0.0054</sup> <sub>-0.0076</sub>	0.2156 <sup>+0.0059</sup> <sub>-0.0071</sub>
$x_1, y_1$ (V band)	0.739, 0.067	0.578, 0.250	<i>Residuals from the fit</i>		
			$\sigma_V$ (mag)	0.008	
			$\sigma_R$ (mag)	0.008	
			$\sigma_I$ (mag)	0.009	
			$\sigma_J$ (mag)	0.053	
			$\sigma_K$ (mag)	0.069	





Observations in  
Astrophysics

Eclipsing Binary  
Systems

Binary Systems

Image Formation

Differential Aperture

Photometry

Eclipsing binary  
ASAS

J052919-1617.3

Ephemeris

Temperature

Orbit

Radial Velocities

System Parameters

References

## Eclipsing binary systems: A fancy way to study stars

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