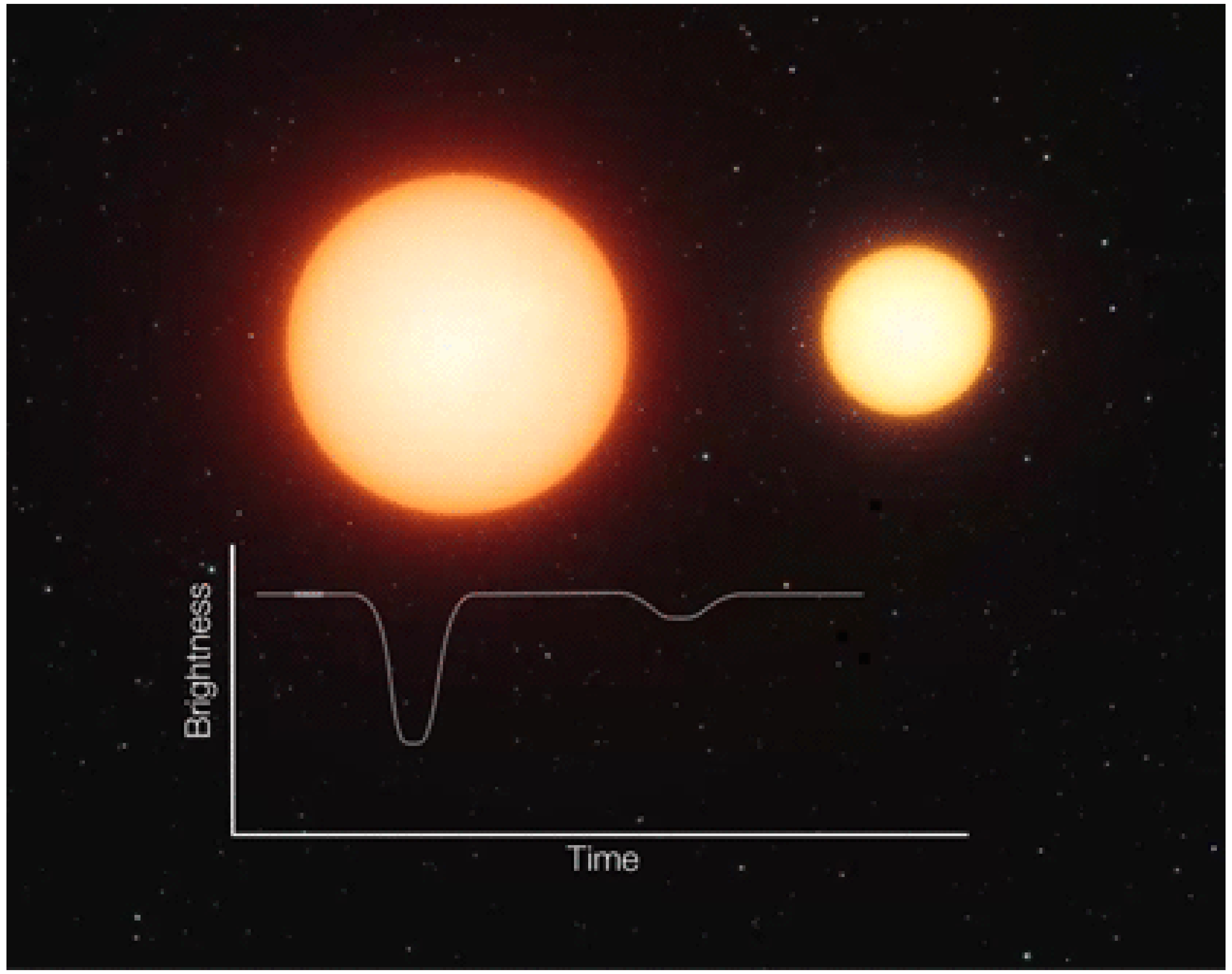
CHARACTERIZATION OF A NEWLY IDENTIFIED PULSATING DETACHED ECLIPSING BINARY

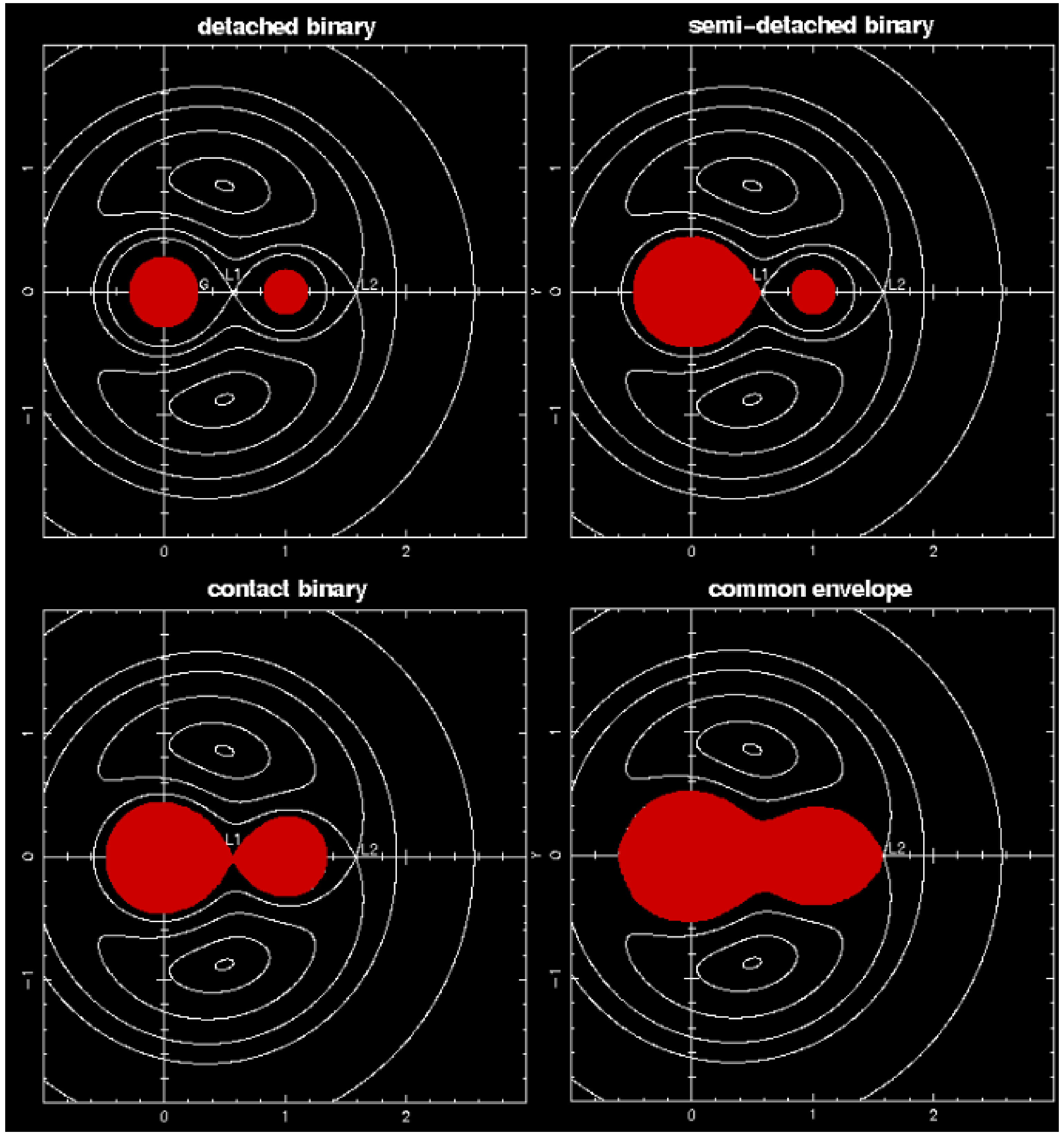
FILIZ KAHRAMAN ALICAVUS

FAHRI ALICAVUS, PETER DE CAT

2024

Eclipsing Binaries





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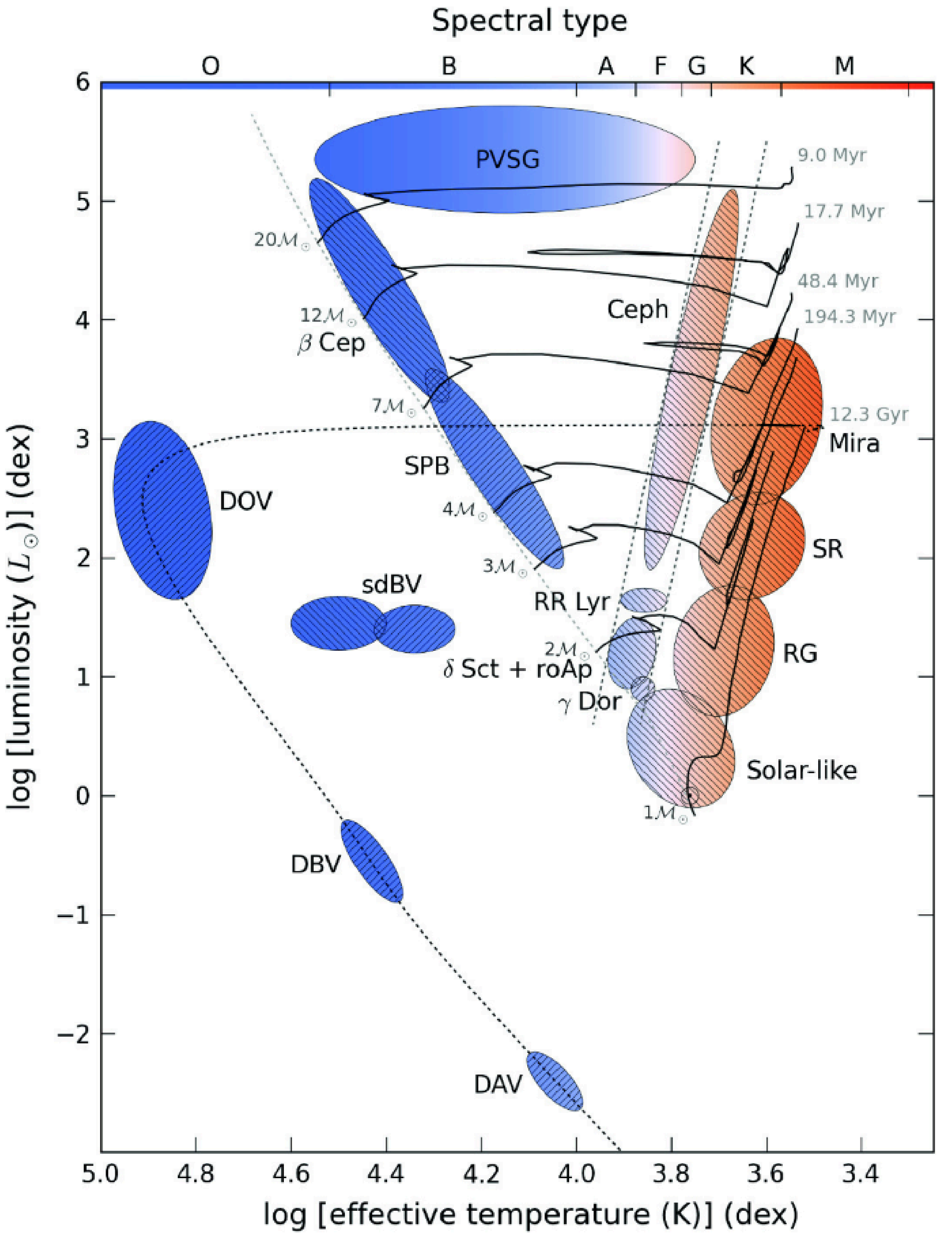
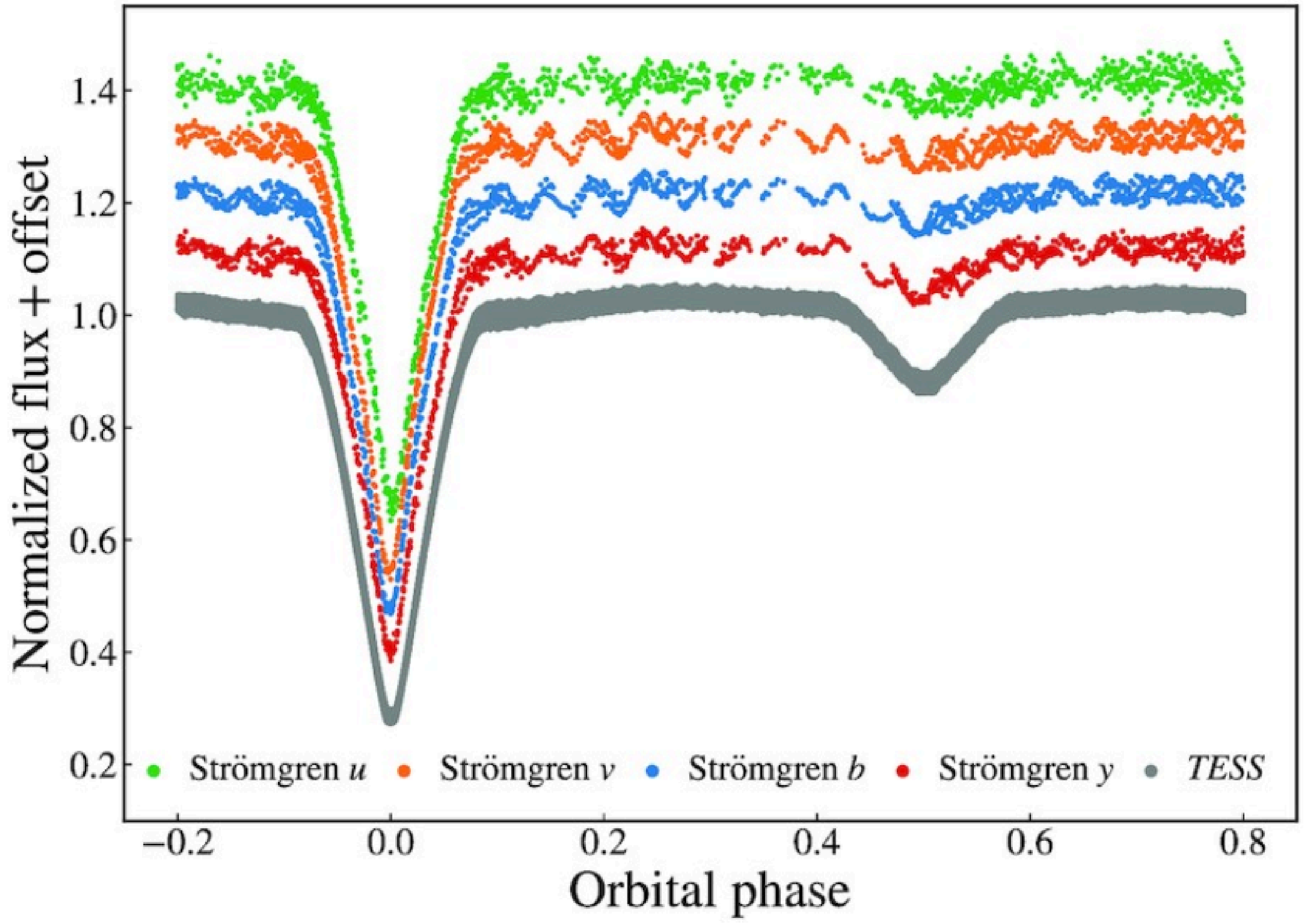
Eclipsing Binaries

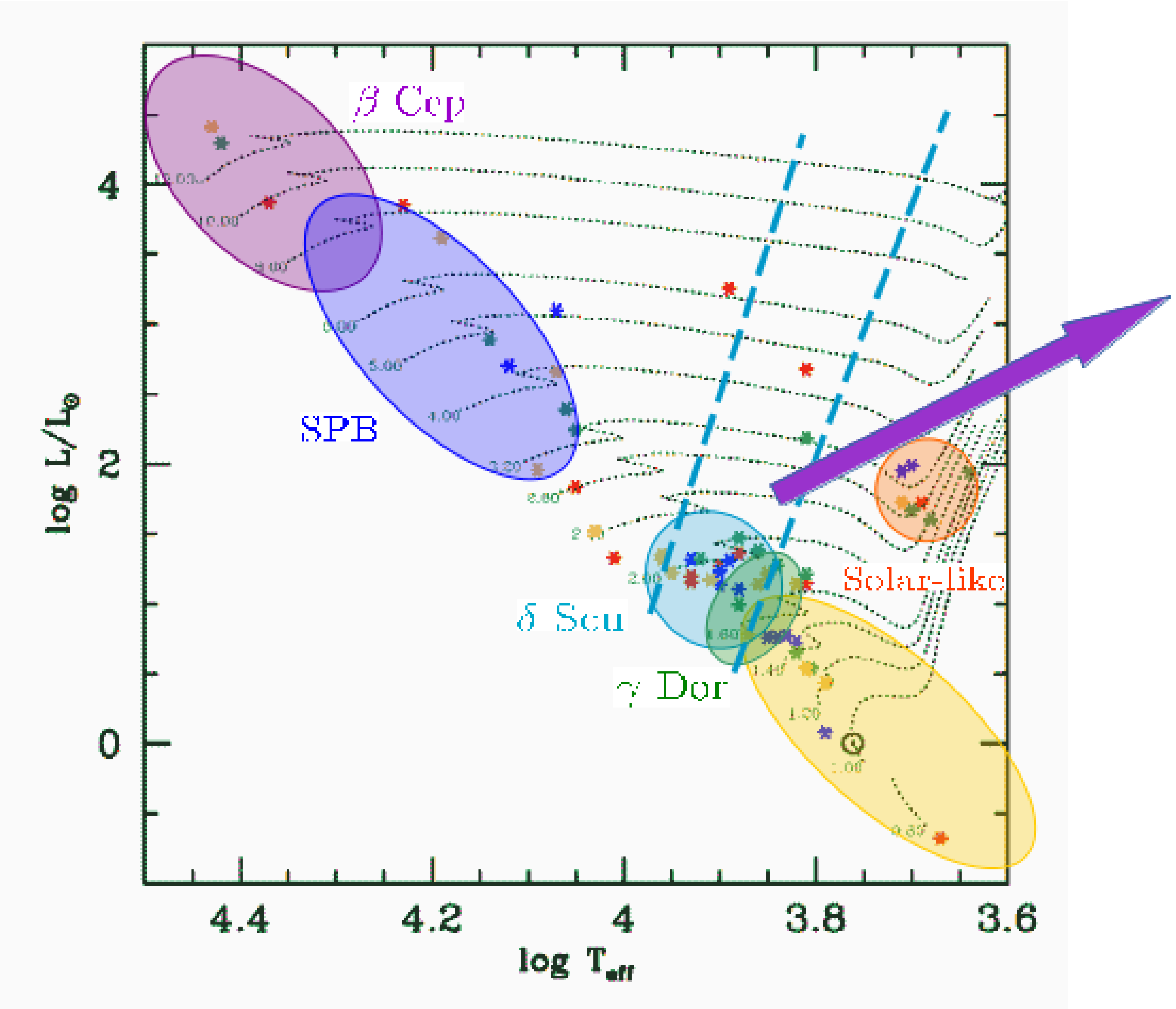




Miszuda et al. 2022

Bowman et. al. 2017

Eclipsing Binaries with pulsating stars: Delta Scuti stars



Early A and F stars

Periods ~ 0.3 - 8 hours, radial-nonradial, pressure, gravity, mixed modes

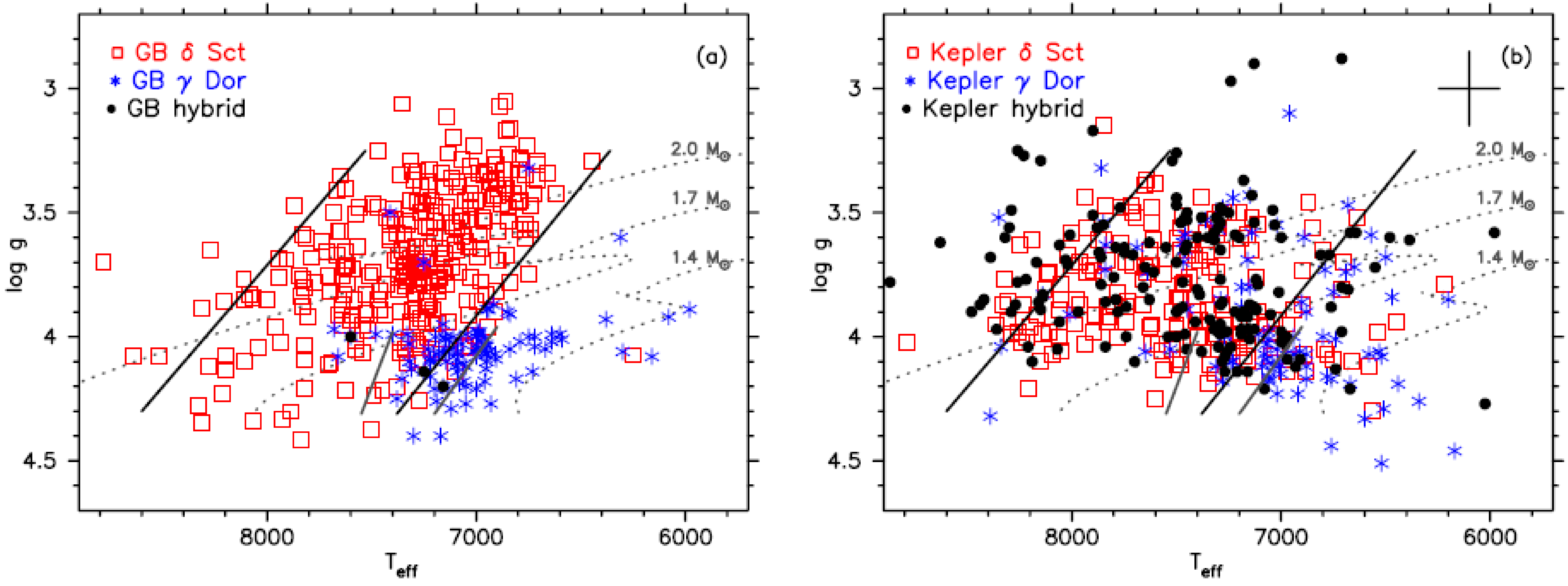
k mechanism

Near main sequence

Frequency > 5 c/d

Uyterhoeven et al 2011

Eclipsing Binaries with pulsating stars



Eclipsing binaries provide the most accurate fundmental stellar prameter

Uyterhoeven et al 2011

New eclipsing binaries with Delta Scuti pulsators

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

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Discovery of delta Scuti variables in eclipsing binary systems II. Southern TESS field search

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Research in Astronomy and Astrophysics, 22:085003 (15pp), 2022 August https://doi.org/10.1088/1674-4527/ac71a4

Candidate Eclipsing Binary Systems with a δ Scuti Star in Northern TESS Field

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The Astrophysical Journal Supplement Series, 263:34 (10pp), 2022 December

Detection of δ Scuti Pulsators in the Eclipsing Binaries Observed by TESS

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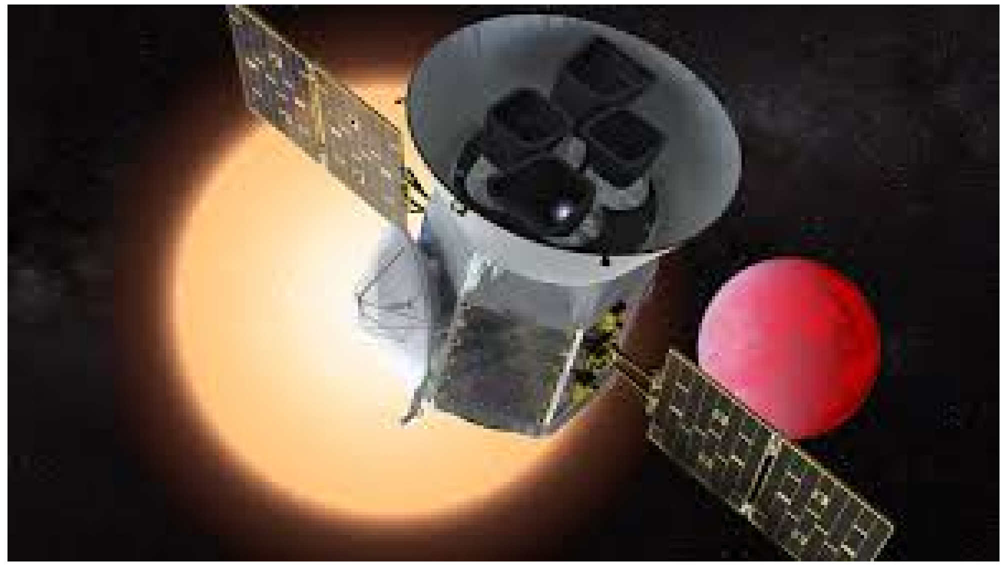
New eclipsing binaries with Delta Scuti pulsators



TESS: Transiting Exoplanet Survey Satellite

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Subscriptions Alert There is a known issue with JWST subscription notifications. Data are continuing to be reprocessed and notifications will be sent after the patch is installed in early September.

MAST: Barbara A. Mikulski Archive for Space Telescopes

The MAST Portal lets you search multiple collections of astronomical datasets all in one place. Use this tool to find astronomical data, publications, and images.

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Currently available data collections:

- MAST Observations: Millions of observations from JWST, Hubble, Kepler, GALEX, IUE, FUSE, and more.

Lightkurve

A friendly Python package for making discoveries with Kepler & TESS.

Lightkurve offers a user-friendly way to analyze time series data on the brightness of planets, stars, and galaxies. The package is focused on supporting science with NASA's Kepler and TESS space telescopes, but can equally be used to analyze light curves obtained by your backyard telescope. Lightkurve aims to lower barriers, promote best practices, reduce costs, and improve scientific fidelity by providing accessible open source Python tools and tutorials for time domain astronomy.

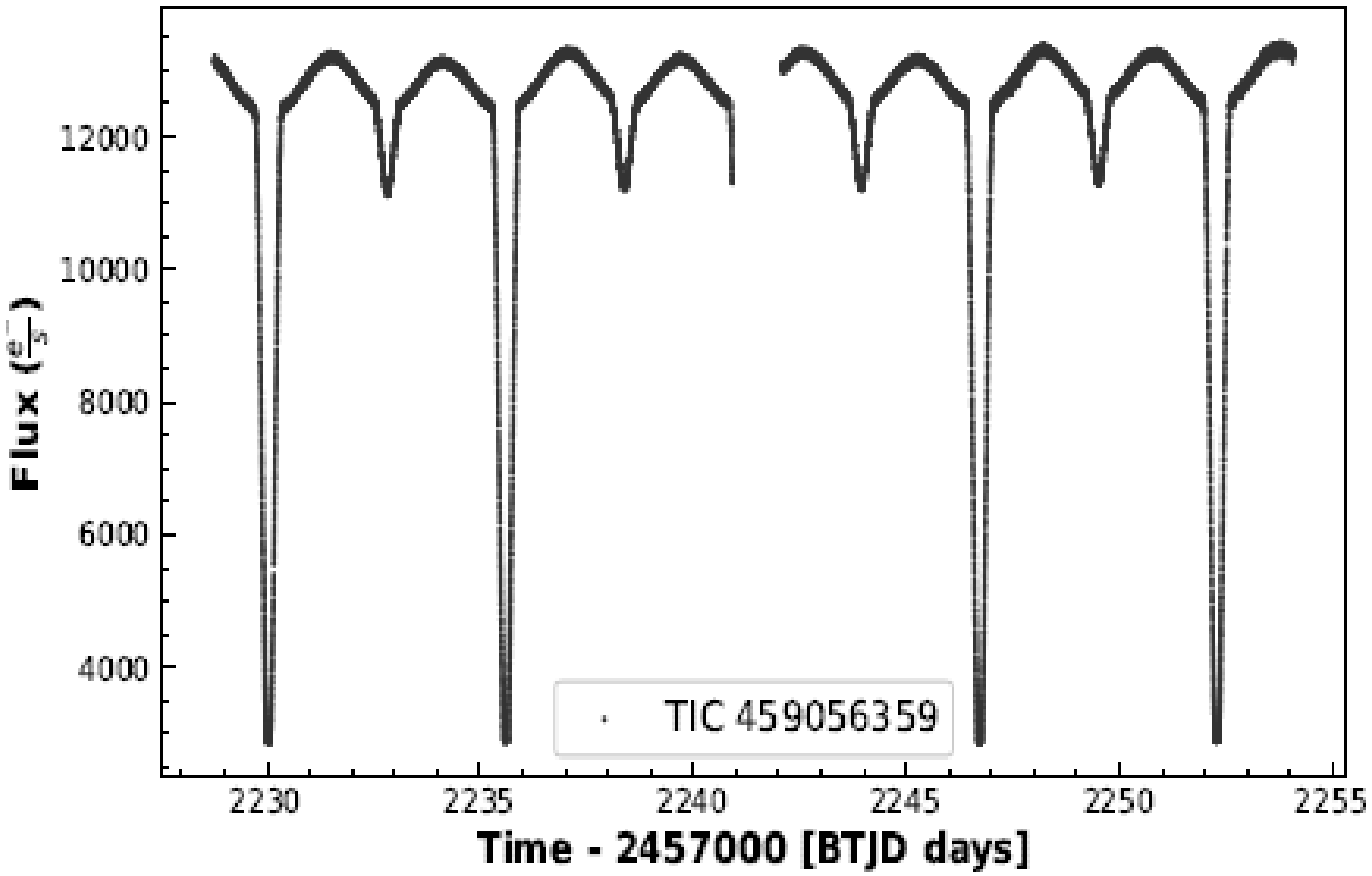
New eclipsing binaries with Delta Scuti pulsators

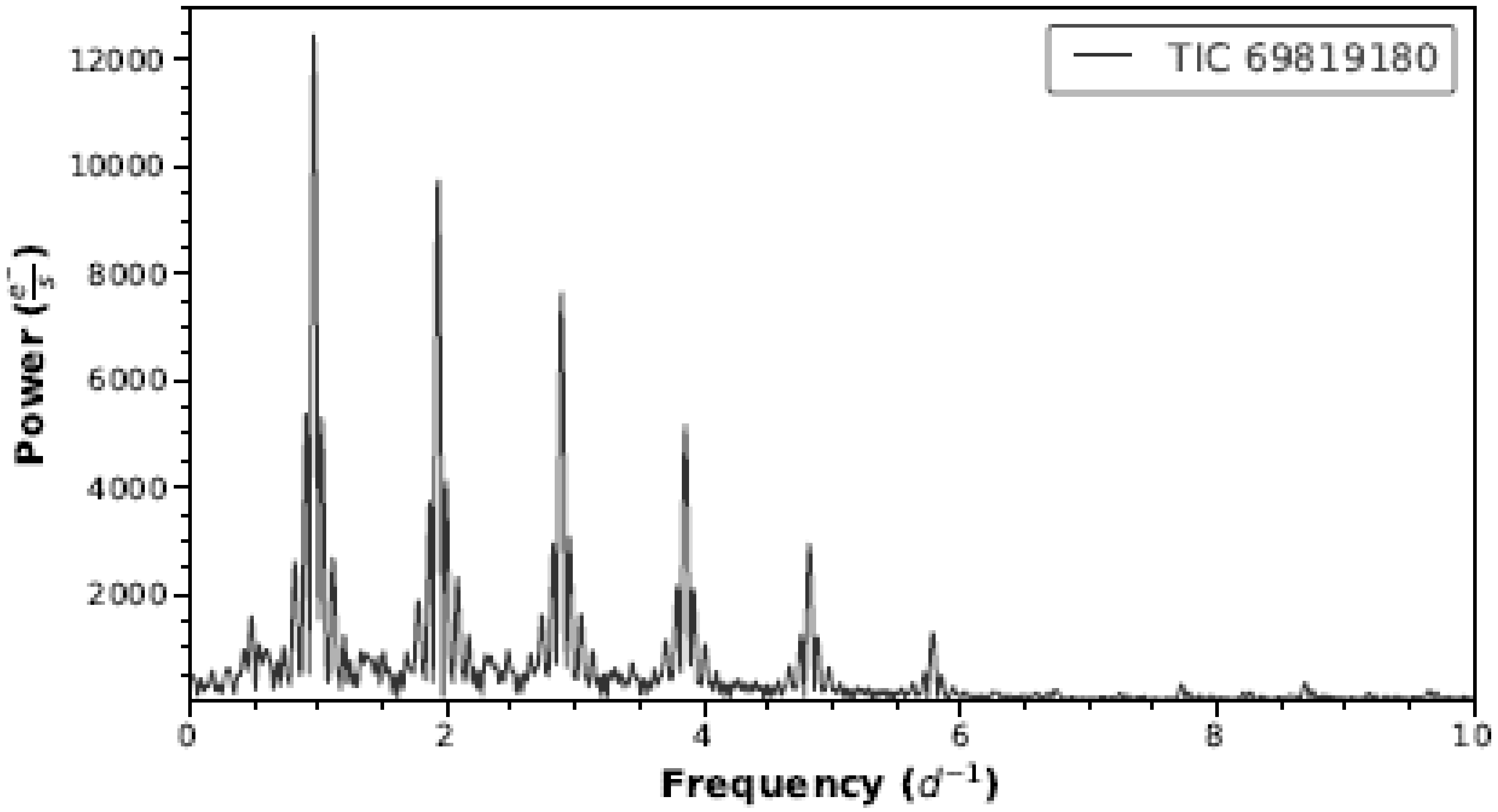
Criteria

- Corrdinates: Right ascension (RA), Declination (DEC)
- Effective temperature rnge: between 5300 and 13000K

for Delta Scuti stars: between 6300–8500 K (Rodriguez and Breger, 2001)

New eclipsing binaries with Delta Scuti pulsators





New eclipsing binaries with Delta Scuti pulsators

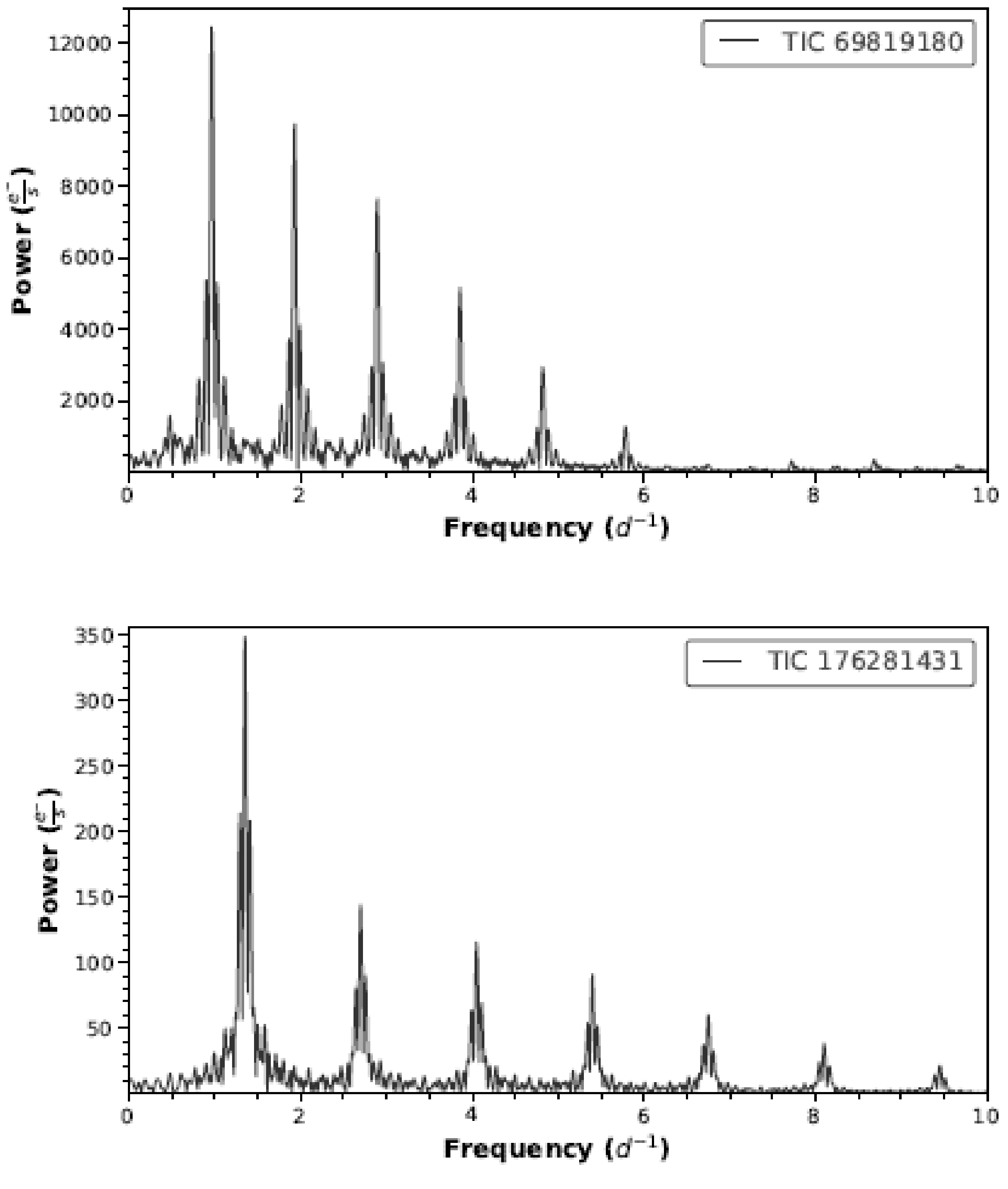
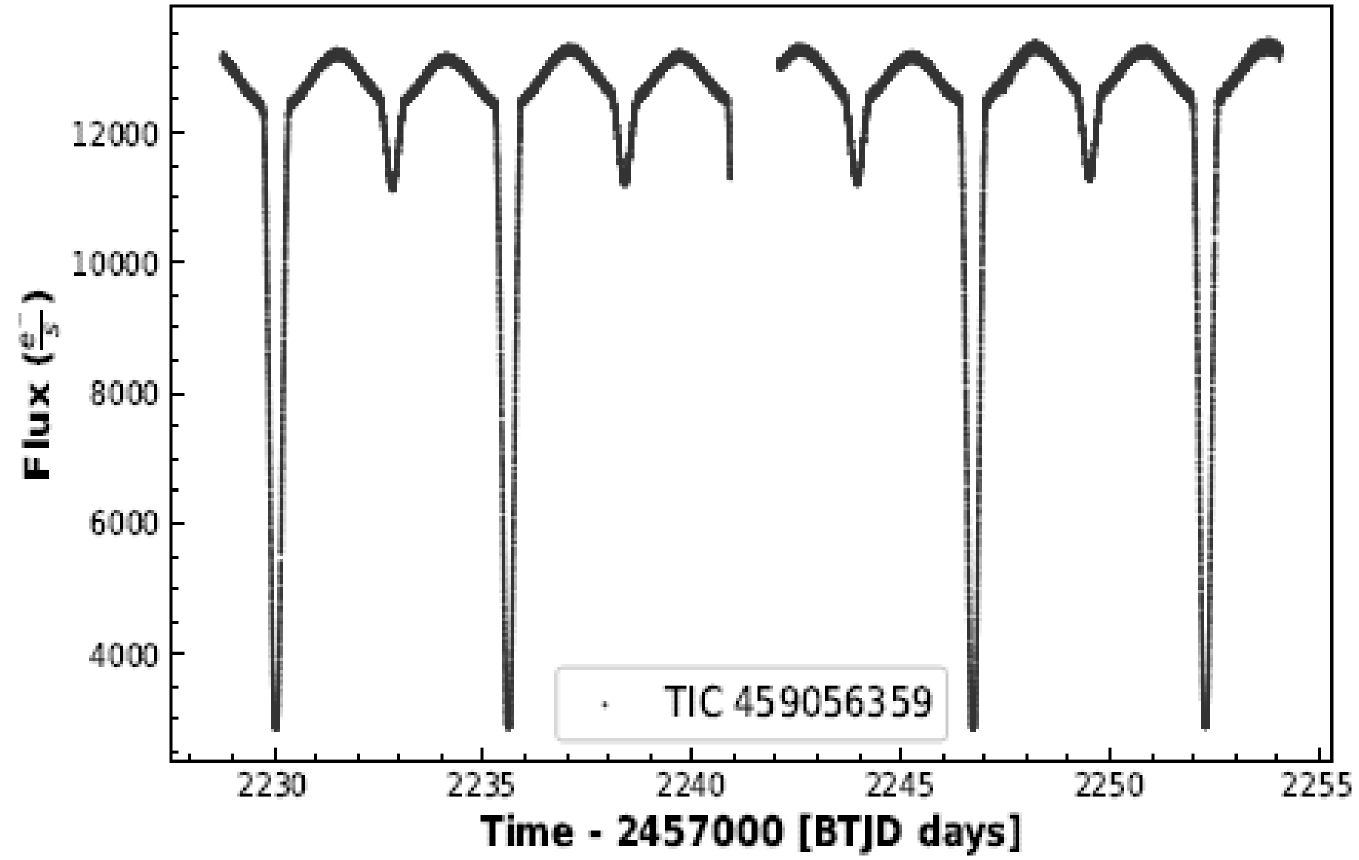
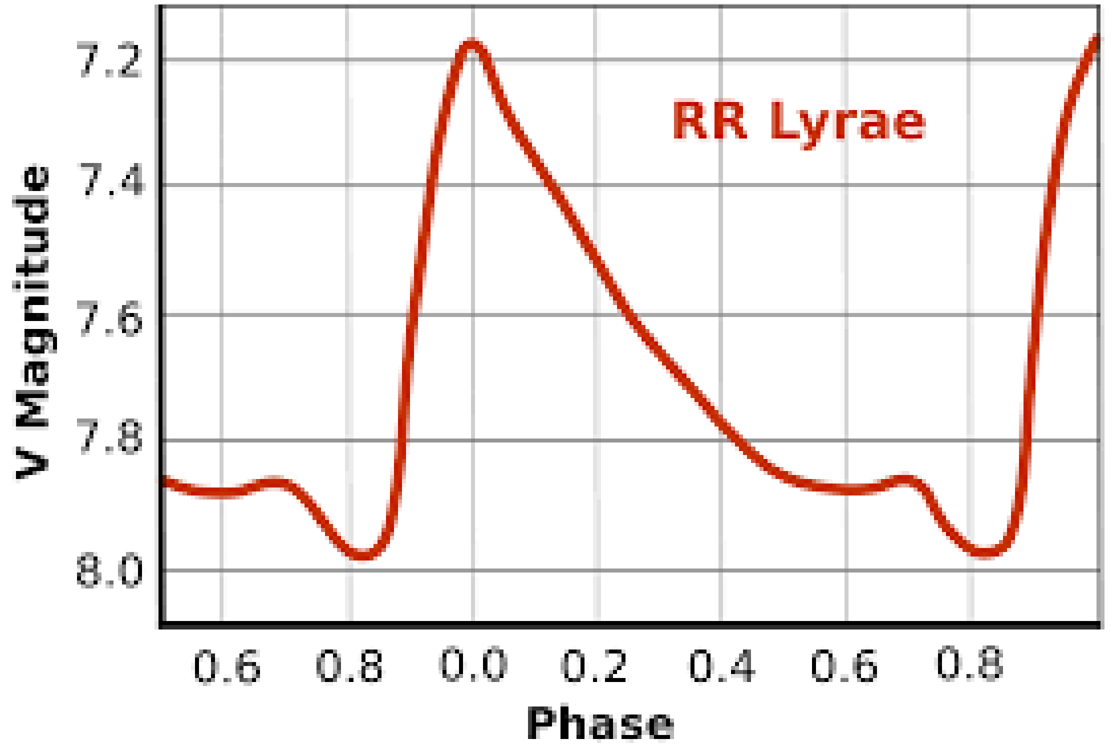


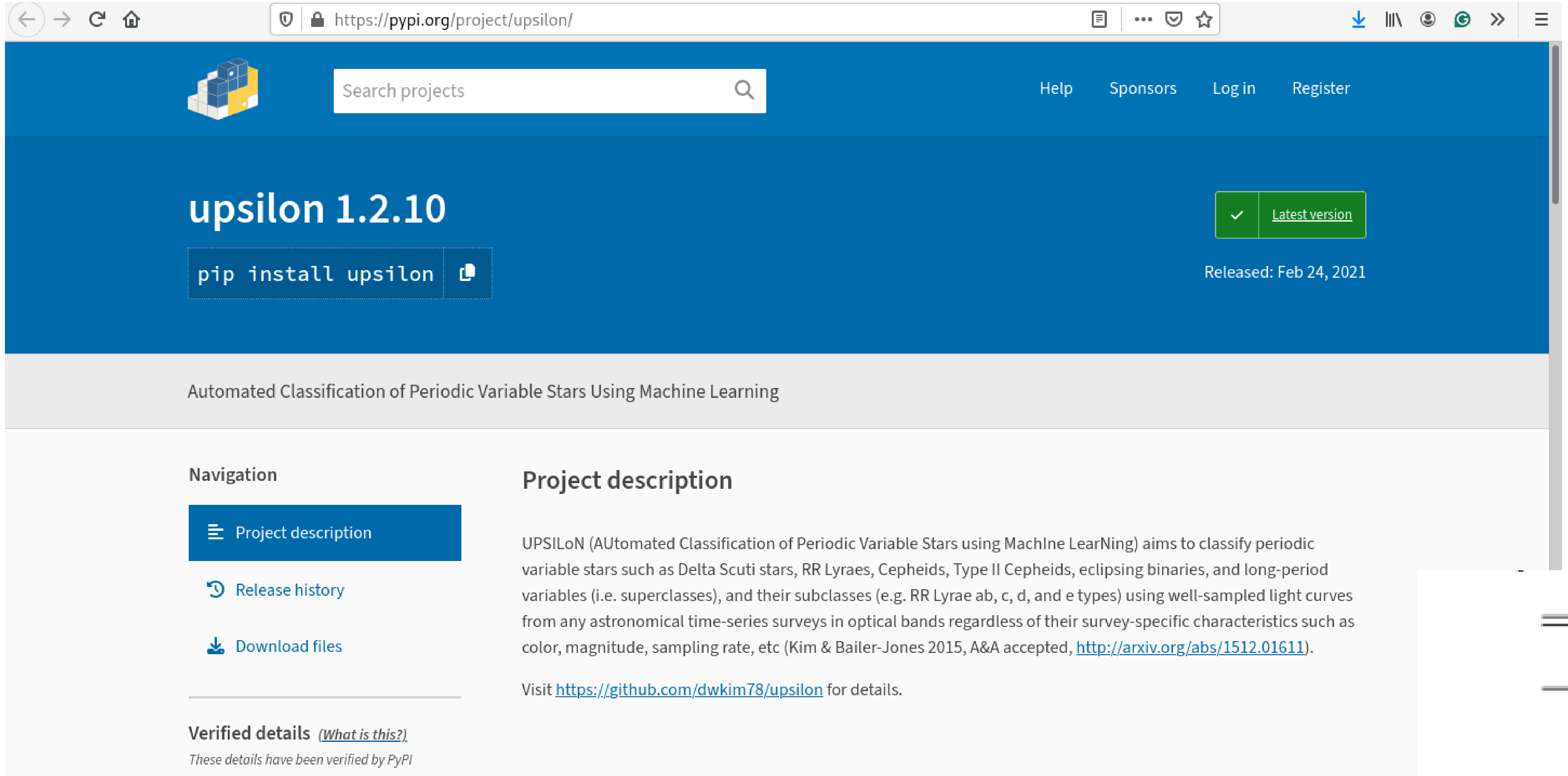
Figure 1. Top panel: Frequency spectrum of an EB system (KX Aqr, TIC 69819180, Kazarovets et al., 1999). Bottom panel: Frequency spectrum of a RR Lyrae system (GK Cet, TIC 176281431, Kinemuchi et al., 2006).





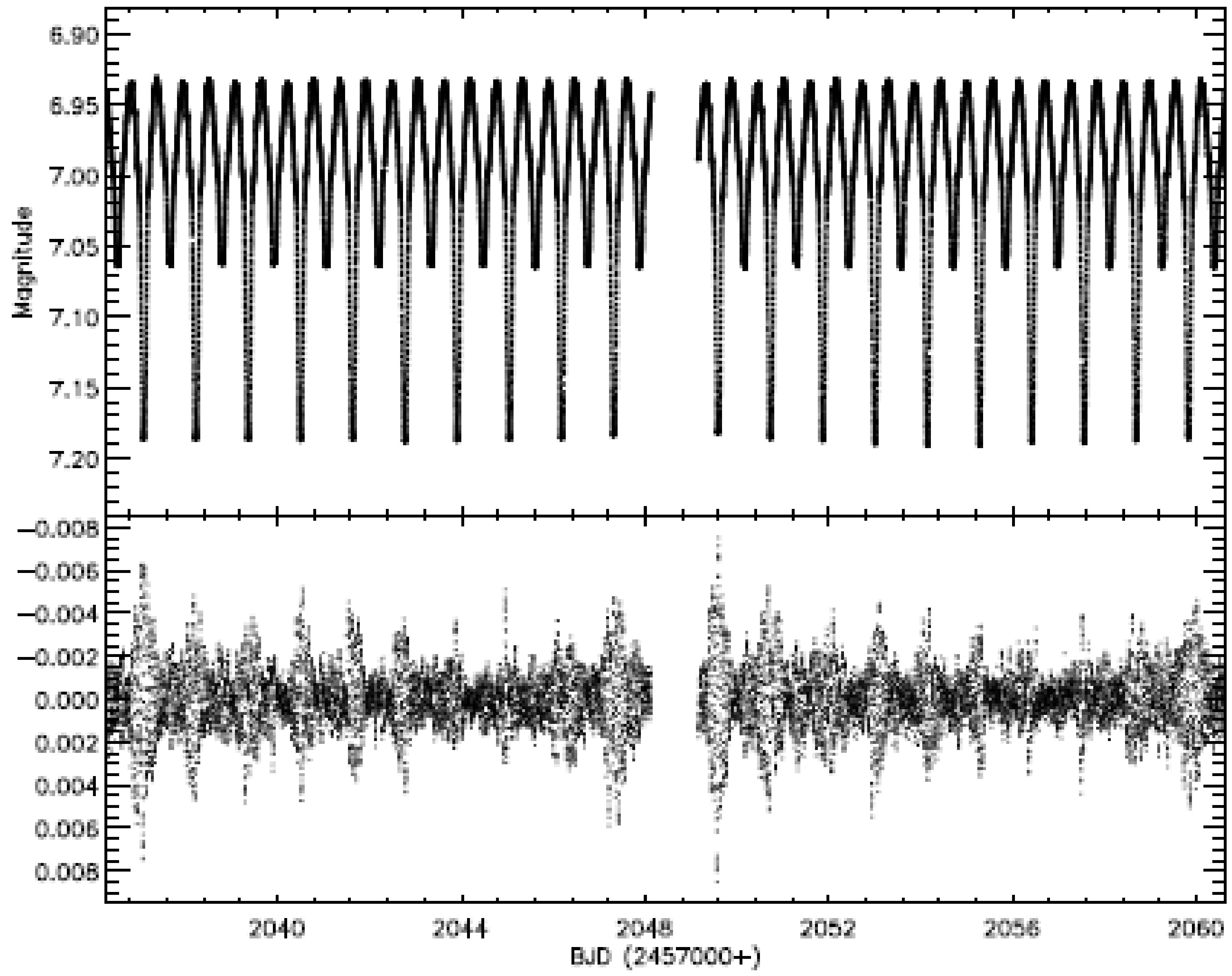
Skewness is a measure of asymmetry or distortion of symmetric distribution

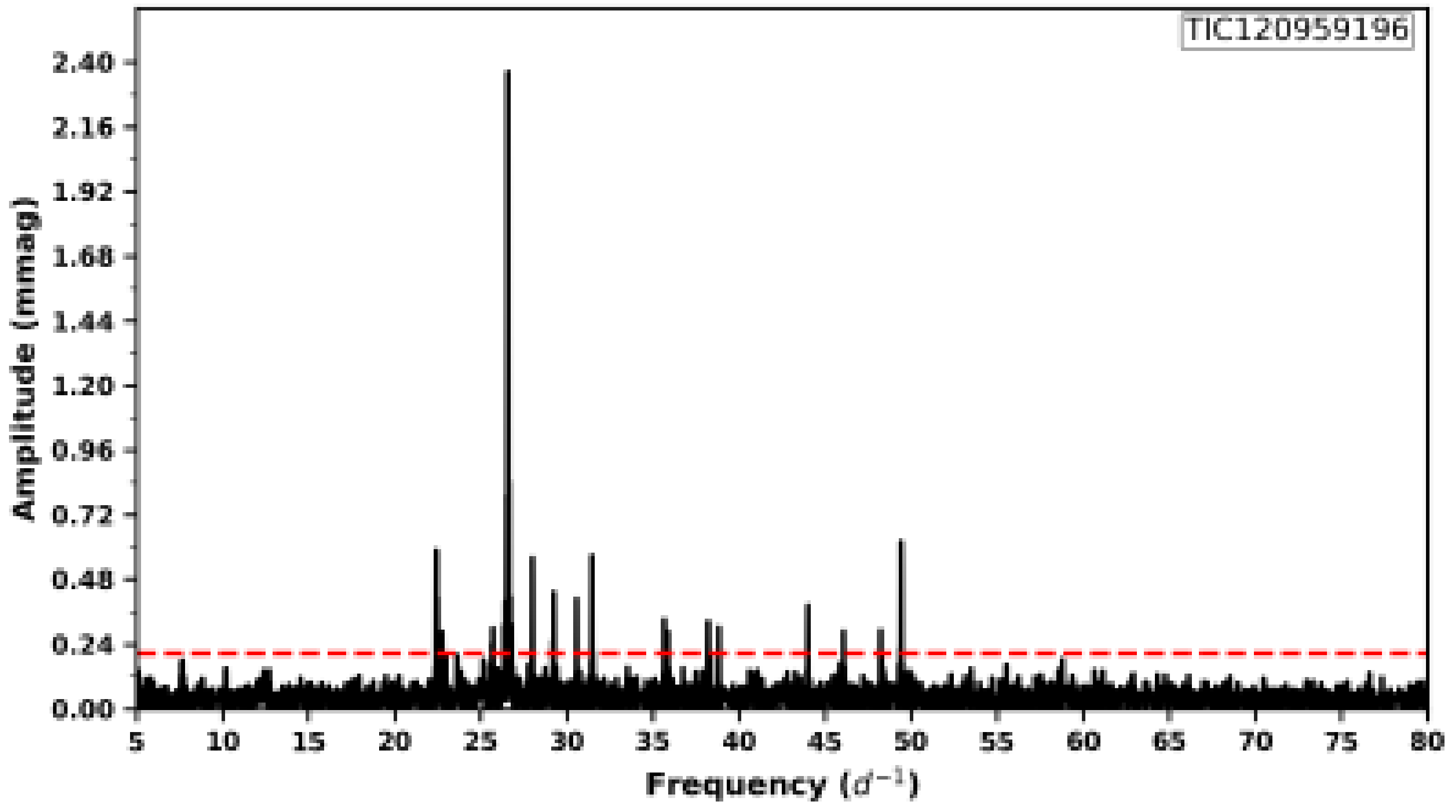
New eclipsing binaries with Delta Scuti pulsators



Variable type	Acronym
δ Scuti star	DSCT
RR Lyrae	RRL
Cepheid	CEPH
Type II Cepheid	T2CEPH
Eclipsing binary	EB
Long-period variable	LPV
Non-variables	NonVar

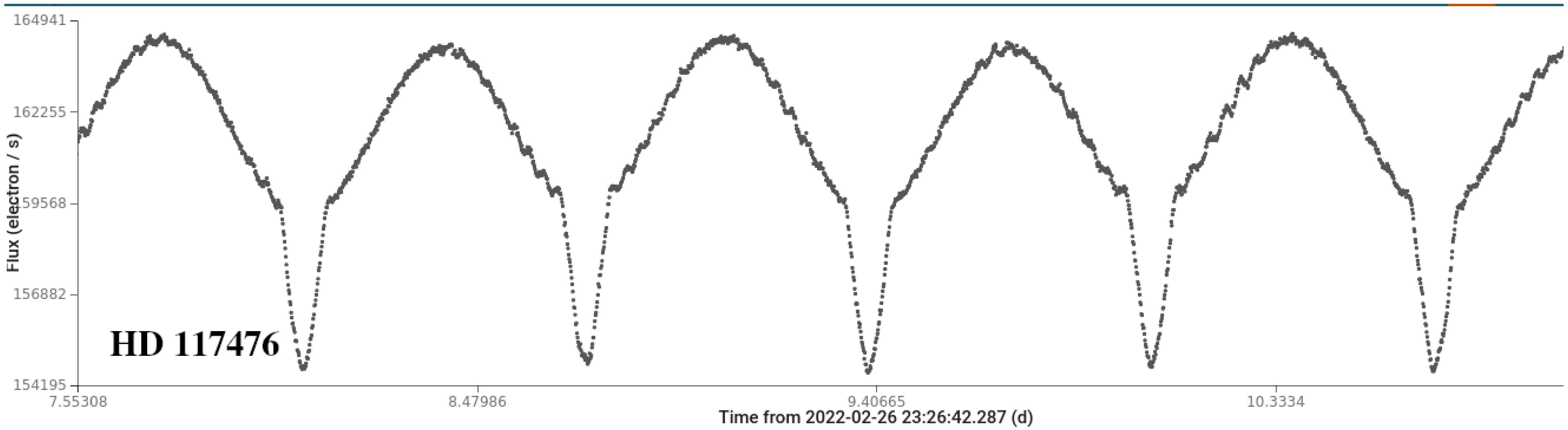
New eclipsing binaries with Delta Scuti pulsators

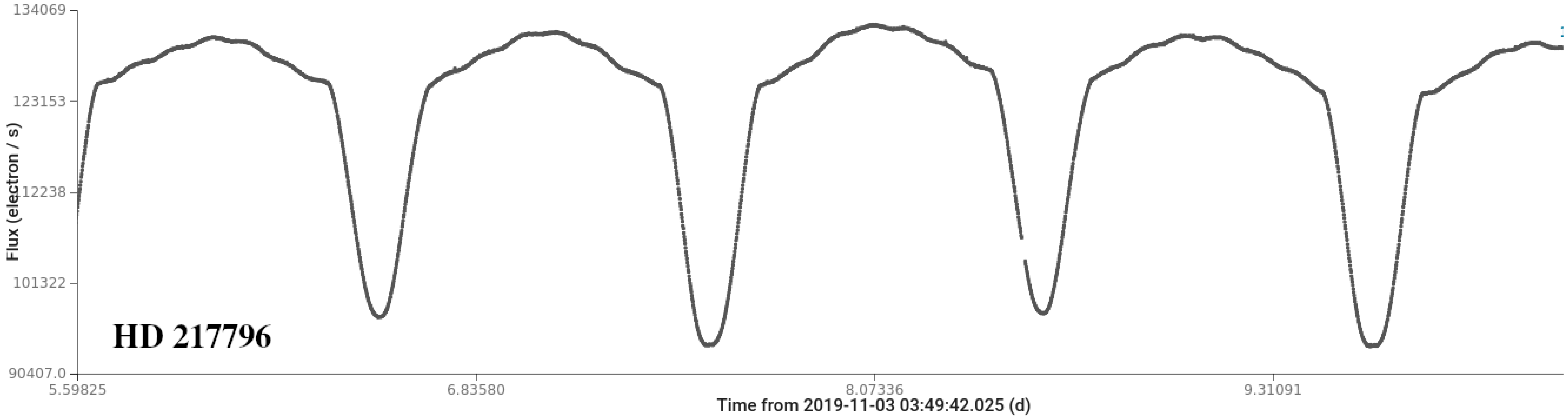




Visually controlled the pulsating ones.

Detached Eclipsing Binaries with pulsating stars





TESS data of two new eclipsing binary with Delta Sct pulsators

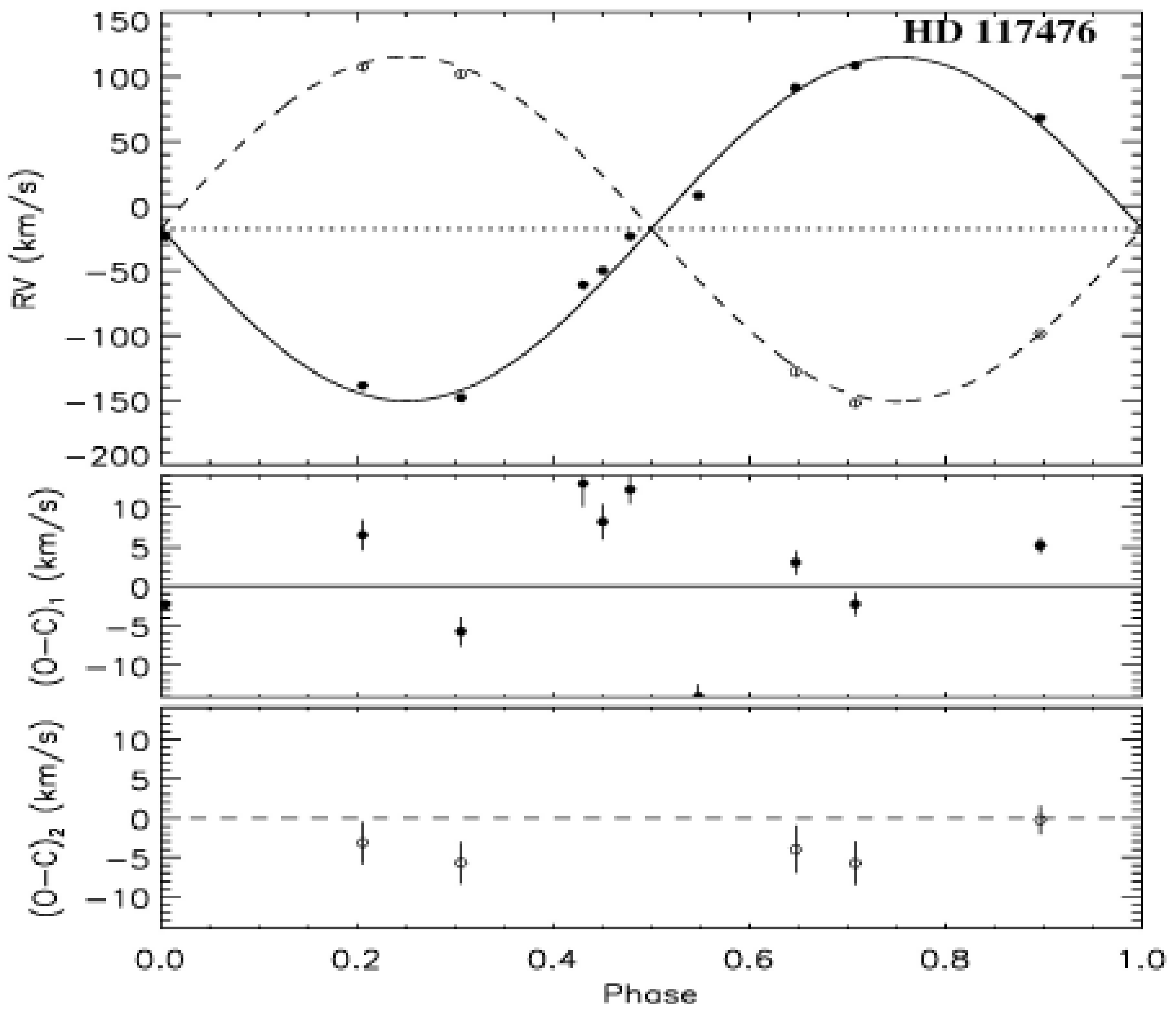
Observational Data

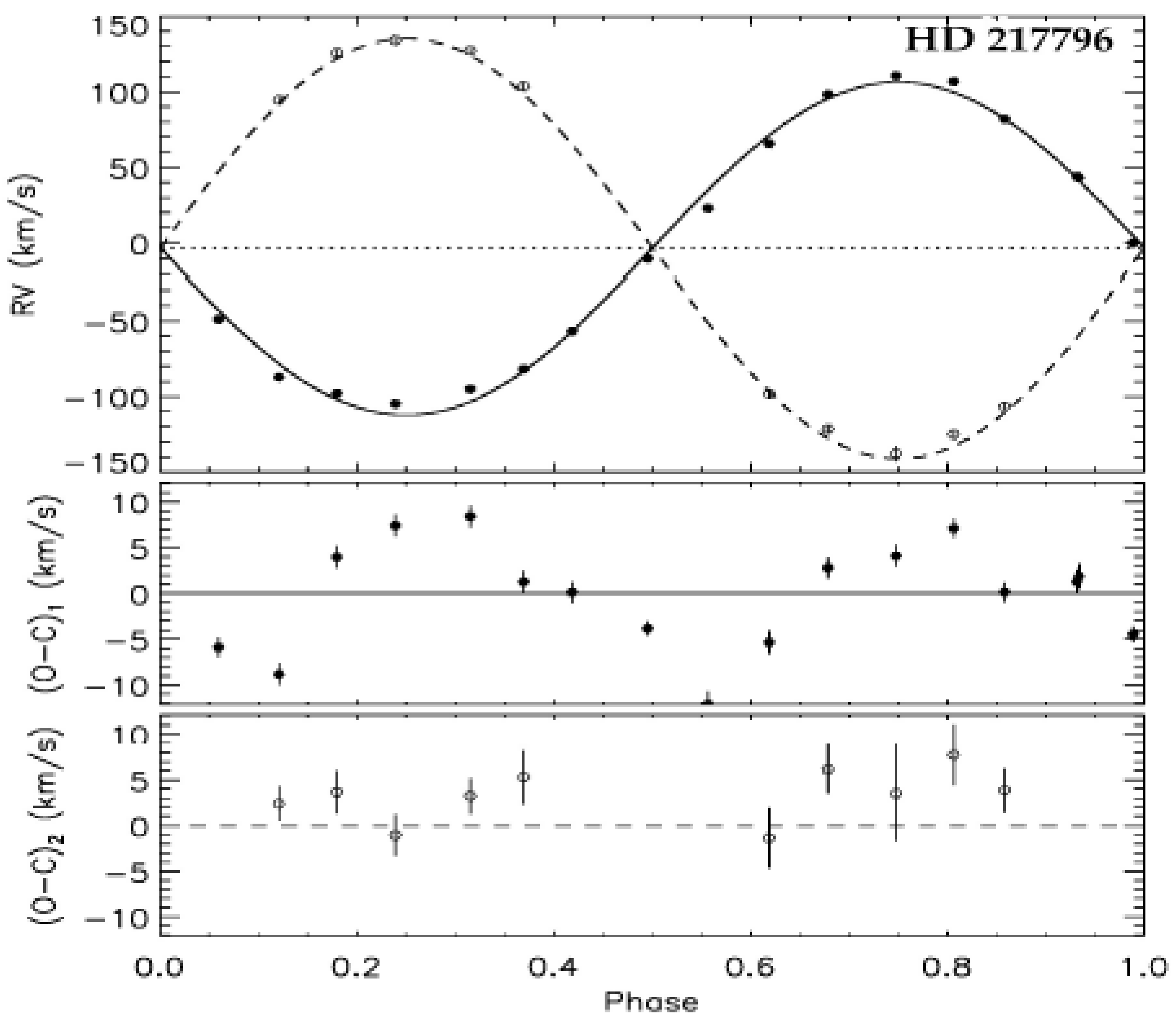
Star Name	RA (deg)	DEC (deg)	V (mag)	P_{orb} (day)	TESS sector	Spectrograph	Number of spectra	Average SNR
HD 117476	202.5	34.5	7.72	1.313542 (7)	23 ,49 ,50	CAOS	10	72
HD 217796	345.5	62.5	8.14	2.058307 (1)	17 ,18 ,24	HERMES	17	105

CAOS: the Catania Astrophysical Observatory Spectropo-larimeter - **R: 38,000**

HERMES: the High Efficiency and Resolution Merca-1https://mast.stsci.edutor échelle spectrograp - **R: 85,000**

Radial Velocity Analysis





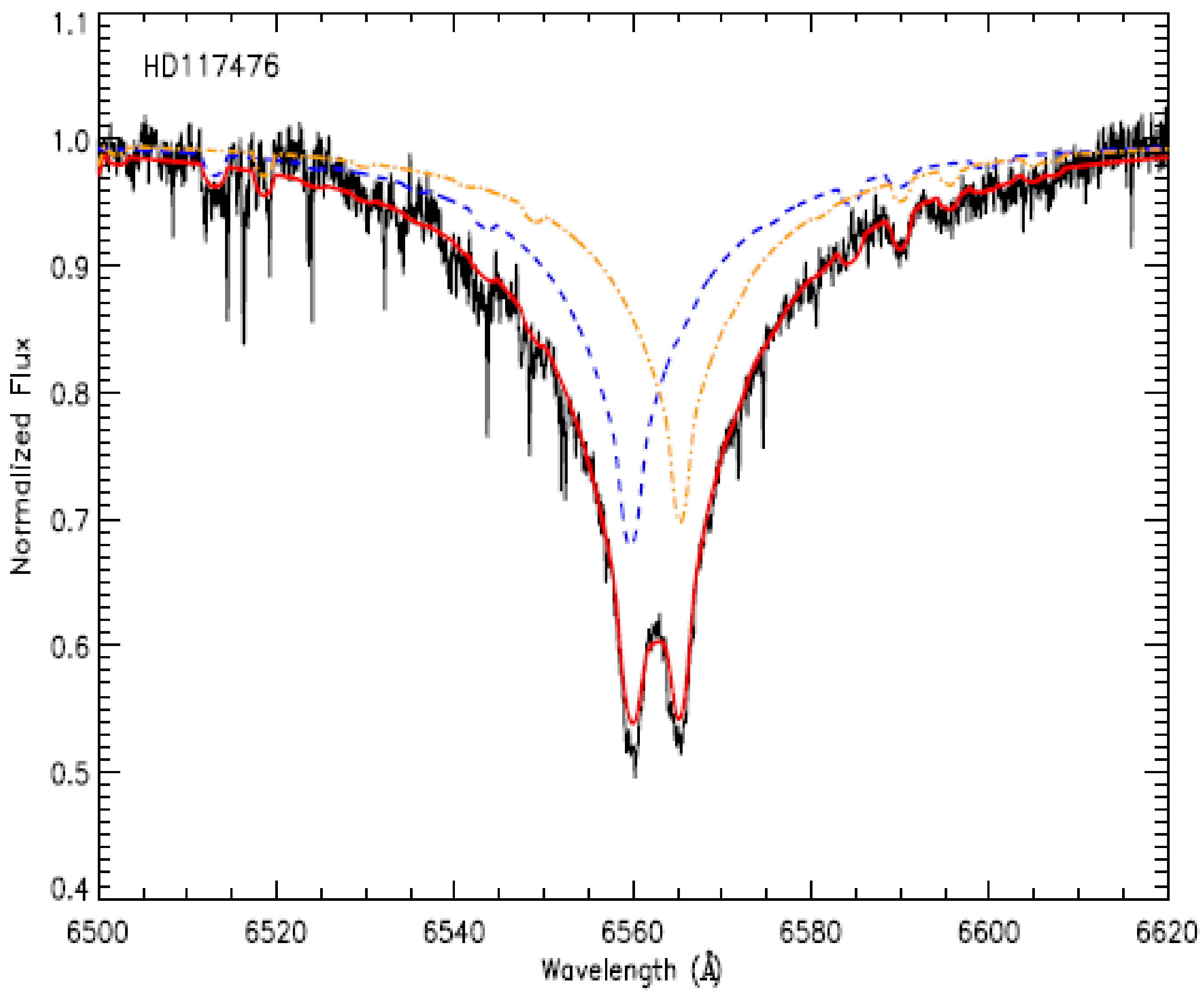
- We employed the FXCOR task from the IRAF2 program package (Tody 1986).
- the ATLAS9 model atmospheres (Kurucz 1993) with the SYNTHE code (Kurucz & Avrett 1981)
- The vr measurements were subsequently analyzed utilizing the rvfit program (Iglesias-Marzoa, López-Morales, & Jesús Arévalo Morales 2015)

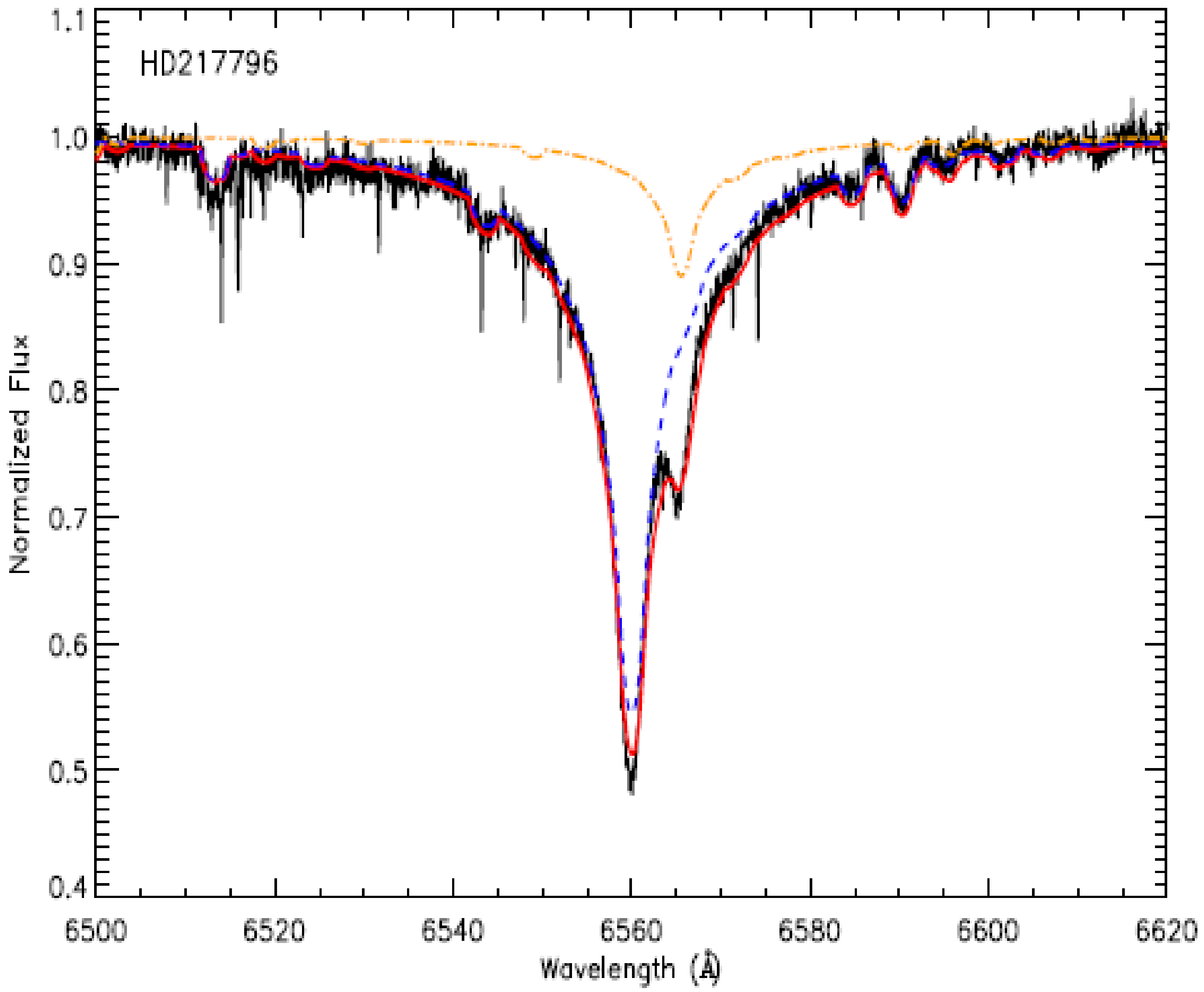
Radial Velocity Analysis

Parameter	HD 117476	HD 217796
T_0 (HJD)	2458000.427 (8)	2458000.638 (2)
γ (km/s)	-17.6 (4)	-3.1 (3)
K_p (km/s)	132.9 (8)	109.4 (4)
K_s (km/s)	133.3 (1.3)	138.3 (9)
e [a]	0.0	0.0
ω[a] (deg)	90.0	90.0
$a_p \sin i$ ($R_\odot$)	3.45 (2)	4.44 (2)
$a_s \sin i$ ($R_\odot$)	3.46 (3)	5.63 (4)
$a \sin i$ ($R_\odot$)	6.91 (4)	10.07 (4)
$M_p \sin^3 i$ ($M_\odot$)	1.29 (3)	1.81 (3)
$M_s \sin^3 i$ ($M_\odot$)	1.28 (2)	1.43 (1)
$q = M_s/M_p$	0.997 (1)	0.791 (6)

Determination of atmospheric parameters

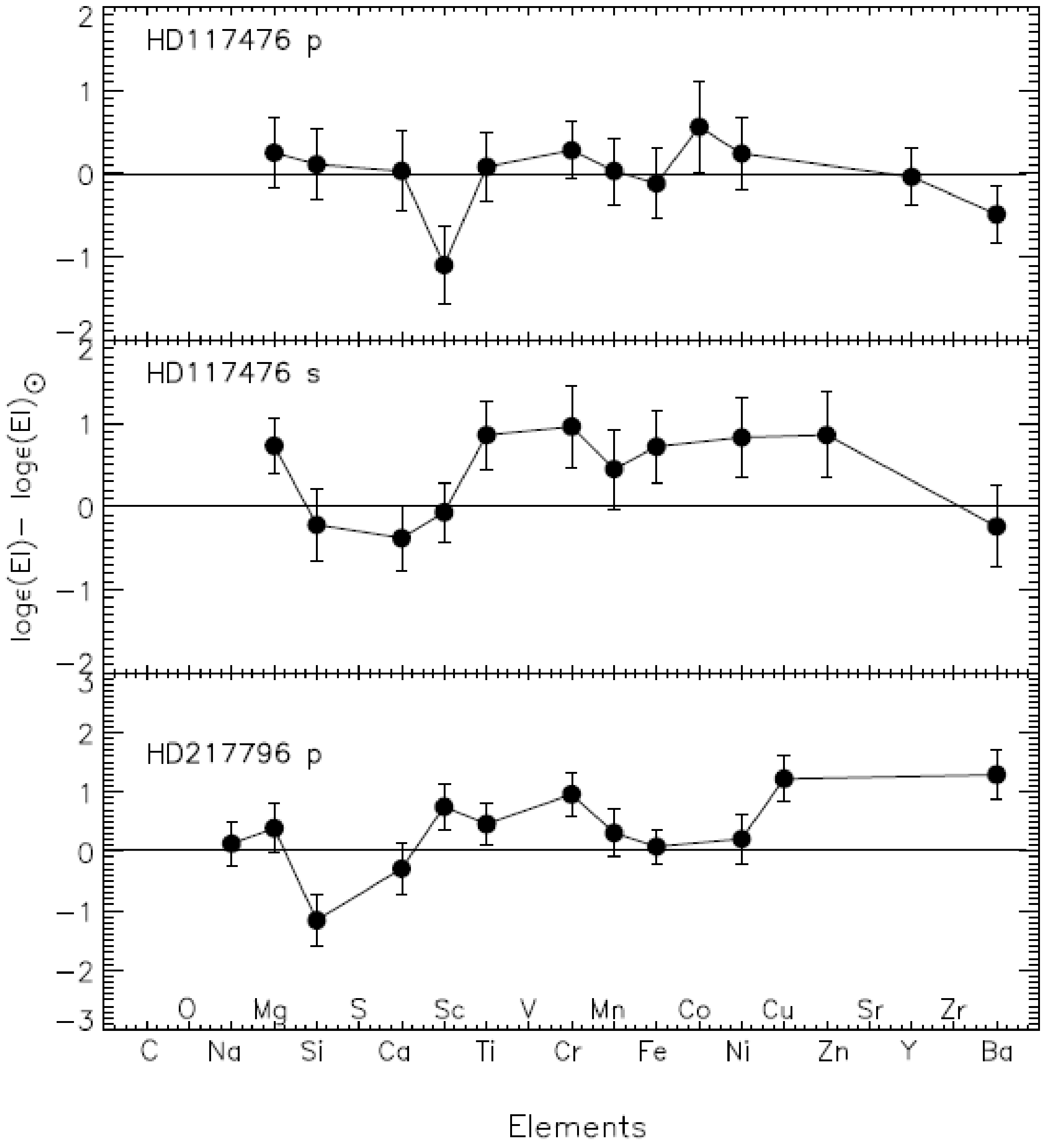
We utilized the FDBINARY code (Ilijic et al. 2004), which disentangles a composite spectrum in Fourier space.



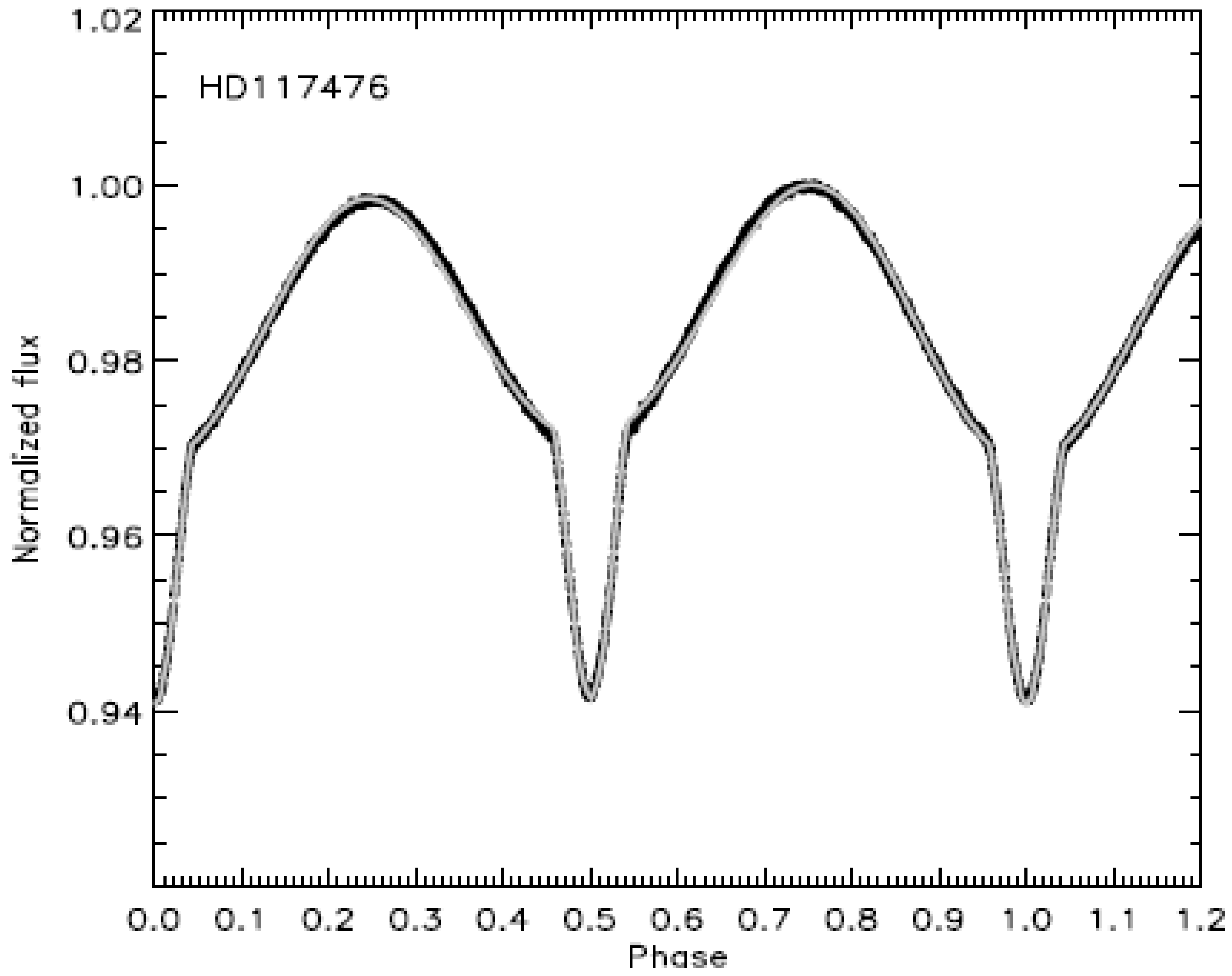


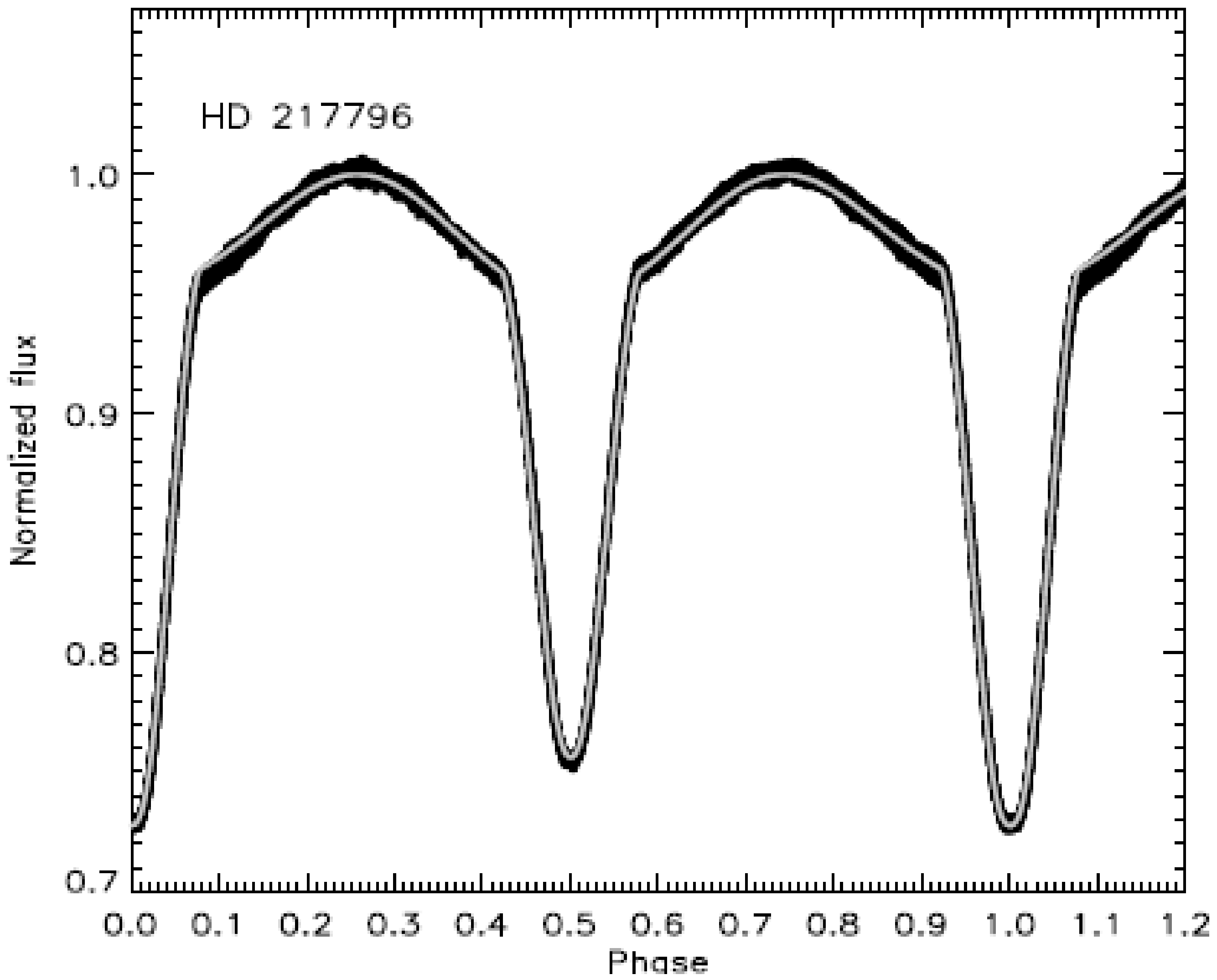
Determination of atmospheric parameters

Star	Hβ line	Fe lines				
	T_{eff} (K)	T_{eff} (K)	log g (cgs)	ξ (km s^{-1})	$v \sin i$ (km s^{-1})	log ϵ (Fe)
HD 117476 $_p$	8000 ± 200	7800 ± 100	4.0 ± 0.1	2.30 ± 0.2	66 ± 4	7.38 ± 0.42
HD 117476 $_s$	7800 ± 200	7900 ± 200	4.3 ± 0.1	3.00 ± 0.2	62 ± 4	8.21 ± 0.44
HD 217796 $_p$	7100 ± 200	7100 ± 200	3.6 ± 0.1	3.1 ± 0.2	79 ± 4	7.50 ± 0.29
HD 217796 $_s$	6900 ± 200	6800 ± 200	4.1 ± 0.2	2.2 ± 0.3	59 ± 7	7.18 ± 0.56



Binary
Modeling





The pulsations were initially modeled using the Period04 program (Lenz&Breger 2005), which applies the Fourier transform to the time series.

For the analysis of binarity, we used the well-known Wilson- Devinney binary modeling code (W-D, Wilson & Devinney 1971).

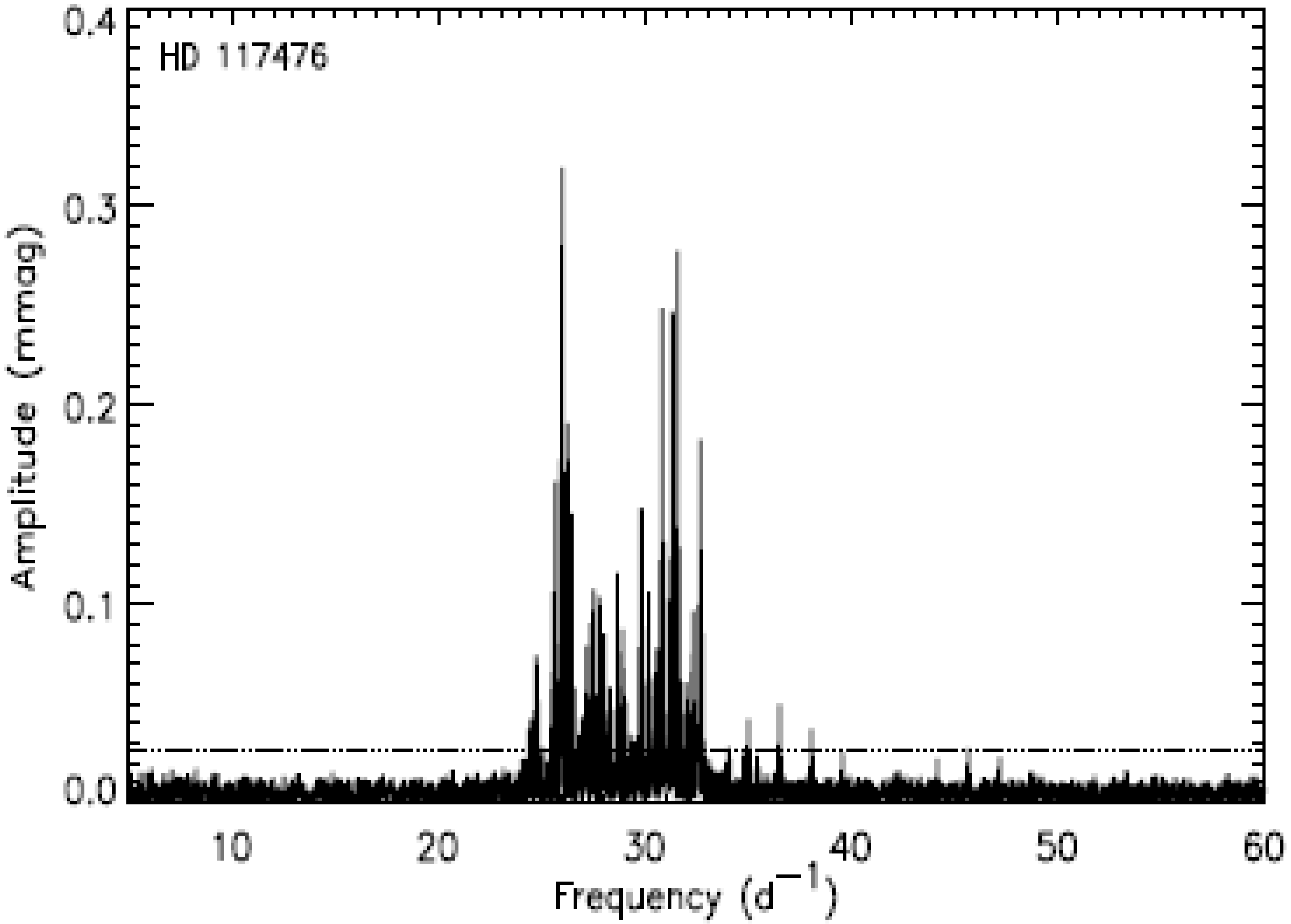
Binary Modeling

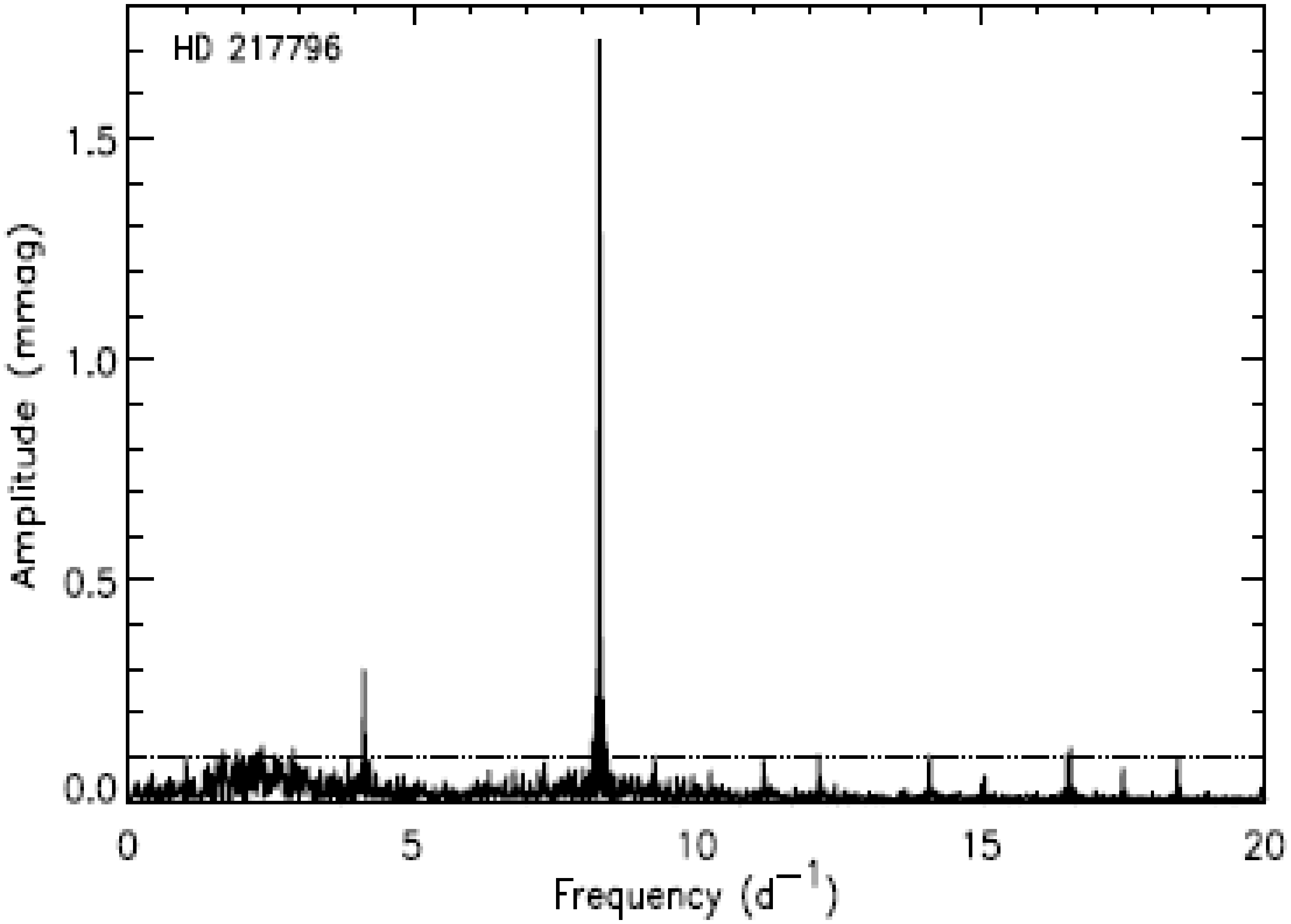
Parameter	HD 117476	HD 217796
i (^{o})	65.17 ± 0.01	80.74 ± 0.01
$T_{\rm eff\,p}{}^a$ (K)	7800 ± 200	7100 ± 200
$T_{\rm eff\,s}$ (K)	7890 ± 225	6720 ± 220
Ω_p	5.050 ± 0.010	4.065 ± 0.012
Ω_s	5.092 ± 0.015	5.698 ± 0.016
ϕ	0.0009 ± 0.0001	0.0002 ± 0.0001
q	0.997 ± 0.001	0.791 ± 0.006
$r_p{}^*$ (mean)	0.249 ± 0.002	0.310 ± 0.002
$r_s{}^*$ (mean)	0.246 ± 0.002	0.173 ± 0.002
l_p / (l_p+l_s)	0.499 ± 0.02	0.80 ± 0.02
l_s /(l_p+l_s)	0.501 ± 0.02	0.20 ± 0.02
l_3	-	0.07 ± 0.01
Derived Quantities		
M_p $(M_\odot)$	1.72 ± 0.03	1.88 ± 0.03
M_s $(M_\odot)$	1.72 ± 0.02	1.49 ± 0.01
R_p $(R_\odot)$	1.90 ± 0.07	3.16 ± 0.04
R_s $(R_\odot)$	1.87 ± 0.06	1.77 ± 0.09
log L_p $(L_\odot)$	1.08 ± 0.02	1.36 ± 0.02
log L_s $(L_\odot)$	1.09 ± 0.01	0.76 ± 0.04
log g_p (cgs)	4.12 ± 0.07	3.70 ± 0.07
log g_s (cgs)	4.13 ± 0.09	4.11 ± 0.06
$M_{bol\,p}$ (mag)	2.05 ± 0.05	1.34 ± 0.07
$M_{bol\,s}$ (mag)	2.03 ± 0.07	2.84 ± 0.03
$M_{V\,p}$ (mag)	1.97 ± 0.09	1.27 ± 0.04
$M_{V\,s}$ (mag)	2.38 ± 0.18	1.03 ± 0.03
Distance (pc)	181 ± 7	260 ± 18

*fractional radius, R/a.

Pulsation Analysis

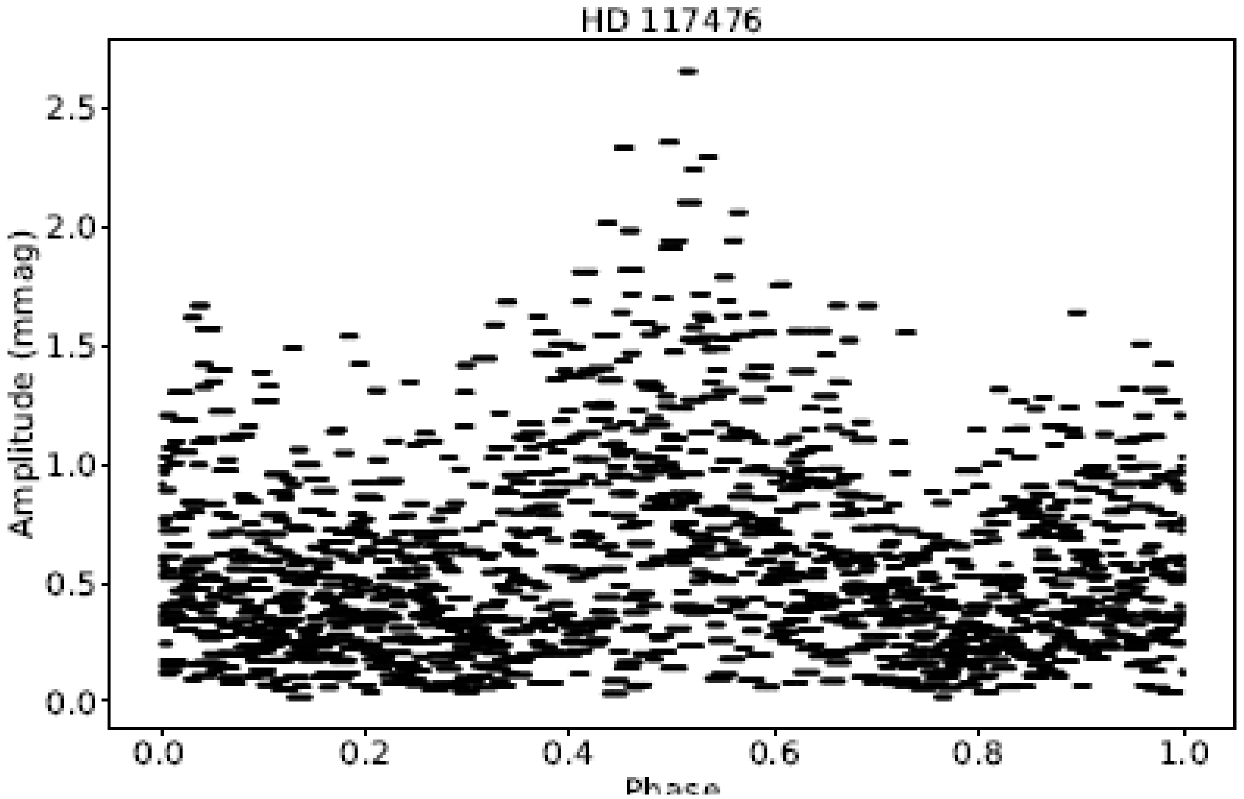
The pulsation frequency analysis of the systems was carried out with the Period04 program (Lenz & Breger 2005).
We took into account the study given by Baran & Koen (2021) to determine the significance limit for the frequencies.

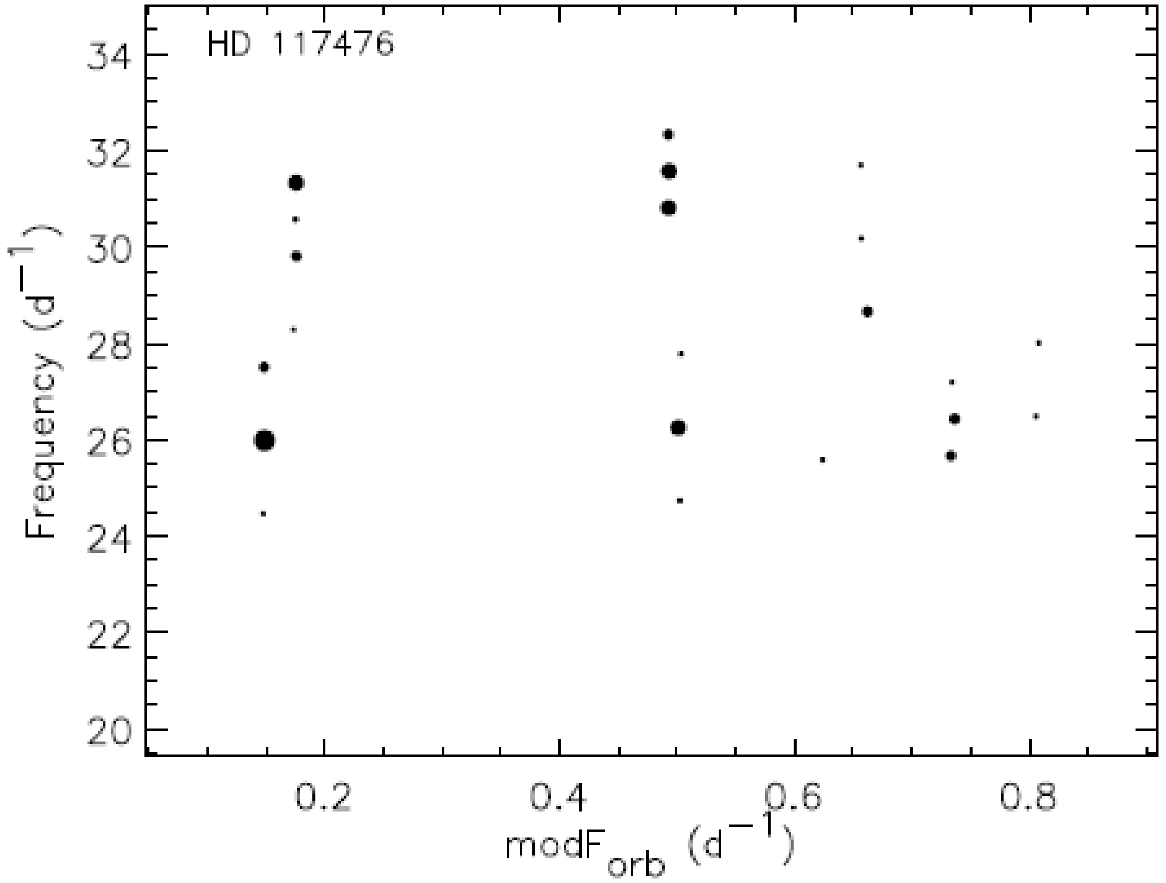




Pulsation Analysis : HD 117476

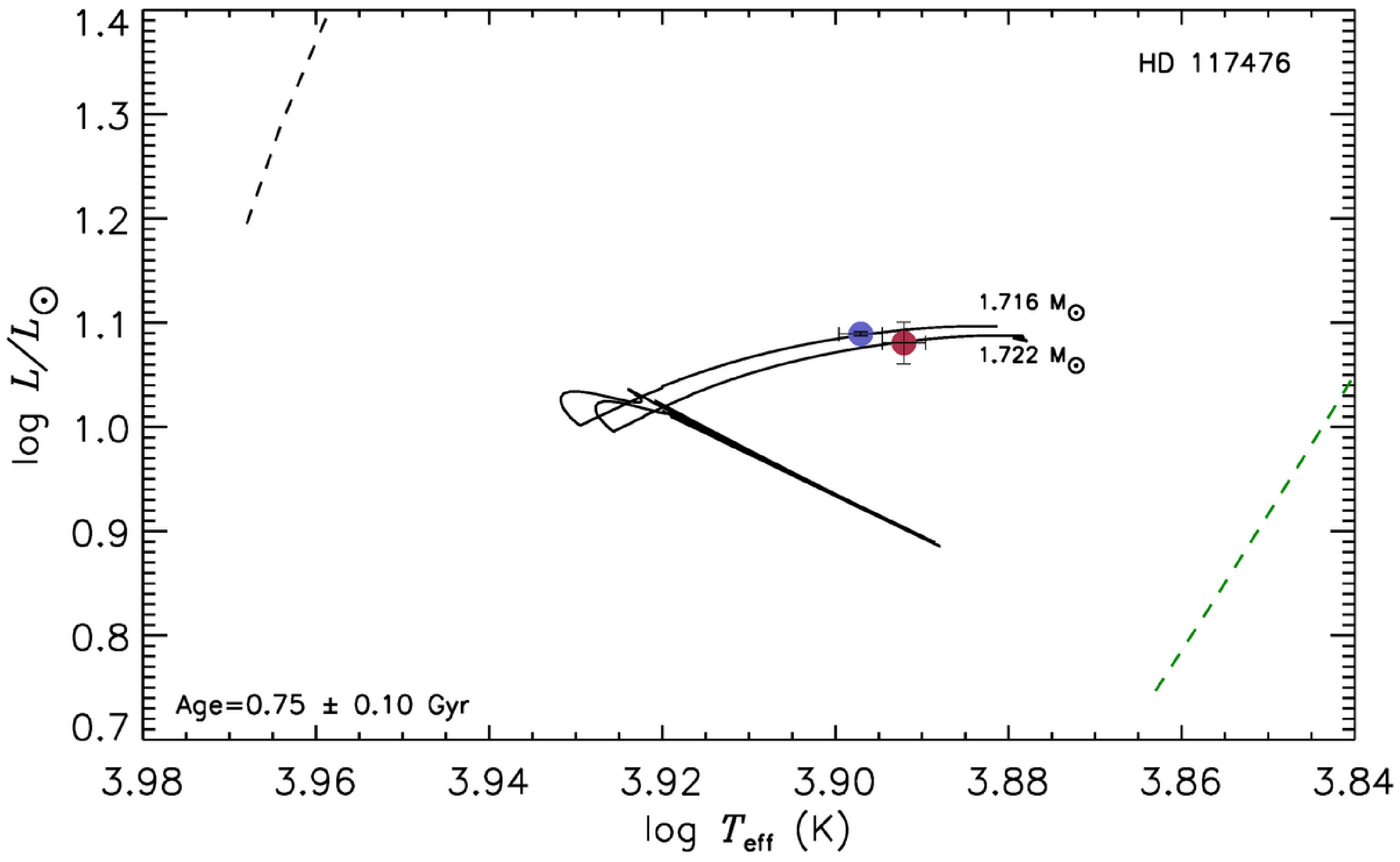
	Frequency d^{-1}	Amplitude mmag ±0.02	SNR
$f_1 + 2f_{orb}$	27.5097 (3)	0.11	10
f_1	25.9878 (1)	0.34	37
$f_2 + f_{orb}$	32.3377 (3)	0.11	10
f_2	31.5772 (1)	0.27	33
$f_2 - f_{orb}$	30.8158 (1)	0.24	29
f_3	31.3355 (1)	0.23	27
$f_3 - f_{orb}$	30.5740 (4)	0.02	8
$f_3 - 2f_{orb}$	29.8136 (2)	0.15	15
$f_3 - 4f_{orb}$	28.2897 (4)	0.06	6
$f_4 + 2f_{orb}$	27.7798 (4)	0.09	8
f_4	26.2560 (2)	0.22	21
$f_4 - 2f_{orb}$	24.7350 (3)	0.09	13
$f_5 + 2f_{orb}$	27.1945(4)	0.08	7
$f_5 + f_{orb}$	26.4351 (3)	0.14	13
f_5	25.6717 (3)	0.17	20
$f_6 + 4f_{orb}$	31.7015 (4)	0.06	7
$f_6 + 2f_{orb}$	30.1796 (3)	0.10	10
f_6	28.6616 (3)	0.12	12
f_7	28.0118 (3)	0.09	8
f_8	25.5885 (3)	0.07	8

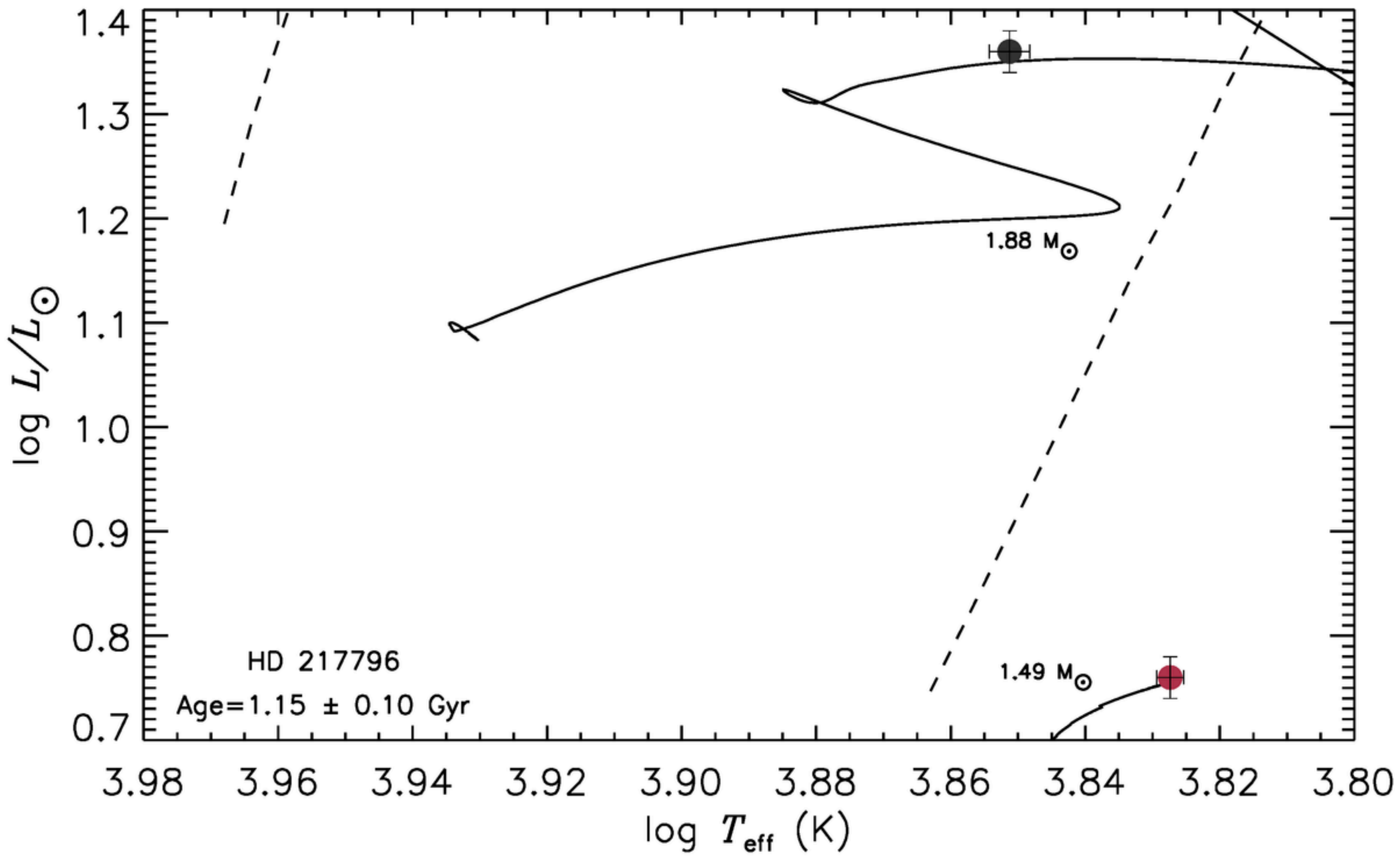




	Frequency d^{-1}	Amplitude mmag ±0.02	SNR
f_1	8.2848 (1)	1.73	113
f_2	4.1436 (2)	0.29	11
f_3	16.5708 (6)	0.12	10

Evolutionary Modeling

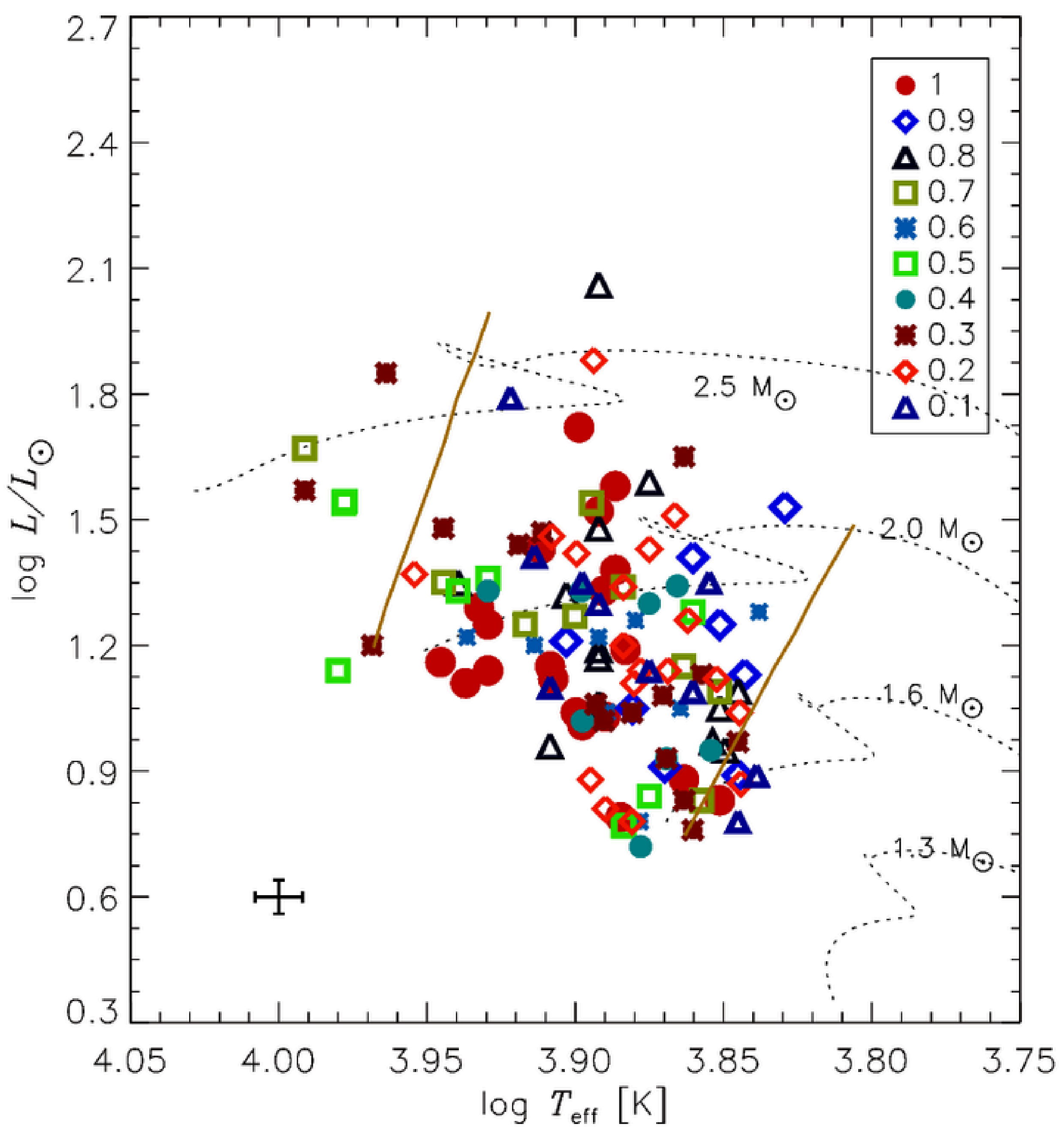


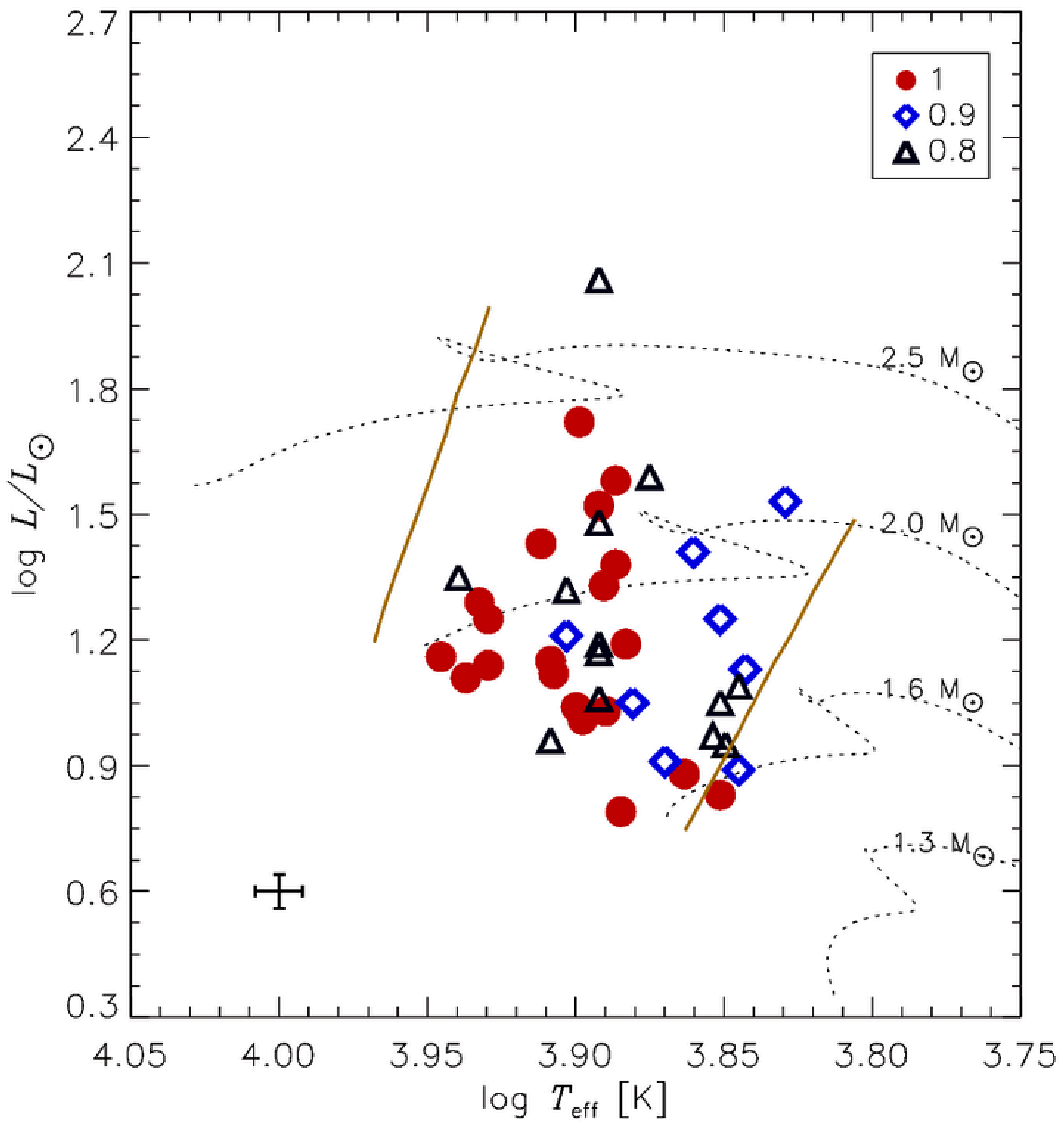


Parameter	HD 117476	HD 217796
$M_{p initial}$ (days)	1.722 (3)	1.88 (1)
$M_{s initial}$ (days)	1.716 (3)	1.49 (1)
$P_{initial}$ (days)	2.14 (3)	2.94 (2)
Z_p	0.014 (2)	0.018 (2)
Z_s	0.013 (2)	0.018 (2)
Age (Gyr)	0.75 (8)	1.15 (3)

The Modules for Experiments in Stellar Astrophysics (MESA) code (Paxton et al. 2011, 2013). This code includes a binary module (Paxton et al. 2015) to analyze the binary orbital evolution and determine the initial parameters of binary systems

Results & Discussion





THANK YOU

FOR LISTENING