Curve of Growth Analysis of High-Resolution and Low-Resolution Spectra of SZ Lyn

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Abstract

SZ Lyn is a high amplitude Delta Scuti type star in a binary system. The star is observed by TESS and Mount Abu observatory in UBVR bands for photometry. The photometric observations reveal the existence of radial and non-radial oscillation modes. We present the high-resolution follow-up spectrum obtained with HERMES at the 1.2-m Mercator telescope (Roque de los Muchachos Observatory, La Palma, Spain) and the temporal variations of 561 low-resolution spectra gathered with the LISA spectrograph at the 0.5-m CDK (Mount Abu Observatory, India). In stellar pulsation, the temperature change is a major component of the variation of equivalent width. The equivalent widths of three Balmer lines, Hα, Hβ and Hγ were measured over the pulsation cycle. The temperature profile of the pulsating star SZ Lyn was derived using the curve of growth analysis. Furthermore, the stellar parameters were determined through a best fit analysis of synthetic spectral lines. The spectroscopic best fit determines T_{eff} = 6750 K, log(g)=3.5 dex, and V_{rot}=10 km/s for a solar abundance star.

1. Introduction

SZ Lyn is a short period Delta Scuti type pulsating star in a binary system. The star pulsates in both radial and non-radial modes, of which the dominant one is radial.

Parameter of SZ Lyn	Value	Remarks
Pulsation Period	0.1205263 days	J. Adassuriya et al. (2021) (Photometric Observation)
Temperature	7500 – 7800 K	
Orbital Period	1187 days	J. Adassuriya et al. (2018) (Photometric Observation)
Eccentricity (*e*)	0.18	
Inclination (*i*)	39 degrees	Sheng-Bang et al. (2013)
Mass function	0.095 M_{sun}	Gazeas (2004)
Mass	M_p=1.90 M_{sun} M_s=1.65 M_{sun} or 0.88 M_{sun}	M_s are the real solutions of binary mass function

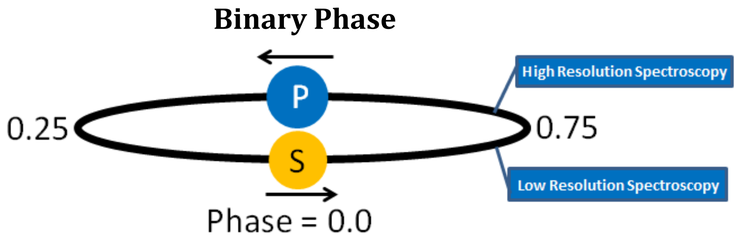
2. Spectroscopic Observations

The 0.5-m CDK with LISA spectrograph, Mount Abu Observatory, India.

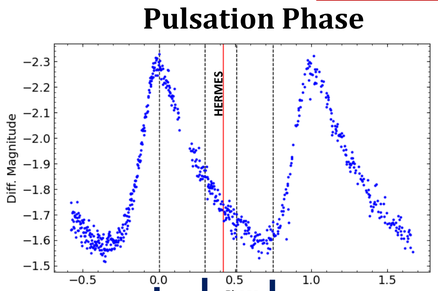
The 1.2-m Mercator Telescope with HERMES Fibre-fed echelle spectrograph, Roque de los Muchachos Observatory, La Palma, Spain.

Low resolution R = 1000 – Mount Abu	High Resolution R = 85000 – HERMES
Number of spectra = 561	Number of spectra = 1
08 Dec. 2016 – 12 Dec. 2016 (9.24 h)	17 Sep. 2020 (0.75 h)
$T_{obs} = T_0 + E \times T_{orb}$	
$T_0(Binary\ Phase) = 2445156.600\ JD\ (Imbert,\ 1984)$	
Binary Phase = 0.69	Binary Phase = 0.80

Binary Phase

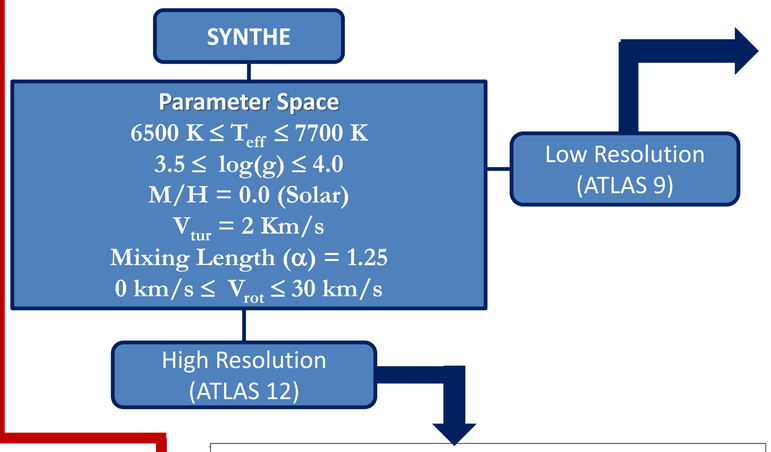


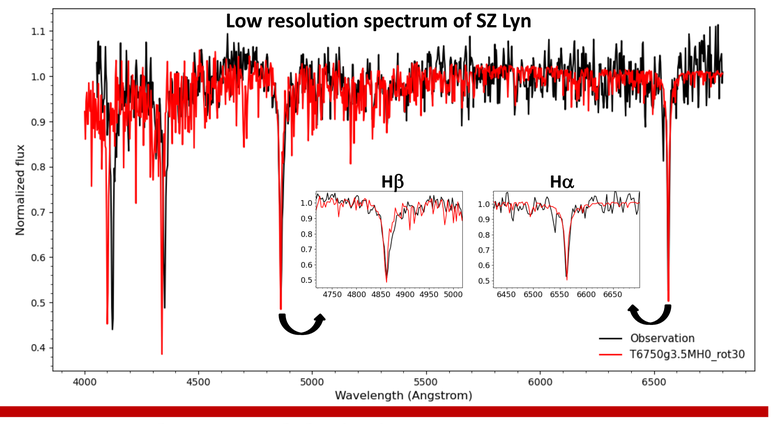
Pulsation Phase

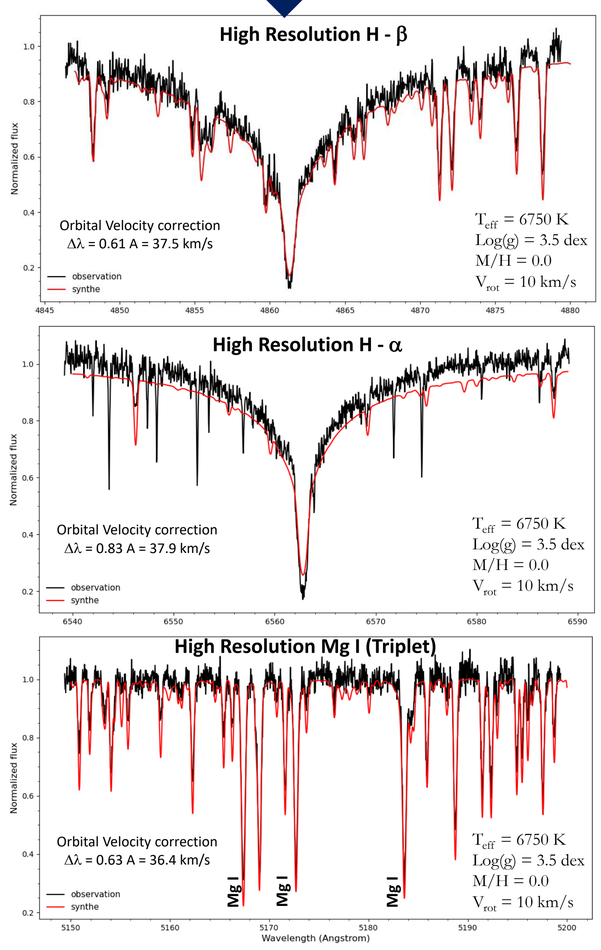


3. Synthetic Spectra of SZ Lyn

The synthetic line profiles of SZ Lyn were produced by the SYNTHE code (Kurucz, 1993). The code uses the atmospheric modes of ATLAS 9 (low-resolution) and ATLAS 12 (high-resolution).

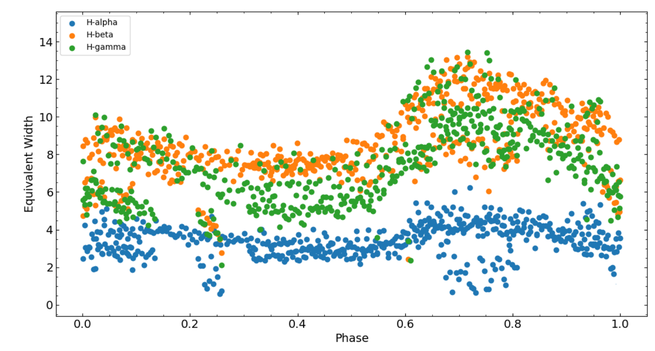






4. Equivalent Width (W)

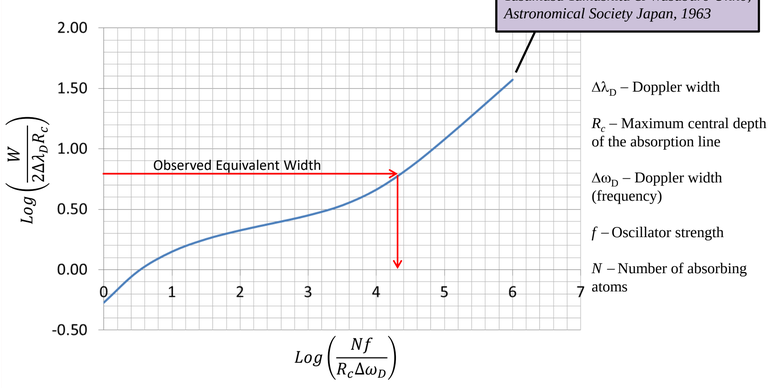
The equivalent width W is a measure of the quantity of light, which is cut out from the continuum of a star within an absorption line by absorption processes. Geometrically it is identical with the area of the considered line under the normalized continuum.



Distribution of the equivalent width of Balmer lines. 561 low-resolution spectra were used to determine the individual equivalent widths values. The phase calculation was done using the epoch of **T_0 = 2456664.261713 HJD**. This is the maximum flux observed on 6th January 2014 at Mount Abu observatory.

5. Curve of Growth Analysis

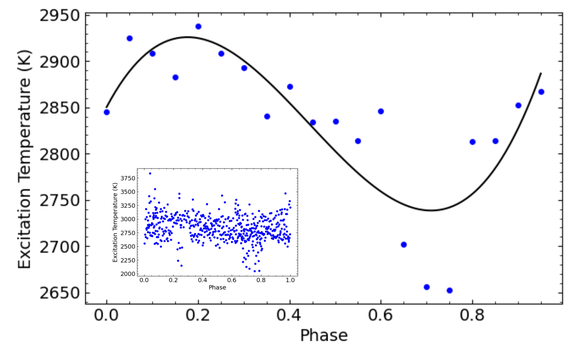
Theoretical study of curve of growth, Yasumasa Yamashita & Wasaburo Unno, Astronomical Society Japan, 1963



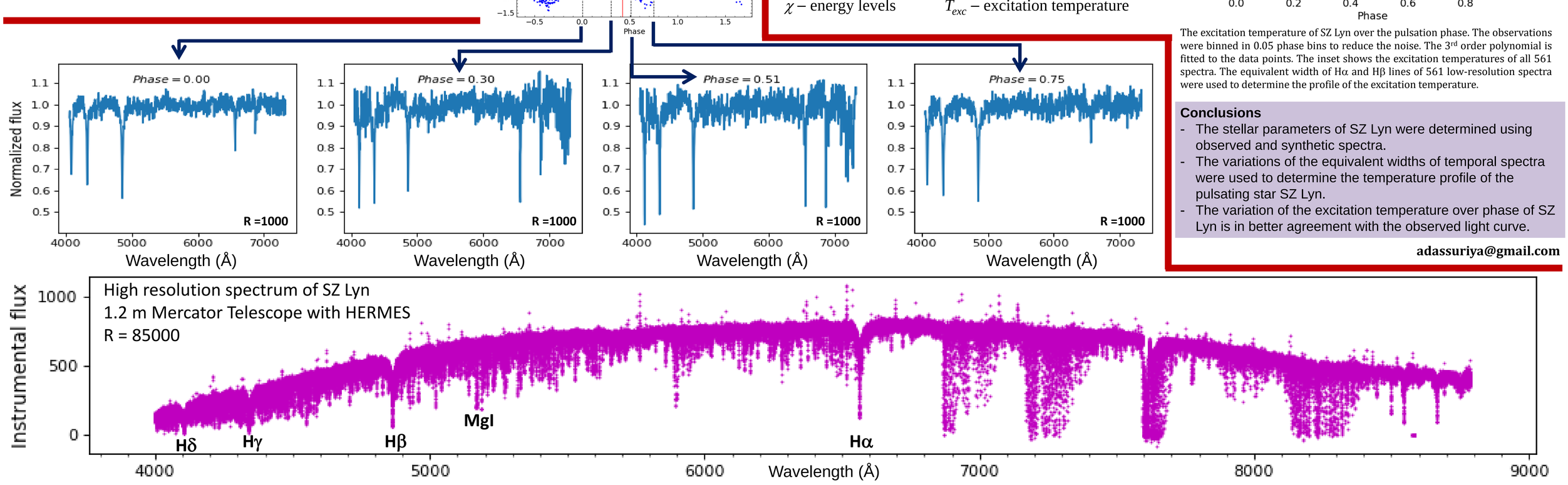
Boltzmann Equation

$$\frac{N_1}{N_2} = \frac{g_1}{g_2} e^{\frac{-(\chi_1 - \chi_2)}{kT_{exc}}}$$

g – statistical weights
χ – energy levels
k – Boltzmann constant
T_{exc} – excitation temperature



The excitation temperature of SZ Lyn over the pulsation phase. The observations were binned in 0.05 phase bins to reduce the noise. The 3rd order polynomial is fitted to the data points. The inset shows the excitation temperatures of all 561 spectra. The equivalent width of Hα and Hβ lines of 561 low-resolution spectra were used to determine the profile of the excitation temperature.



Conclusions

- The stellar parameters of SZ Lyn were determined using observed and synthetic spectra.
- The variations of the equivalent widths of temporal spectra were used to determine the temperature profile of the pulsating star SZ Lyn.
- The variation of the excitation temperature over phase of SZ Lyn is in better agreement with the observed light curve.

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