



## Data Collection

SZ Lyn is a Delta Scuti type variable star<sup>1</sup>, which is the second most common type of pulsating variable star in our galaxy<sup>7</sup>. On April 14, 2016, at the Rochester Institute of Technology (RIT) Observatory, pictures of SZ Lyn were taken. Using an ATIK 11000 CCD camera, with a Meade 12" telescope, pictures were taken in the V-band. The data was taken over the course of 2 hours and 55 minutes.

The target, SZ LYN, is located at RA: 08:09:35.73888 and DEC: +44:28:17.5476, see Figure 1.

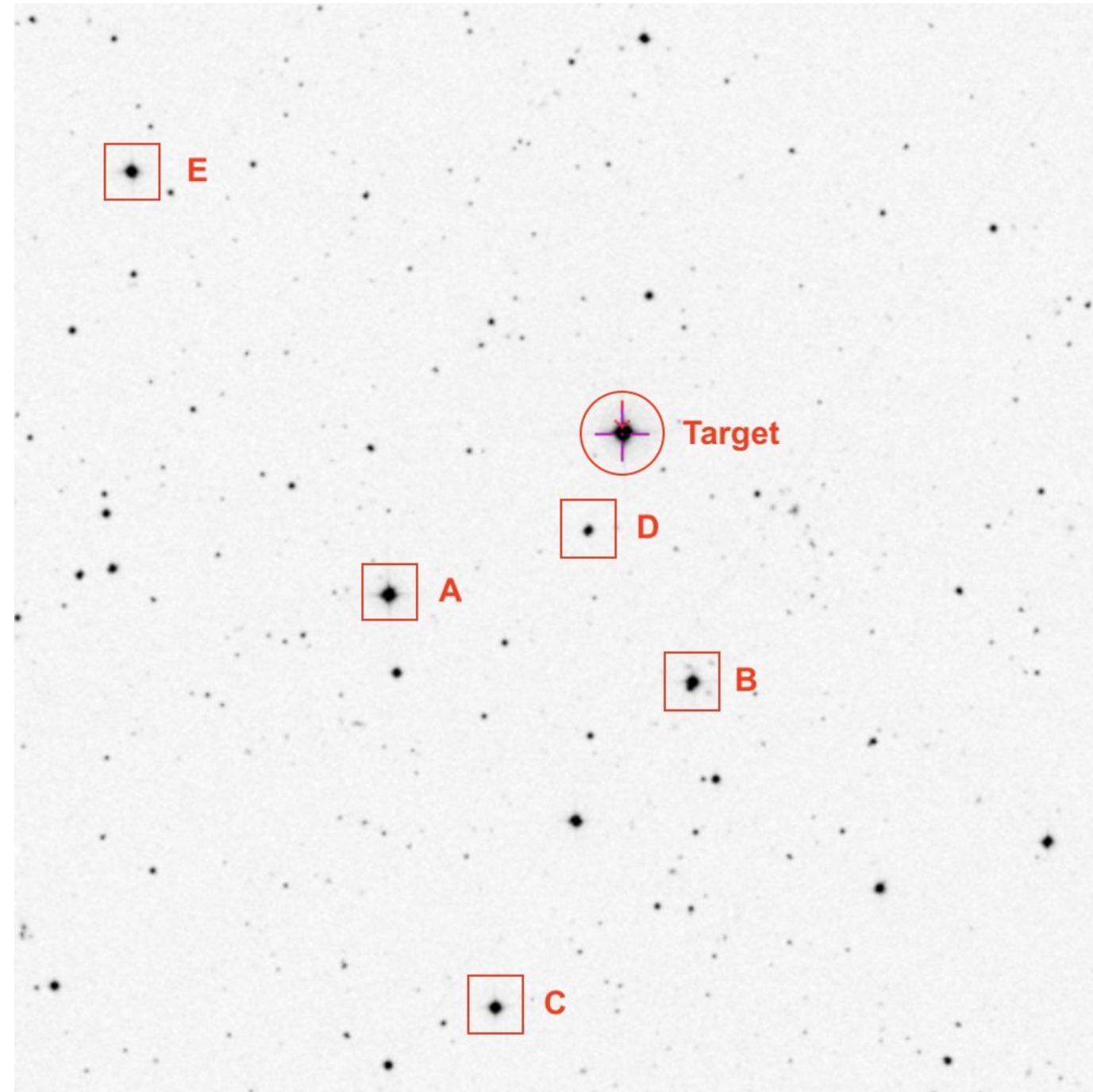


Figure 1: The field we are analysing, featuring our target star and five other chosen stars.

## Making Light Curves

$$\text{instrumental mag of star X} = -2.5 \log_{10} \left( \frac{\text{intensity of X}}{\text{intensity of ref}} \right) \quad (1)$$

Below, we analyze the intensity data using *AstroImageJ* and construct light curves over the 2 hours and 55 minutes of data. Instrumental magnitude of each star is calculated using Equation 1 where our reference star is Star B.

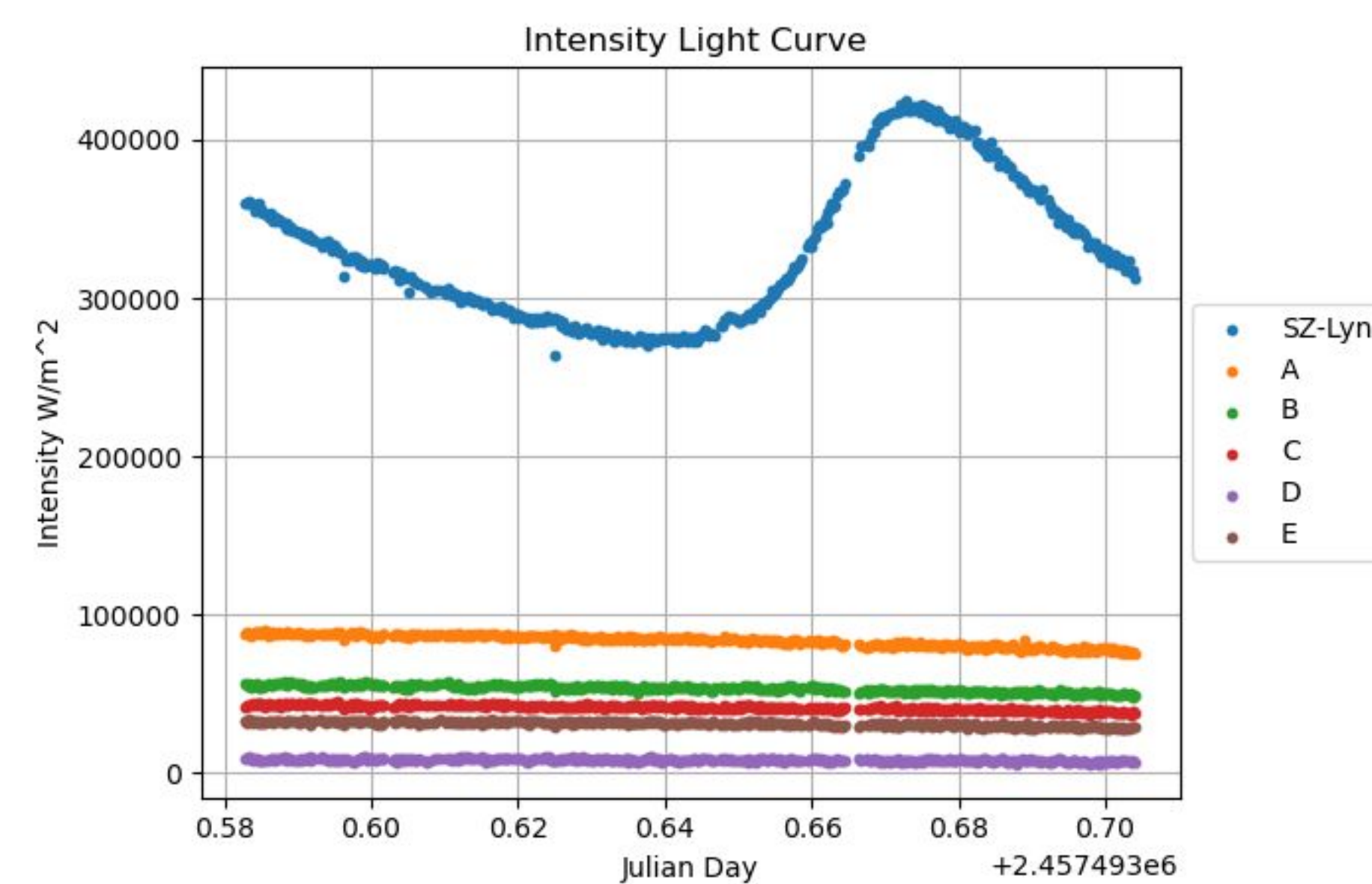


Figure 2: The intensity of the target star compared to surrounding stars.

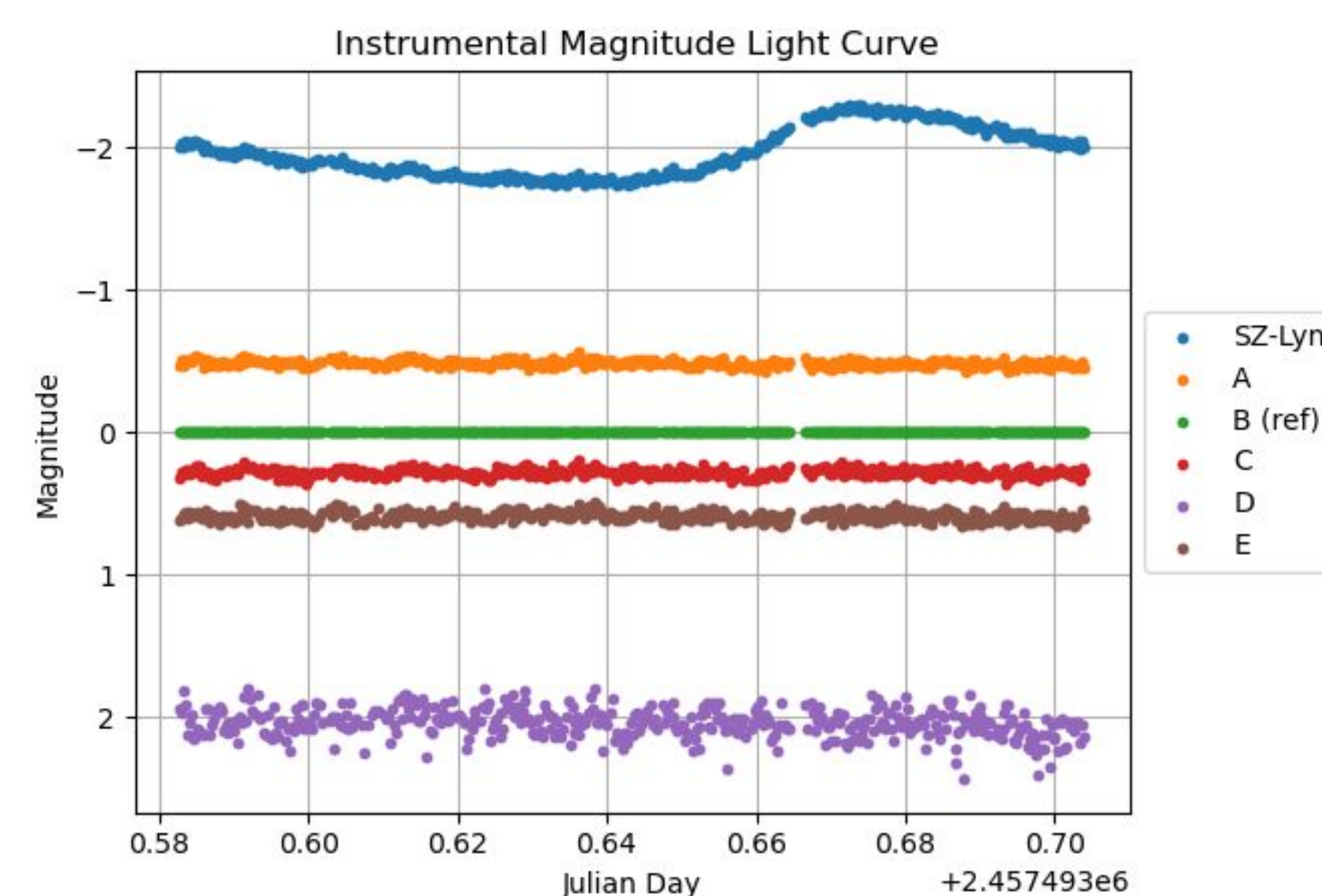


Figure 3: The intensity of each star converted to relative magnitude using star B as the reference.

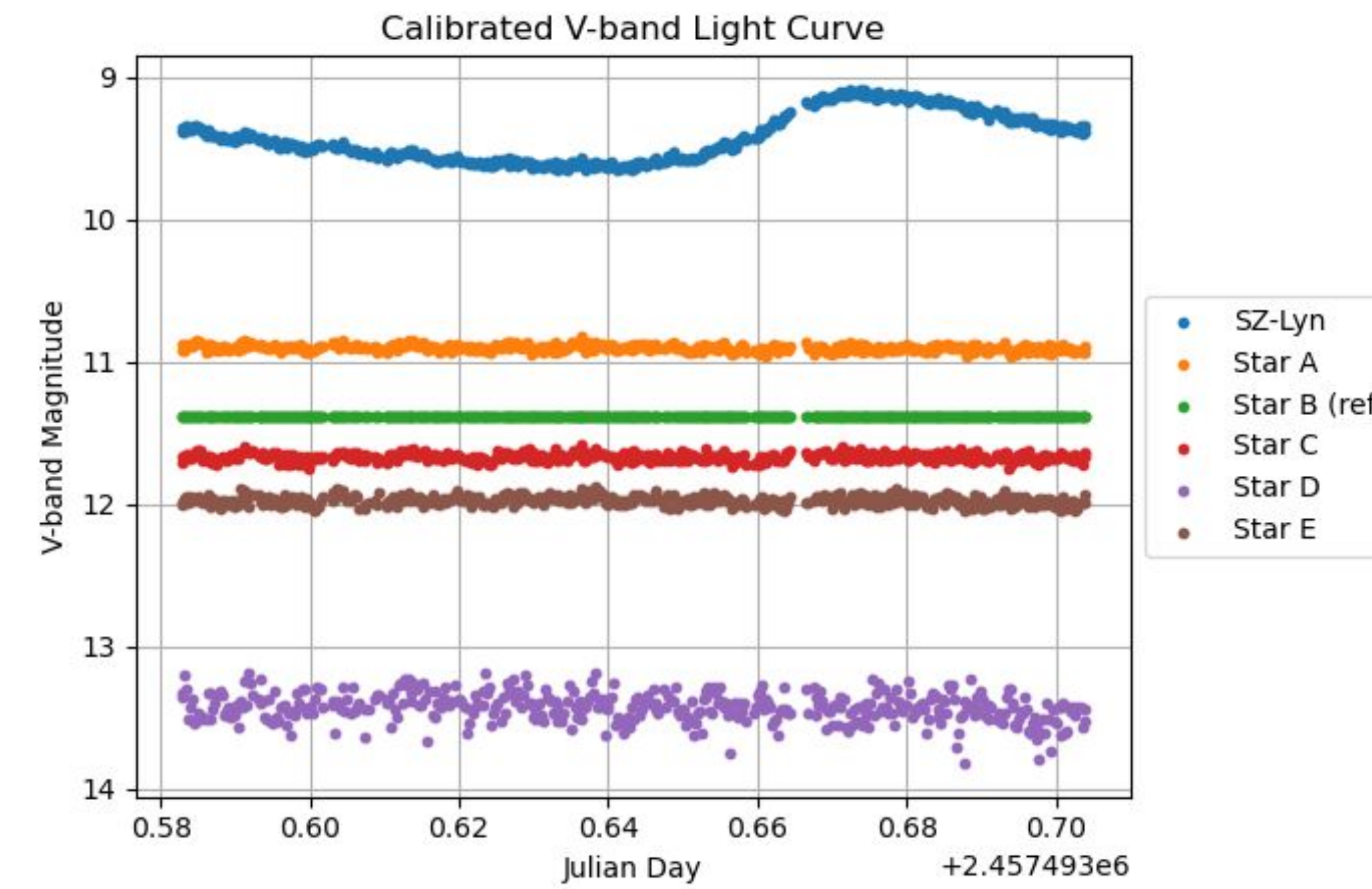


Figure 4: The instrumental magnitude converted to V-band magnitudes using a v-band magnitude of 11.391 for star B<sup>1</sup>.

## Calculating Period

We calculate the phase using the Equation 2 and compare it to the calibrated magnitude over a full cycle. We find the period by estimating the period of the star based on the light curves and adjust the period until a smooth curve is visible as shown in Figure 5. The period  $P$  is 2 hours and 53 minutes.

$$\text{phase}(\phi) = \left( \frac{t}{\text{Period}} \right) - \text{int} \left( \frac{t}{\text{Period}} \right) \quad (2)$$

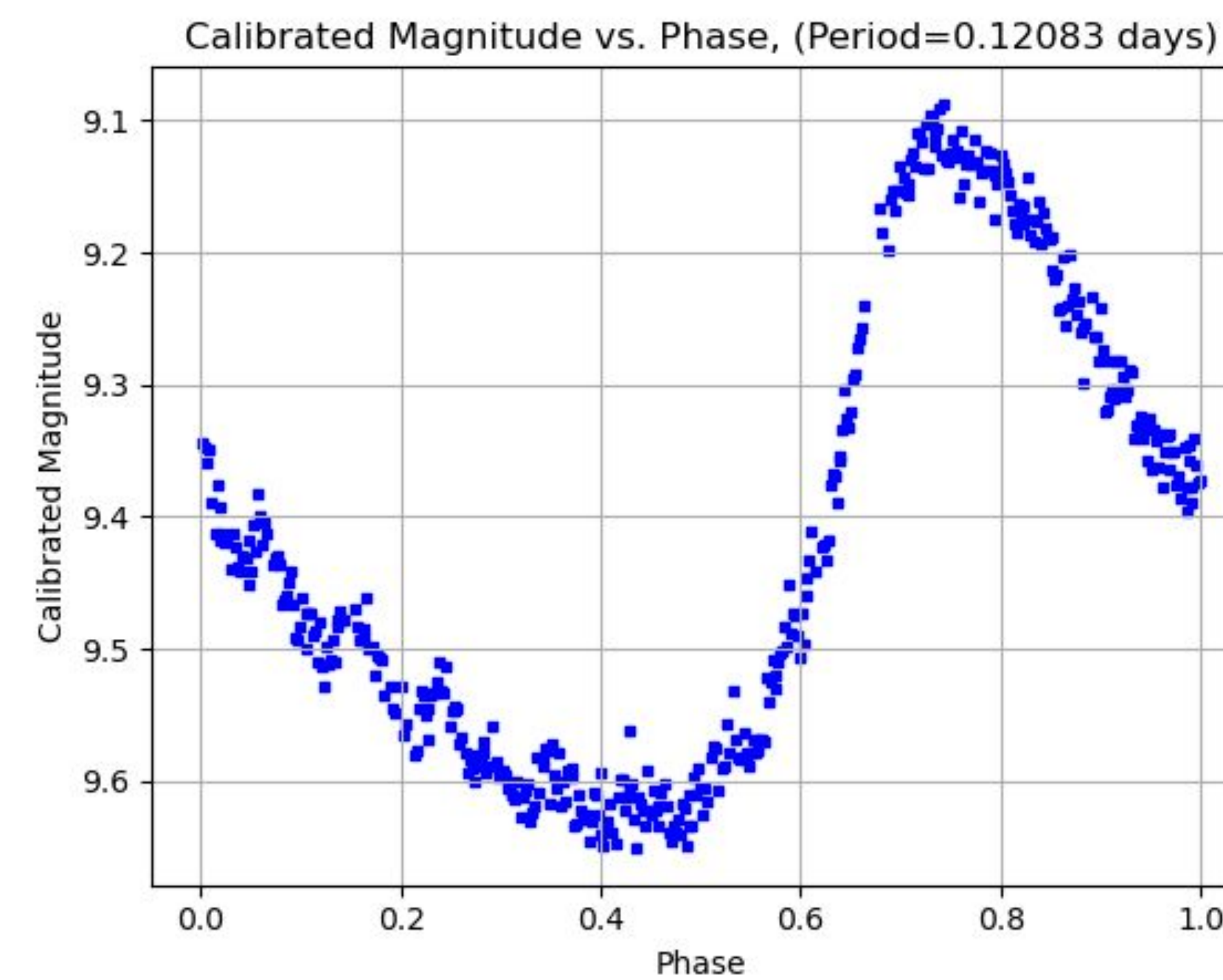


Figure 5: The time converted to phase to show the magnitude of SZ Lyn over an entire cycle.

## Calculating Distance and Magnitude

$$d = \frac{1 \text{ AU}}{p} \quad (3)$$

Using the parallax  $p$  found in the Gaia Archive for SZ Lyn<sup>2</sup>, we are able to find the distance  $d$  using Equation 3. The distance is 523.4 parsecs.

$$m - M = 5 \log_{10} \left( \frac{d}{10} \right) \rightarrow M = m - 5 \log_{10} \left( \frac{d}{10} \right) \quad (4)$$

Once we have the distance, we are able to calculate the absolute magnitude  $M$  with Equation 4. The absolute visual magnitude  $M$  is 0.826. Additionally, using the average V-band magnitude we calculated from our light curves, 9.421, and the B-band magnitude, 10.05<sup>1</sup>, we found the B-V magnitude which is 0.631.

With both the absolute magnitude and the B-V value, we are able to find where SZ Lyn falls on Figure 6, an Hertzsprung-Russell (HR) diagram. This allows us estimate the temperature  $T$  at 5,900 K and the visual luminosity  $L$  at 2.500e28 W.

## Calculating Radius

$$L = 4\pi R^2 \sigma T^4 \rightarrow R = \frac{1}{2T^2} \sqrt{\frac{L}{\pi \sigma}} \quad (5)$$

If we assume SZ Lyn is a black body, then Equation 5 can be used to find the radius  $R$  since we already know the luminosity and temperature from the HR diagram. The radius is 5.381e9 meters. This is equivalent to 7.73x the radius of the sun. As a helpful visualization, Figure 7 shows the relative scale between the sun and SZ Lyn.

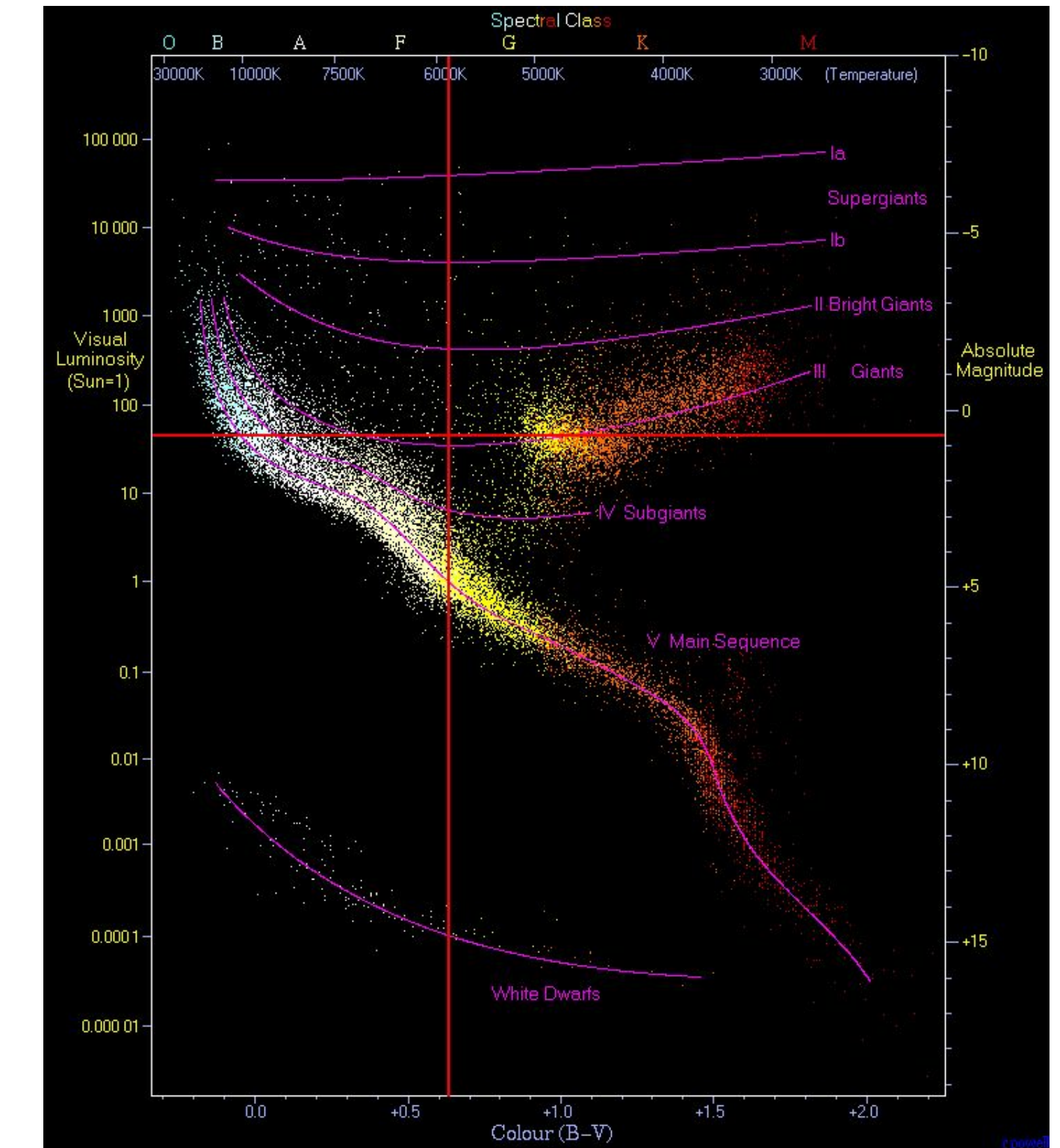


Figure 6: HR Diagram with the location of SZ Lyn marked.<sup>3</sup>

By doing the same process with the minimum and maximum instrumental magnitudes we can find that when SZ Lyn is at its brightest, it's radius is 13.2x the radius of our sun. When it is at its dimmest, it is 4.82x the radius of our sun.

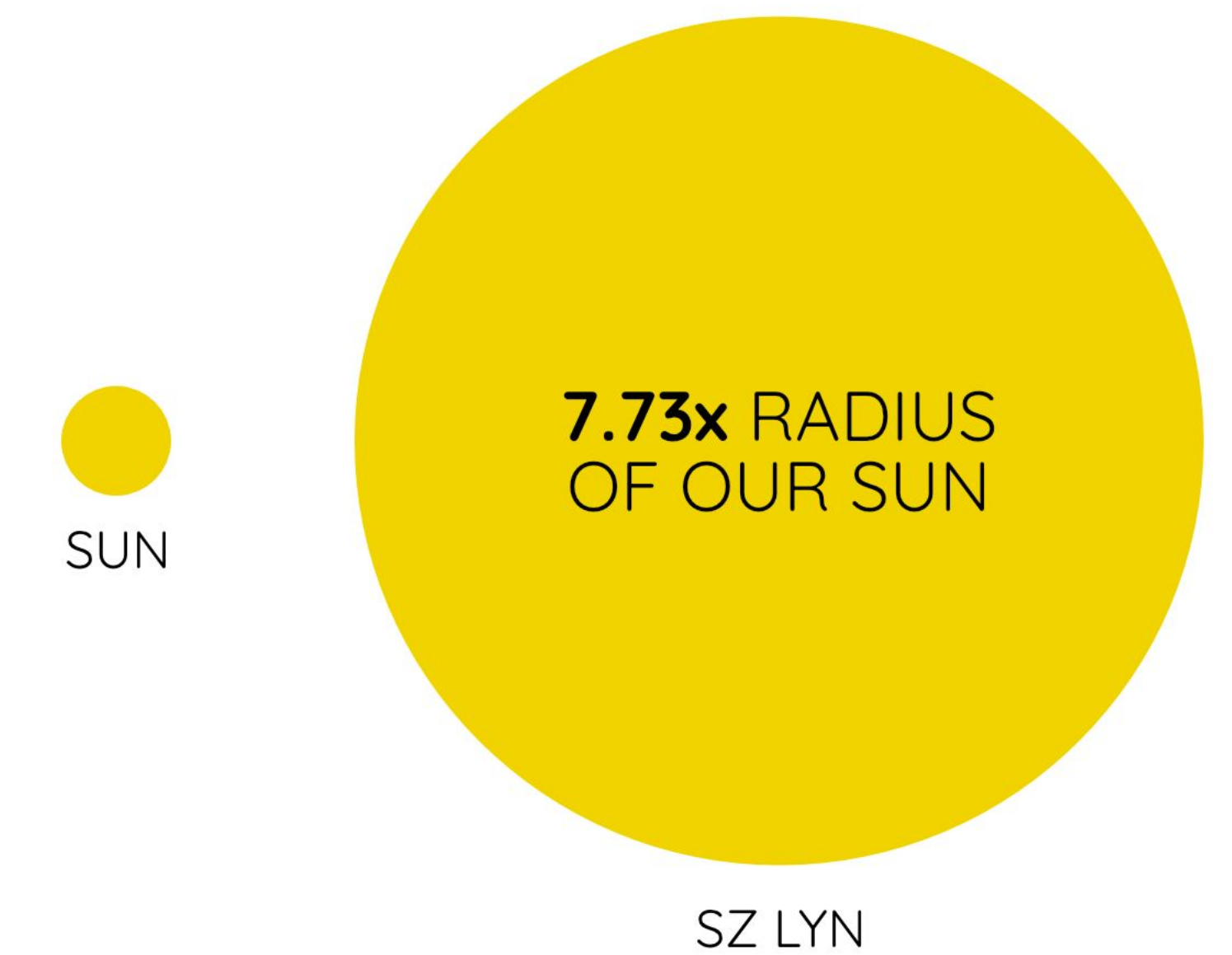


Figure 7: Relative size of SZ Lyn versus our sun.

## Results

Relative Magnitude ( $m$ ) = 9.421
Absolute Magnitude ( $M$ ) = 0.826
Period ( $P$ ) = 2.9 hours
Parallax ( $p$ ) = 0.0019104263"
Distance ( $d$ ) = 523.443 parsecs
Temperature ( $T$ ) = 5,900 K
Luminosity ( $L$ ) = 2.500 * 10 <sup>28</sup> W
Radius ( $R$ ) = 5.381 * 10 <sup>9</sup> m
Solar Radius Ratio ( $R/R_{\odot}$ ) = 7.73436194

Figure 8: Summary of SZ Lyn.

The radius of SZ Lyn has been previously measured as 2.76 solar radii<sup>4</sup>. The distance is 397 ± 11 pc<sup>5</sup>. This discrepancy is due to the limitations of our calculation technique, as well as variations of the parallax listed in the Gaia archive.

Our magnitude is consistent with the magnitude measured by Gaia which is 9.45<sup>2</sup>. Also the magnitudes place it in the instability strip on the HR diagram, where many variable stars are<sup>6</sup>.

## References:

- 1 VizieR. Ochslein F. et al. "The VizieR database of astronomical catalogues." 10.26093/cds/vizieR.
- 2 Gaia EDR3 Data Model. v.2.14. European Space Agency. <https://gea.esac.esa.int/archive/>.
- 3 An Atlas of the Universe. <http://www.atlasoftheuniverse.com/hr.html>.
- 4 J Adassuriya et al. "Astroseismology of SZ Lyn using multiband high time resolution photometry from ground and space." *Monthly Notices of the Royal Astronomical Society*, Volume 502, Issue 1, March 2021, Pages 541-555.
- 5 Bailer-Jones, C. A. L. "Estimating Distance from Parallaxes. IV. Distances to 1.33 Billion Stars in Gaia Data Release 2." *The Astronomical Journal*, Volume 156, Issue 2, article id. 58, 11 pp. (2018).
- 6 Cosmos. "Instability Strip." Swinburne University of Technology. <https://astronomy.swin.edu.au/cosmos/i/Instability+Strip>.
- 7 What are Delta Scuti Stars? [https://www.univie.ac.at/tops/dsn/texts/what\\_deltascuti.html](https://www.univie.ac.at/tops/dsn/texts/what_deltascuti.html)