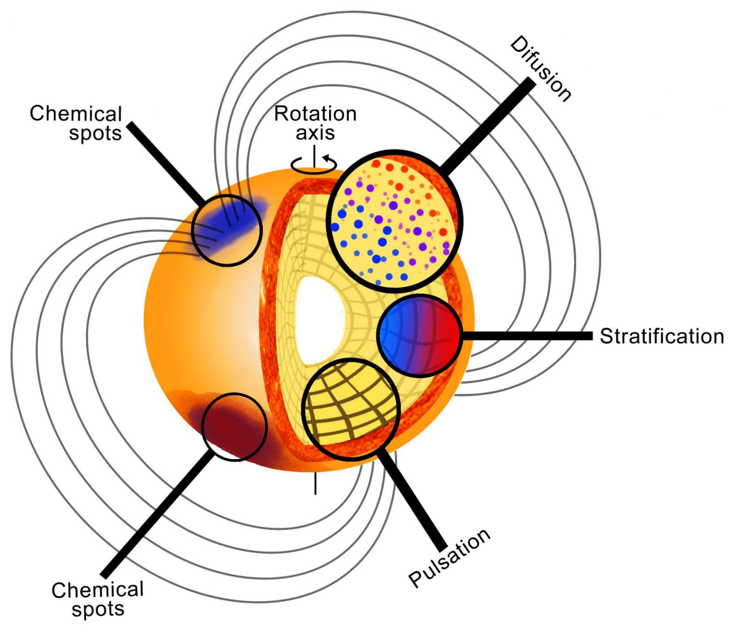

Investigating Frequency Variability and Rotational Rate of KIC7582608

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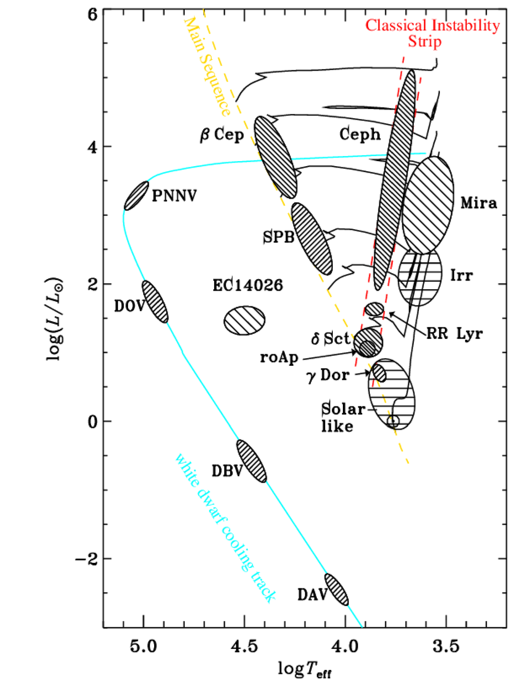

01. Introduction

Rapidly Oscillating, chemically peculiar A (roAp) stars, positioned at the junction of the classical instability strip and the main sequence, are known for their unique pulsation behaviors. They pulsate rapidly with periods in the range of 5.7–23.6 min. The strengths of their magnetic field have been observed to lie between 1–25 kG [1], and may vary with rotational phase. KIC 7582608 (B 11.85) exhibits high-frequency pulsation at 181.7324 d−1 (P = 7.9 min) coupled with a lower-frequency rotational period of 20.4339 d [2], with an amplitude of 7.64 mmag. Through spectral analysis, this target has been confirmed as an Ap star, marked by the presence of characteristic lines of Eu II, Nd III, and Pr III. Spectral observations have led to the estimation of a lower limit on the mean magnetic field modulus at B = 3.05 ± 0.23 kG [2]. This study seeks the origins of the long-term variations of brightness pulsations in KIC7582608 by isolating the principal pulsation frequency and studying the components of variation.

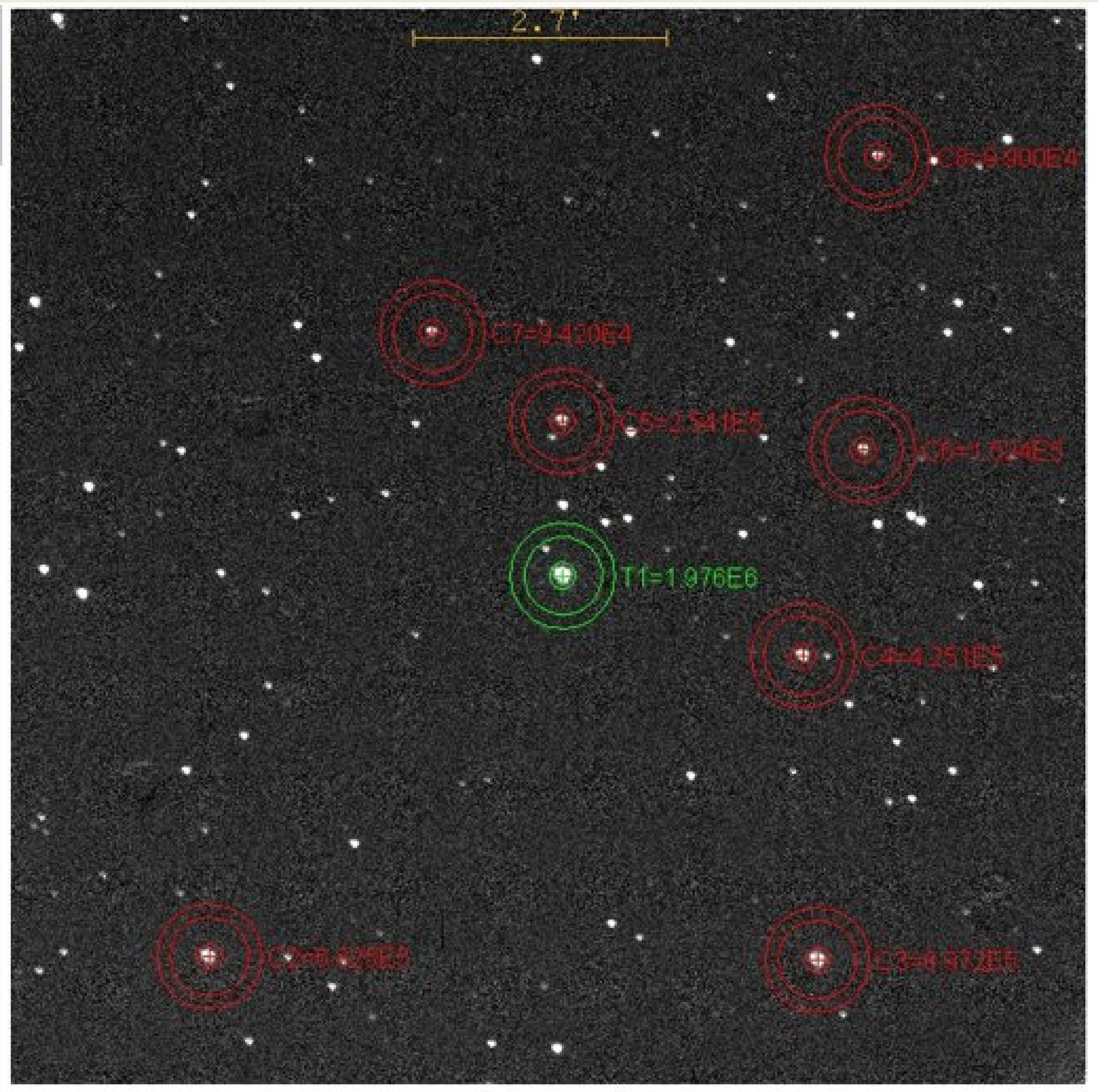

Figure.1. Finder chart displaying KIC 7582608 encircled in a green annulus for target identification. Comparison stars utilized for differential photometry are highlighted within red annuli.

Observing log

Observation Date	Observers	Data Analysts	Telescope/CCD	Filter	Exposure (sec)	Exposures	Cadence (sec)
2460080.876826	Gillam, Vansadia, Thiyagarajan	Thiyagarajan	0.9-m/ARC	Johnson B	74	187	81
2459700.885254	Gillam	Thiyagarajan	0.9-m/ARC	Johnson B	45	304	52
2460132.490039	Gillam, Thiyagarajan	Gillam	1m/AndorIkon-L	Johnson B	60	340	66
2460081.608958	Gillam, Reynolds	Weddle	1m/AndorIkon-L	Johnson B	60	314	66
2460080.565054	Gillam, Romeo, Barnier, Weddle	Barnier	1m/AndorIkon-L	Johnson B	30	96	36
2459793.421638	Gillam, Romeo, Talman-Bogusta	Thiyagarajan	1m/AndorIkon-L	Johnson B	55	123	61
2459792.513473	Gillam, Romeo, Alamos	Gillam	1m/AndorIkon-L	Johnson B	50	254	56
2459791.520144	Gillam, Romeo	Barnier	1m/AndorIkon-L	Johnson B	40	425	46
2459790.516863	Gillam, Alamos, Talman-Bogusta	Gillam	1m/AndorIkon-L	Johnson B	45	739	51
2459789.552128	Gillam, Alamos, Talman-Bogusta	Barnier	1m/AndorIkon-L	Johnson B	45	421	51
2459433.454165	Gillam	Thiyagarajan	1m/AndorIkon-L	Johnson B	60	198	66
2459404.539986	Gillam, Nelson, Thiyagarajan, Alamos, Pepe	Thiyagarajan	1m/AndorIkon-L	Johnson B	60	362	66
2459403.576677	Gillam, Nelson, Thiyagarajan, Alamos, Pepe	Thiyagarajan	1m/AndorIkon-L	Johnson B	60	407	66
2459051.456175	Gillam	Thiyagarajan	1m/AndorIkon-L	Johnson B	30	217	36
2459023.557200	Gillam	Thiyagarajan	1m/AndorIkon-L	Johnson B	60	414	66
2459021.509513	Gillam	Thiyagarajan	1m/AndorIkon-L	Johnson B	60	205	66
2459020.607000	Gillam	Weddle	1m/AndorIkon-L	Johnson B	60	262	67
2458991.715432	Gillam	Gillam	1m/AndorIkon-L	Johnson B	60	205	66
2458990.633711	Gillam	Gillam	1m/AndorIkon-L	Johnson B	60	194	66

Table.1. Observing log of KIC 7582608

02. Methodology

Over a span of four years, observations of KIC7582608 were conducted on 18 nights using telescopes affiliated with the South Eastern Association of Research in Astronomy. On a typical observation night, data was gathered employing the SARA Kitt Peak 0.96m telescope with ARC CCD imager or the SARA Roque de los Muchachos 1m telescope with Andor Ikon-L CCD imager. The collected data encompassed bias, flat, and light frames utilizing a Johnson B filter, ensuring the target was optimally positioned within the field of view to minimize flat field correction.

03. Analysis

Post-data collection, image calibration processes, such as bias subtraction and flat field correction using AstroImageJ, were undertaken to reduce artifacts and ensure the reliability of the data. The bias level inherent in the imaging system was captured by the bias frames and subtracted from other frames to generate clean images. Corrections for variations in sensitivity across the detector were made by the flat field frames, ensuring a uniform response. Actual brightness variations were revealed through differential photometry, which involved comparing target stars with stable comparison stars. A time series curve was constructed from the calibrated data to track these brightness changes over time. Further analysis employed Fourier analysis in Period04 on the time series to isolate dominant frequencies, shedding light on periodic changes in a star's brightness and informing future investigations. Additionally, statistical analysis involved using least square fit and Monte Carlo simulations to further examine and validate the obtained data. Monte Carlo simulation is a computational technique that uses random sampling methods to model and simulate complex systems or processes. By running multiple simulations, statistical properties or patterns are observed and summarized, providing insights into the behavior and uncertainty of the model.

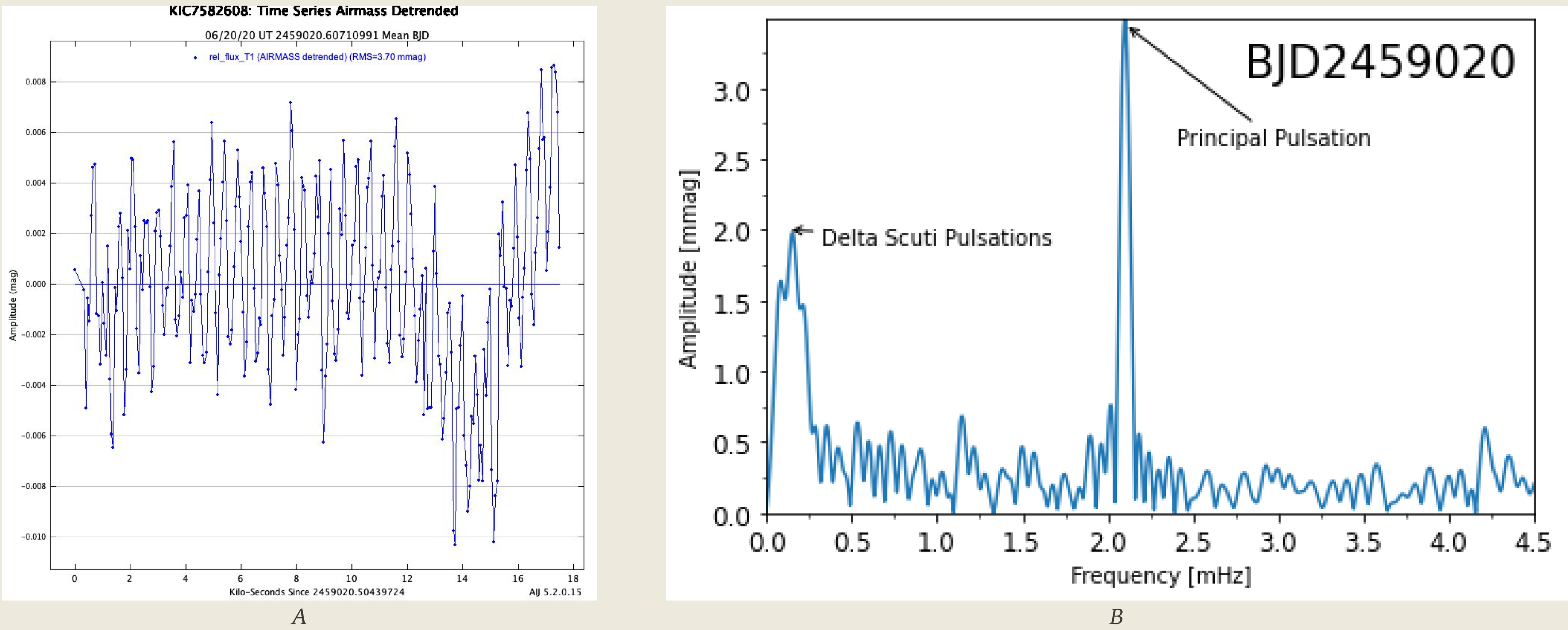

Figure.2. Figure A: Comparative brightness variation of KIC 7582608 concerning the reference stars from Figure 1, corrected for airmass. Figure B: Amplitude spectrum displaying the principal pulsation frequency of KIC 7582608, with the larger peak denoting the dominant pulsation frequency.

References

[1] Balona, L. A., Cunha, M. S., Kurtz, D. W., Brandão, I. M., Gruberbauer, M., Saio, H., Østensen, R., Elkin, V. G., Borucki, W. J., Christensen-Dalsgaard, J., Kjeldsen, H., Koch, D. G., & Bryson, S. T. (2010). Kepler observations of rapidly oscillating AP, δ Scuti and γ Doradus Pulsations in AP stars. Monthly Notices of the Royal Astronomical Society, 410(1), 517–524. https://doi.org/10.1111/j.1365-2966.2010.17461.x

[2] Holdsworth, D. L. (2021). The roap stars are observed by the Kepler Space Telescope. Frontiers in Astronomy and Space Sciences, 8. https://doi.org/10.3389/fspas.2021.626398

[3] Lenz, P. (2007). Period04 User Guide. Communications in Asteroseismology, 146, 53–136. https://doi.org/10.1553/cia146s53

04. Results/Findings

Our tentative result is that the principal pulsation (frequency 2.10688+/-0.01911 mHz) varies in amplitude with a period of (20.45261+/-0.01911)mHz and an amplitude of (1.30833+/-0.16645) mmag. The other two components found are Period 2: (10.21179+\-0.00649) days Period 3: (21.39545+\-0.122856) days

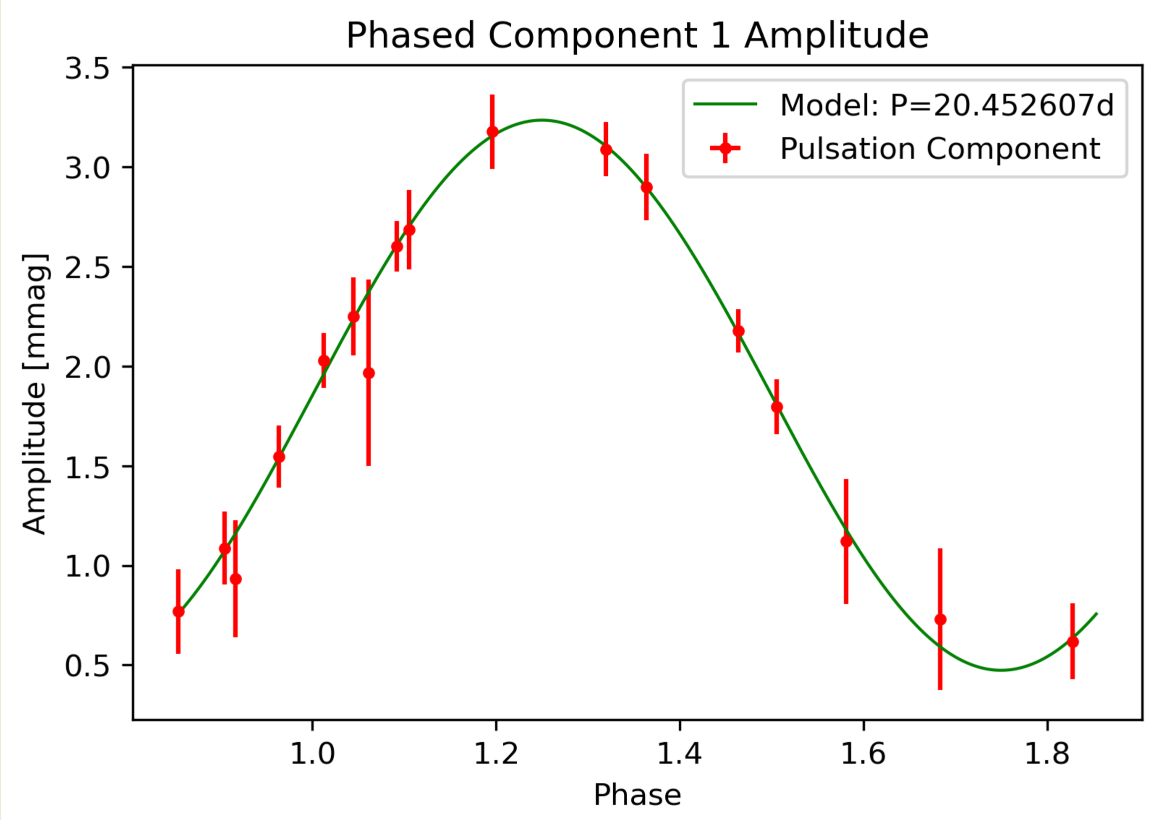

Figure.3. Representation of the P1 component fitted to sine wave, derived from 18 nights of observations, used for statistical analysis of periodic variation.

06. Conclusion

In conclusion, this analysis provides strong evidence for detecting KIC7582608's rotation period, with results consistent with previous estimates. The study's methodology and significant findings enhance our understanding of this object's behavior. Our results agree with the existing literature, the pulsation frequency of KIC7582608 is stable and not evolving in annual timescale.

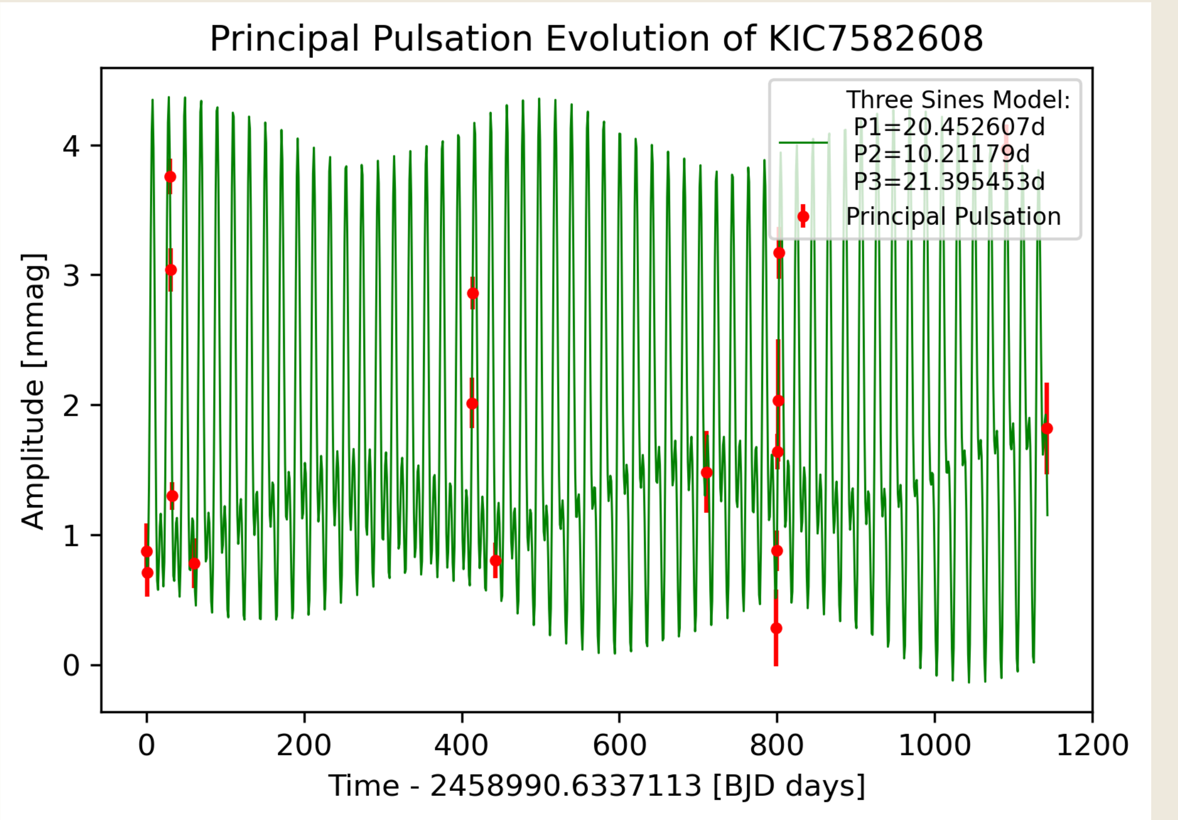

Figure 4. This is a graphical representation of our statistical analysis where the amplitudes of the principal frequency (red dots). The green curve is a model of three superimposed sine waves.