Mysterious Modulations:
TESS Insights into the Dwarf Nova AT 2019muu

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Introduction

Cataclysmic Variable (CV) systems are close binary stars where a white dwarf accretes material from a donor star. These systems exhibit complex behaviors such as periodic outbursts, superhumps, and variability caused by accretion disk precession. **AT 2019muu** is a CV superoutburst discovered by ASAS-SN in 2019 and then observed by TESS. Its light curve exhibits a pronounced beat frequency.

Figure 1: An artist representation of a CV system. Image credit: NASA/CXC/M.Weiss

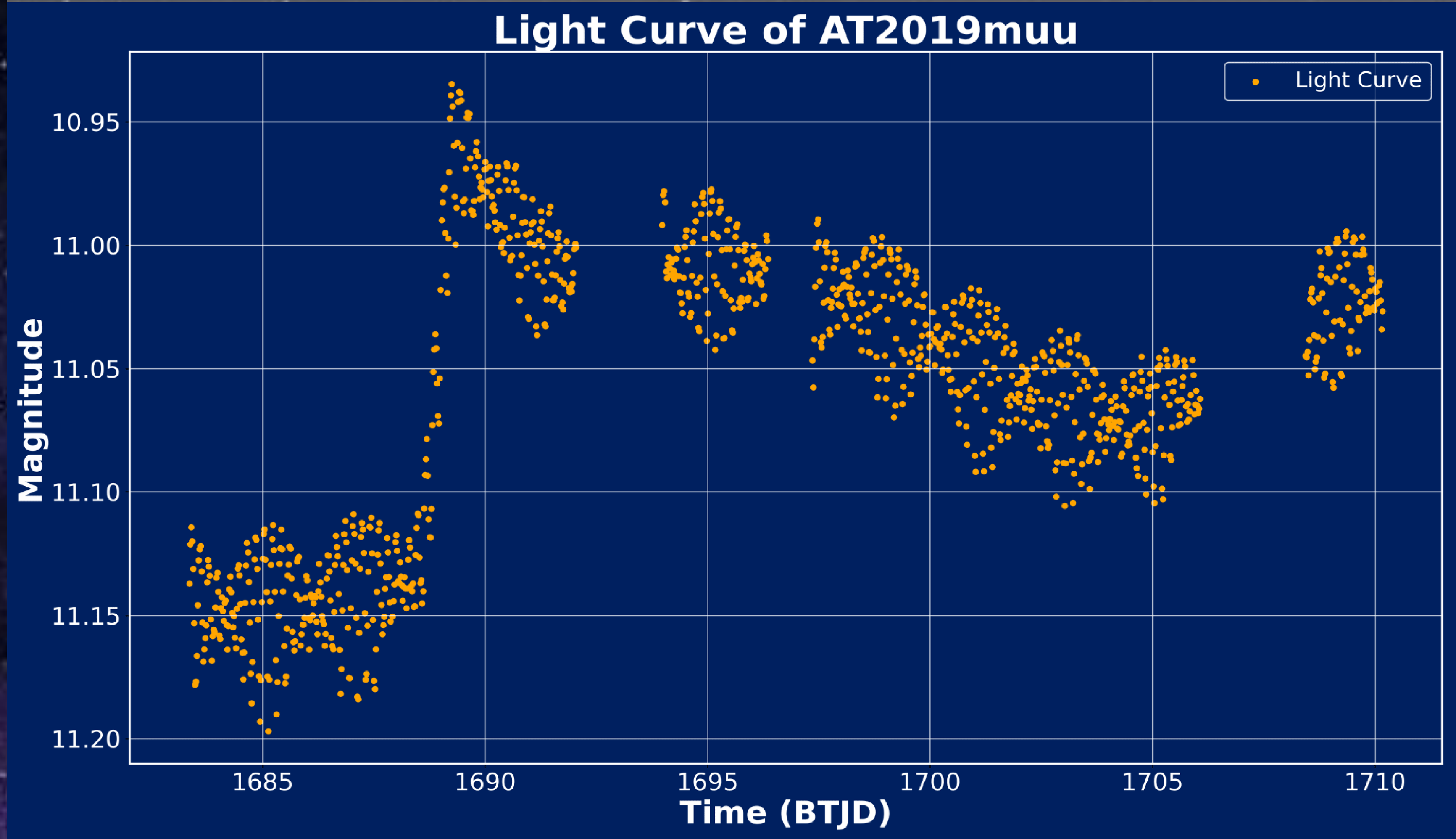
Challenges

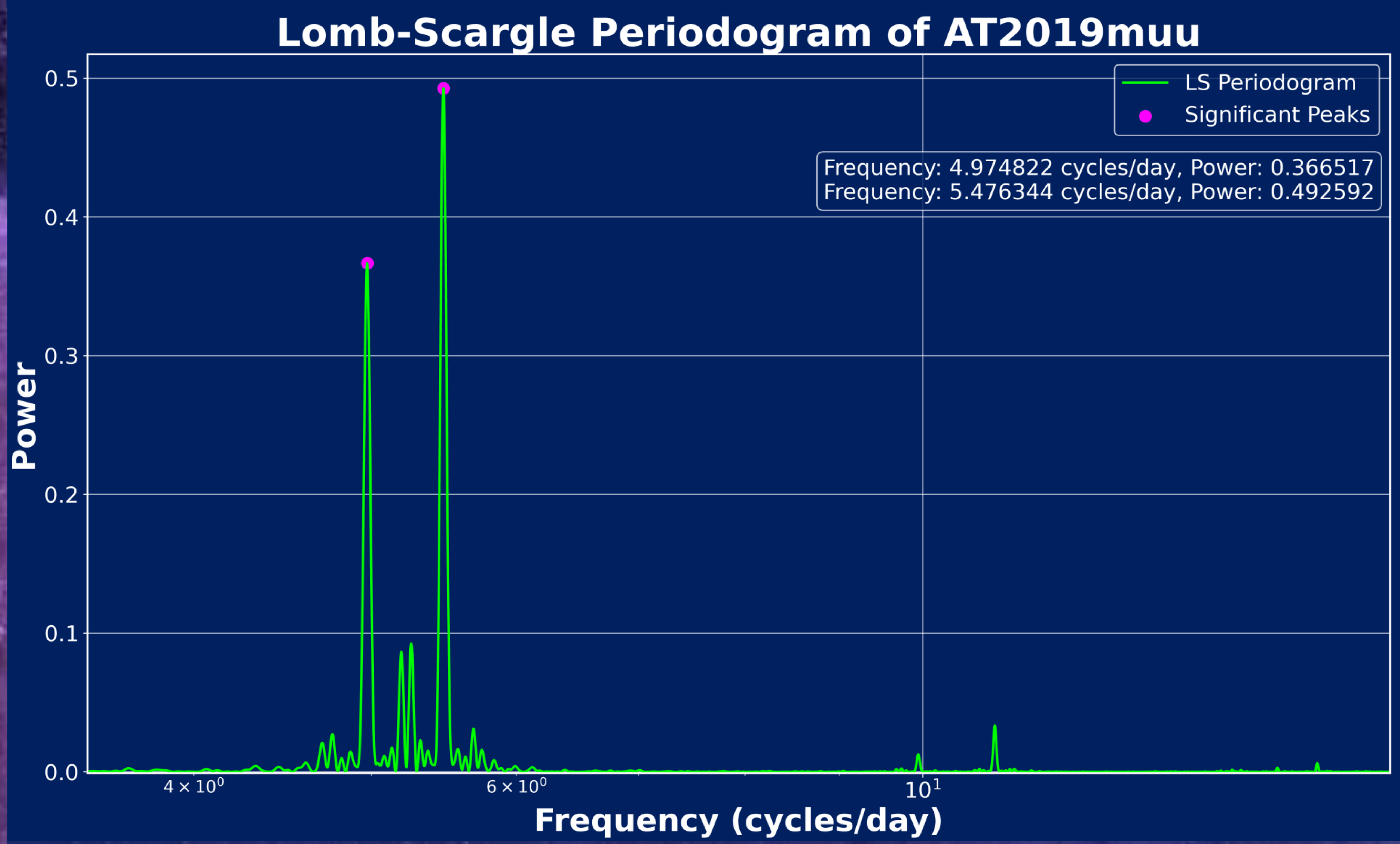
Proximity of Blending Sources: Target A, located at RA: 291.8745 and DEC: 33.0553, and Target B, located at RA: 291.8737 and DEC: 33.0537, are separated by only 5 arcseconds, while TESS pixels are 21x21 arcseconds across. This proximity poses a significant challenge in distinguishing individual signals using traditional aperture photometry, causing signals from both Target A and Target B to contaminate the light curve of AT 2019muu.

Figure 2: DSS colored image of Target A and B

Gaia Classification: According to the Gaia DR3 and DR2 catalogs, Target A is a solar-like main sequence star with a BP-RP value of .81, effective temperature (Teff) of 5652.95 K, and surface gravity (log g) of 4.288 while Target B is a cooler red giant star, with a BP-RP value of 1.32 Teff of 3306 K, and radius of 75.65 solar radii. Additionally, Target B is located closer at 4351 pc, than Target A which is at 9159 pc.

Analysis





Data Processing:

1. Applied constraints on the time range (BTJD: 1689.5–1710) to focus on the observations after the superoutburst occurs, giving the chance to observe possible orbital or superhump signals.
2. Detrended this time range by fitting a 4th degree polynomial.
3. Phase-folded the light curve using detected frequencies via Lomb-Scargle Periodogram.

Findings:

Lomb-Scargle periodogram analysis identified significant periodicities of **4.97 and 5.48 cycles/day** (4.82 and 4.38 hours, respectively).

The dynamical timescale of the Sun is **55 minutes**, while that of a red giant star is much longer, on the order of days due to the inverse relationship with mean density. Thus, we conclude that the variability is unlikely originating from **Target B** and instead supports **Target A** as the primary source for the beat frequency. Notably, this beat envelope is present before the superoutburst, further showing that the beat signal is not from the CV system.

We additionally detected up to the 3rd harmonic of these periods.

Interpretation

High amplitude, beating oscillations similar to those observed here have been observed on ∂-Scuti stars with similar frequency spacings[1,2]. ∂-Scuti stars are hydrogen-burning stars that have standing-mode radial pulsations. Typically, ∂-Scuti stars have effective temperatures between 6,000 and 8,000 K, which would make Target A an unusually cool ∂-Scuti star.

Follow-up Observations

To confirm that Target A is the source of the variability seen with TESS, we took follow-up observations at the TTU Preston Gott Skyview Observatory. 2 12-inch aperture telescopes were used in November 2024 and 3 12-inch aperture telescopes were used in July 2025, with both observations being conducted in SDSS g′ and r′. Analysis of this data is ongoing.

Figure 3: Telescope array at Skyview Observatory

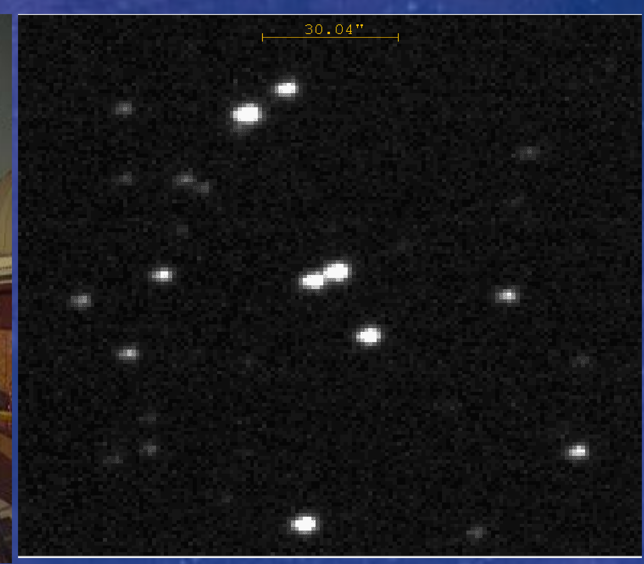


Figure 4: Raw science image of Target A and B

Conclusion

We found that the beat frequency is associated with at least one of two bright blended sources, with the culprit likely being a low temperature ∂-Scuti pulsator. This conclusion aligns with the periodogram analysis, suggesting that Target A is a ∂-Scuti pulsator, though further work is in progress to confirm the nature of Target A.

References

1: Antoci et al. 2019, 10.1093/mnras/stz2787.
2: Michel, Estefanía & Baglin, Annie & Weiss, Werner & Auvergne, Michel & Catala, Claude & Aerts, C. & Appourchaux, Thierry & Barban, C & Baudin, F & Briquet, M & Carrier, F. & Degroote, P & De Ridder, J. & García, R. & Garrido, Rafael & Soto, Juan & Kallinger, T & Lefèvre, Laure & Neiner, C & Zwintz, Konstanze. (2008). First asteroseismic results from CoRoT. Communications in Asteroseismology. 156. 73-87.