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PHOTOMETRIC AND SPECTROSCOPIC INVESTIGATION OF FIVE CATACLYSMIC VARIABLE STARS USING TESS AND LAMOST

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Abstract: This study presents a combined photometric and spectroscopic investigation of five cataclysmic variable (CV) systems, 2MASS J04132921+3116279, HQ And, V1434 TAU, SDSS J003303.94+380105.4, and SDSS J090628.24+052656.9 using data from the TESS space telescope and the LAMOST spectroscopic survey. The primary aim is to classify the nature of these CVs and assess their accretion behavior through time-series analysis and emission line diagnostics. TESS light curves were analyzed to determine orbital and superhump periods, while LAMOST spectra were used to estimate equivalent widths of key lines such as Hα, Hβ, and He II. My results identify two SU UMa-type dwarf novae (V1434 TAU and SDSS J003303.94+380105.4), one likely U Gem-type system (SDSS J090628.24+052656.9), one non-magnetic nova-like variable (HQ And), and one magnetic CV candidate (2MASS J04132921+3116279), possibly an intermediate polar or nona-like system. The combination of photometric variability and spectral features allows for detailed classification and offers insights into the mass transfer states and evolutionary status of these systems.

1 Introduction

Cataclysmic variables (CVs) are semi-detached binary systems that consist of a white dwarf primary and a companion star, which is typically a main-sequence star or, in some cases, a red giant. These systems are of particular interest due to their sudden, dramatic increase in brightness caused by the accretion of material from the companion star. The companion fills its Roche lobe, allowing matter to stream through the inner Lagrangian point and form an accretion disk around the white dwarf, unless the white dwarf's magnetic field is strong enough to disrupt disk formation. This accretion process is responsible for the wide range of photometric and spectroscopic variability observed in CVs (Warner, 1995).

CVs are classified into several subtypes based on their observational features, including novae, dwarf novae, and nova-like variables. Novae exhibit explosive outbursts caused by thermonuclear runaways on the surface of the white dwarf, while dwarf novae show frequent periodic outbursts due to thermal-viscous instabilities in the accretion disk (Osaki, 1974, Mineshige, S.; Osaki, Y., 1985). Nova-like systems, on the other hand, have high and steady accretion rates without prominent outbursts. The periods of CVs typically range from an hour to a dozen hours.

According to the CV evolution model, the orbital period gradually decreases from long to short until it reaches a minimum period of approximately 75 minutes, after which it increases (Hellier, 2001). This orbital period shrinkage is caused by the loss of angular momentum from the secondary star, which in turn affects the binary system's orbital period. Many believe that this is caused by the magnetic braking model (MB) (Rappaport et al. 1982, 1983; Spruit & Ritter 1983).

Recent theoretical advances have refined our understanding of angular momentum loss in CVs. Barraza-Jorquera et al. (2025) propose a saturated, boosted, and disrupted (SBD) prescription that reproduces observed period-gap boundaries and the minimum period when integrated into MESA simulations. Complementing this, Larsen & MacDonald (2025) show that magneto-convection in secondary stars can elevate the period minimum by ~14 minutes, addressing discrepancies in traditional evolution models. Schreiber et al. (2024) utilize SDSS-based samples to reinforce that disrupted MB remains the most consistent explanation for the orbital period gap in non-magnetic CVs, whereas polars display a far less pronounced gap. This underscores the crucial role of the white dwarf's magnetic field in modifying angular momentum loss.

While many well-known CVs have been extensively studied, there remains a large population of relatively faint and poorly characterized systems that have yet to be explored in detail. My study focuses on a set of such under-studied CV systems that have been observed by both the Transiting Exoplanet Survey Satellite (TESS) and the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) surveys. These two rich datasets, one photometric, the other spectroscopic allow for a comprehensive time-domain and spectral analysis, which is essential to understand the nature and behavior of these compact binaries.

The selected targets are: 2MASS J04132921+3116279 (CV), HQ Andromedae (Nova-like), V1434 Tau (SU UMa-type dwarf nova), SDSS J003303.94+380105.4 (SU UMa), and SDSS J090628.24+052656.9 (U Gem-type dwarf nova). Each of these systems represents a distinct subtype of cataclysmic variable, offering a diverse sampling of accretion phenomena. For instance, SU UMa-type stars exhibit both normal and superoutbursts along with superhumps, providing critical insight into disk precession and resonance effects. Nova-like variables such as HQ And maintain a high, relatively steady accretion rate, often lacking the typical outburst behavior, making them important for studying stable disk structures and white dwarf irradiation effects. U Gem-type stars, on the other hand, present periodic dwarf nova outbursts due to disk instabilities, making them ideal for tracing thermal-viscous cycles (Osaki, 1974).

This paper is organized as follows: Section 2 describes the observations and data acquisition for the five selected cataclysmic variable (CV) systems. Section 3 outlines the data analysis techniques and methodologies used in both photometric and spectroscopic studies. In Section 4, I present and discuss the results obtained from the TESS and LAMOST datasets for each system. Finally, the conclusion and a summary of the main findings are provided.

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2 Observation and Data acquisitions

The photometric data for the selected cataclysmic variable (CV) systems were acquired from the Transiting Exoplanet Survey Satellite (TESS), whose primary mission is to search for exoplanets using the transit method. However, its continuous, high-precision, wide-field monitoring photometric data has observed various types of variable stars, including CVs. TESS observes the sky by dividing it into 26 sectors, covering the southern ecliptic hemisphere and the northern hemisphere. Each sector is observed continuously for approximately 27 days, corresponding to two spacecraft orbits (Ritter & Kolb, 2003).
The TESS detectors are sensitive to optical and near-infrared wavelengths between 600 nm and 1000 nm. The light curves provided simple aperture photometry (SAP) and Pre-search Data Conditioning SAP flux (PDCSAP). For this study, the Simple Aperture Photometry (SAP) light curves with a 120 second cadence were used from TESS light curve because PDCSAP flux has more treatment to remove long-term variability that helps to intact the main objective of TESS but in Cataclysmic Variable stars (CV) research, the long-term variability plays a key role in uncovering the evolutionary facts in CVs. The TESS observations were downloaded from the Mikulski Archive for Space Telescopes[1] (MAST). These light curves offer sufficient temporal resolution to capture outbursts, eclipses, and superhumps in CV systems.
Complementary spectroscopic data were obtained from the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST), also known as the Guo Shoujing Telescope. Operated by the National Astronomical Observatories of China, LAMOST is a unique, large-aperture, wide-field telescope designed for high-throughput spectral surveys. Located at Xinglong Station, the telescope utilizes a quasi-meridian design featuring a large spherical primary mirror (Mb, 6.67 m × 6.05 m) and a reflecting Schmidt corrector mirror (Ma, 5.72 m × 4.40 m). The optical system focuses incoming light onto a 1.75-meter diameter focal plane with a 20-meter focal length, supporting up to 4000 optical fibers (Xianming L. Han, et al., 2018).
Each fiber is precisely positioned to capture light from individual celestial objects near their meridian passage, feeding the light into spectrographs mounted beneath the telescope. These spectrographs record spectra with a spectral range of 370–900 nm at different resolution modes (R = 500, 1000, 1500), depending on the observational setup. LAMOST's large field of view (5 degrees) and its ability to obtain tens of thousands of spectra per night make it highly efficient for surveying faint objects up to 20.5 magnitudes in brightness. The combination of TESS's high-cadence photometric monitoring and LAMOST's wide-field spectroscopic capabilities provides a powerful dataset for investigating both the temporal behavior and spectral characteristics of CVs (Wang et al. 1996).
For this research, I selected five cataclysmic variable (CV) systems that have been least studied in literature but are observed in both the TESS and LAMOST surveys. These targets were chosen to explore underrepresented CVs using combined photometric and spectroscopic data. Table 01 presents the list of selected CVs along with the details of their respective TESS and LAMOST observations, including sector coverage, cadence, and spectral availability.

[1] https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html

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Table 01: list of selected CVs along with the details of their respective TESS and LAMOST observations.

Star system	TESS sector	Duration of Observation (BJD)	LAMOST observation ID	LAMOST observation date (UTC)
2MASS J04132921+3116279	70,71	3208.537–3259.795	31815210	2012-01-22 12:09:00
HQ And	57 84	2853.358–2882.119 3584.594–3610.345	472208156	2016-10-26 13:42:00
V1434 TAU	43,44,45 71	2474.175–2550.630 3234.041–3259.957	371907018	2015-10-16 20:18:00
SDSS J003303.94+380105.4	57	2853.359–2882.120	372109067	2015-10-16 15:07:00
	84	3584.594–3610.345	372606191	2015-10-17 14:52:00
SDSS J090628.24+052656.9	61 72 88	2962.804–2988.218 3260.183–3285.586 3690.161–3717.153	435116180	2016-03-05 15:24:00

3 Data analysis and methodology

Photometric Data from TESS

In this research, I utilized TESS light curve data to perform periodicity analysis of the selected cataclysmic variable (CV) systems. Several stars in my sample exhibited outburst activity, which introduced long-term trends in the light curves. To isolate periodic signals, I first applied the Locally Weighted Scatterplot Smoothing (LOWESS) (Cleveland, 1979) technique to remove these global trends. After fitting the LOWESS model to the light curves, I subtracted the fitted trend to obtain the detrended (residual) light curves, which were then used for subsequent periodicity analysis.

I then employed the Lomb-Scargle Periodogram (LSP) (Lomb, 1986; Scargle, 1982; Press & Rybicki, 1989; VanderPlas, 2018) method to estimate the periodic modulation present in the residual light curves. The LSP is particularly effective for detecting and characterizing periodic signals in unevenly spaced or noisy time-series data, making it well-suited for the variable nature of CV light curves observed by TESS. The resulting periods for the CV sample are summarized in Table 02.

To estimate the uncertainty in the period derived from the Lomb-Scargle Periodogram (LSP), I performed a least-squares fit of a sinusoidal model to the TESS light curve data. The sinusoidal function was defined as:

$$f(t) = A \cdot \sin(2\pi t/P + \phi) + \text{offset}$$

where A is the amplitude, P is the period, ϕ is the phase, and offset is the vertical shift. The initial period used in the fit was taken from the LSP peak. Using the "curve_fit" function from the SciPy optimization package, I fit this model to the observed data and extracted the best-fit parameters and their corresponding covariance matrix. The uncertainty in the period was then calculated as the square root of the diagonal element of the covariance matrix associated with the period parameter. This approach provides a more robust and quantitative estimate of the period error, accounting for noise and sampling effects in the light curve.

For system, 2MASS J04132921+3116279, I performed a more detailed period variation analysis using the O−C (Observed minus Calculated) method. This technique is commonly used to study period changes in eclipsing and variable stars. Here, O refers to the observed time of a specific event (e.g., eclipse), while C is the calculated time based on an initial ephemeris. The ephemeris is defined as:

$$O-C = T_{obs}-(T_0+E \cdot P)$$

where:

- T_{obs} = observed eclipse times,
- T_0 = initial eclipse epoch,
- E= eclipse cycle number,
- P= period.

To determine the mid-eclipse times, I fitted a Gaussian profile to each eclipse feature in the light curve. Using the resulting eclipse centers, I constructed the O−C diagram. To estimate the rate of period change, I applied a quadratic fit to the O−C values using the equation:

$$O-C= a E^2 + b E + c$$

From the quadratic coefficient a, I computed the period derivative $\dot{P}$ using:

$$\dot{P}=2 a \cdot P$$

Unfortunately, for the other systems in my sample, I was unable to determine orbital period changes due to either the low eclipse depth or the absence of clearly defined eclipse centers in their light curves. Additionally, some systems exhibit prominent superhump modulations, which can mask or dominate the underlying orbital variations, making the detection of subtle period changes challenging.

LAMOST Spectroscopic Analysis

In addition to photometric data from TESS, I utilized spectroscopic data from the LAMOST survey to qualitatively characterize the stellar properties of the selected cataclysmic variable (CV) systems. My primary focus was on analyzing prominent Balmer emission lines and the He II 4686 line, which are key spectral features associated with accretion processes in CVs. These emission lines provide valuable information about the structure and dynamics of the accretion disk, mass transfer activity, and excitation conditions in the systems.

To assess the strength of these lines, I measured their equivalent widths (EWs), which quantify the area of the line relative to the continuum level. The EW values serve as indicators of emission line intensity, allowing us to compare the activity levels across different systems.

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By examining the variation in EW among my sample, I could identify which systems exhibit stronger accretion signatures.

4 Results

2MASS J04132921+3116279

The system 2MASS J04132921+3116279 was observed by TESS in two consecutive sectors, Sector 70 and Sector 71 (see Figures 01). From the TESS light curve analysis, an orbital period of 0.135350 ± 0.000009 days was determined using the Lomb-Scargle Periodogram method. To further investigate potential orbital evolution, I applied the O–C (Observed minus Calculated) method, using Gaussian fitting to determine mid-eclipse times for each orbital cycle. The resulting O–C diagram (Figure 02) reveals a period change rate of $-3.028\times10^{-10} \pm 1.702\times10^{-9}$ days/day, suggesting a slight but currently statistically insignificant decrease in orbital period. The uncertainty of the period change was estimated following the approach of Press et al. (2007) using the covariance matrix from the quadratic polynomial fit.

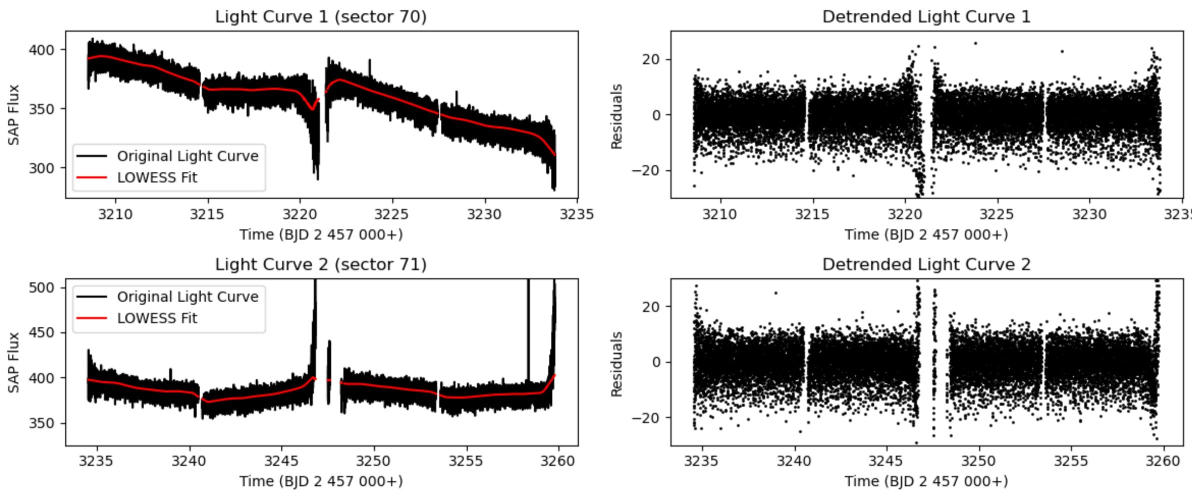

Figure 01: TESS SAP flux light curves and corresponding detrended residuals for 2MASS J04132921+3116279 across four observation sectors. The left column shows the original light curves (black) with LOWESS fits (red) for Sectors 70 and 71, respectively. The right column displays the residuals obtained by subtracting the LOWESS fit.

This system has been previously classified as a cataclysmic variable (CV) by Hoffmann (2020). To further assess its nature, I analyzed its spectroscopic data from LAMOST (see Figure 05), focusing on emission line diagnostics. Key features observed include Balmer emission lines and the He II (Table 02). The equivalent width (EW) of the Hα line is notably strong, indicating intense emission, likely from a hot and dense region of the accretion disk or a wind component. The He II line, a high ionization feature often associated with emission near the white dwarf or magnetic accretion columns, is also present and relatively strong. This

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supports the possibility of a magnetic CV, potentially an intermediate polar (IP), or a nova-like variable in a high accretion state. The presence of a blue continuum in the spectrum is consistent with a hot accretion disk, and the combined spectroscopic features align well with systems in active, high mass transfer states.

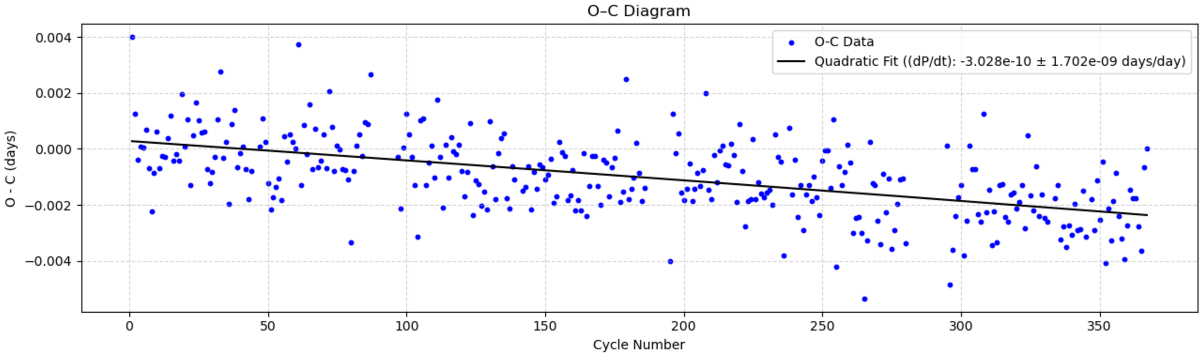

Figure 02: O–C diagram for two TESS observations of the 2MASS J04132921+3116279 system, along with a quadratic fit.

In summary, 2MASS J04132921+3116279 exhibits characteristics consistent with a magnetic cataclysmic variable, likely an intermediate polar or nova-like system in a high accretion state. The strong Hα emission, presence of He II, broad line profiles, and short orbital period all support this classification.

HQ And

The star HQ And was first recorded and classified as a cataclysmic variable (CV) by Meinunger (1975). Later, Andronov & Meinunger (1987) proposed a possible polar nature for the system, which was later supported by polarimetric observations. Finally, this was categorized as nona-like by Xianming L. Han et al (2018)

TESS observations of HQ And were obtained in Sectors 57 and 84 (see Figures 03). The LSP analysis of the TESS light curves revealed two significant periodicities: a superhump period of 0.139809 ± 0.000008 days and an orbital period of 0.127975 ± 0.000015 days. The presence of both periods is a typical feature of systems undergoing superhump modulation, commonly associated with nova-like variables or SU UMa-type dwarf novae in a high accretion state. The small period excess between the superhump and orbital periods further supports the presence of a precessing, eccentric accretion disk.

The LAMOST spectrum of HQ And (Figure 05) offers additional constraints on its classification. The spectral profile is dominated by a blue continuum, characteristic of a hot accretion disk, suggesting the system was in a high accretion state at the time of observation. The spectrum shows a strong Hα emission line with an equivalent width (EW) of −6.7 Å, while higher-order Balmer lines such as Hβ and Hγ are present but significantly weaker (Table 02). This imbalance may indicate optically thick conditions in the Balmer-emitting

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region or Balmer decrement flattening, potentially caused by disk irradiation or moderate-density gas.

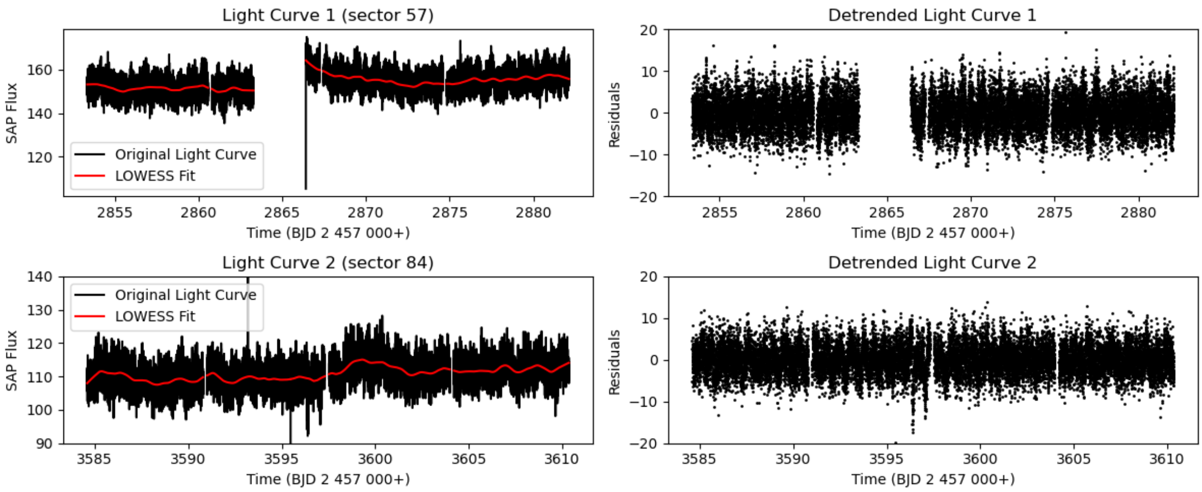

Figure 03: TESS SAP flux light curves and corresponding detrended residuals for HQ And across four observation sectors. The left column shows the original light curves (black) with LOWESS fits (red) for Sectors 57 and 84, respectively. The right column displays the residuals obtained by subtracting the LOWESS fit.

The absence of He II emission is notable, as it suggests the system may be a non-magnetic nona-like. Additionally, the lack of broad absorption wings implies that the white dwarf's photosphere does not dominate the optical continuum, reinforcing the conclusion that the emission arises primarily from the accretion disk.
In summary, the photometric and spectroscopic evidence indicates that HQ And is most likely a non-magnetic cataclysmic variable, possibly a nova-like system in a high accretion state. The detected superhump modulation, blue continuum, and Balmer line profile support the presence of a hot, active accretion disk, while the lack of He II emission argues against a strong magnetic field.

V1434 TAU

The cataclysmic variable V1434 TAU was observed by TESS across four sectors: 43, 44, 45, and 71. The light curve from Sector 71 clearly shows a superoutburst, during which superhumps were identified. The estimated superhump period of 0.069724 ± 0.000002 days is consistent with the typical behavior of SU UMa-type dwarf novae and is similar to the 0.06978-day period reported by Kazarovets, E. V et al. (2023). Additionally, the Sector 43 light curve, observed shortly after the superoutburst, shows residual periodic modulation likely corresponding to post-superhump activity.

While the superhump period was measurable, the orbital period signal could not be clearly extracted from the other sectors. This is attributed to the dominance of flickering and quasi-periodic oscillations (QPOs) in the power spectra, which obscure regular orbital modulation.

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Such complex photometric behavior is commonly observed in systems with low inclination angles, where eclipses and other geometrical variations are not prominent.

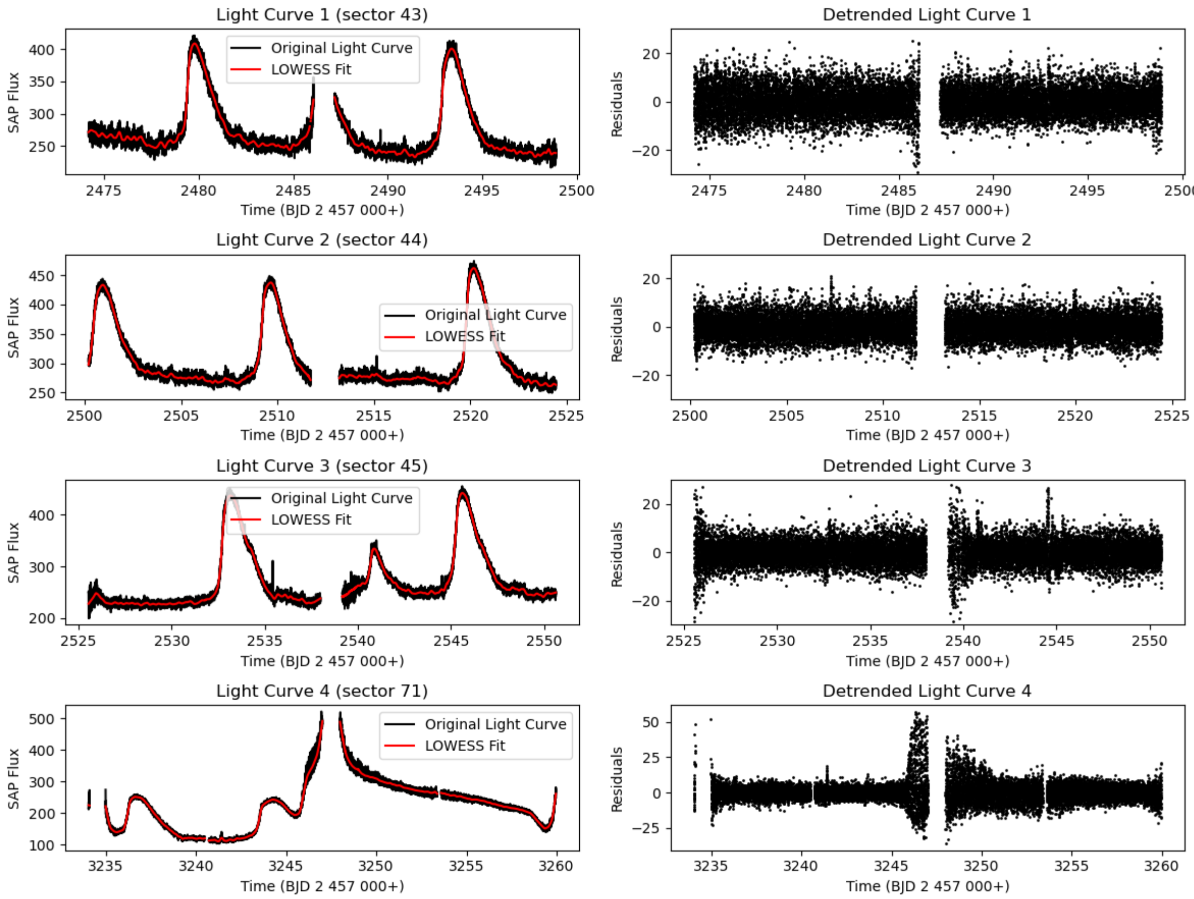

Figure 04: TESS SAP flux light curves and corresponding detrended residuals for V1434 TAU across four observation sectors. The left column shows the original light curves (black) with LOWESS fits (red) for Sectors 43, 44, 45, and 71, respectively. The right column displays the residuals obtained by subtracting the LOWESS fit

The three contiguous observations in Sectors 43, 44, and 45 allowed us to estimate the recurrence time of normal outbursts, based on the intervals between periodic brightening. I derived a recurrence time of 6.608 ± 0.003 days, which is within the expected range for short-period SU UMa systems undergoing frequent disk instabilities.
The spectroscopic data from LAMOST further support the SU UMa classification. The spectrum reveals strong Balmer emission lines, with equivalent widths (EWs) ranging from -13 Å to –54 Å (Table 2), indicating an optically thin, moderately hot accretion disk, likely in a quiescent state or in the early/late phase of an outburst. The Hα line is notably strong, consistent with active but non-explosive mass transfer. The continuum is relatively stable and lacks extreme blue excess, suggesting that the accretion disk is in quiescent state. The absence of the He II line is significant. This implies that V1434 TAU is not a magnetic system. The system appears to be dominated by disk processes rather than magnetic accretion.

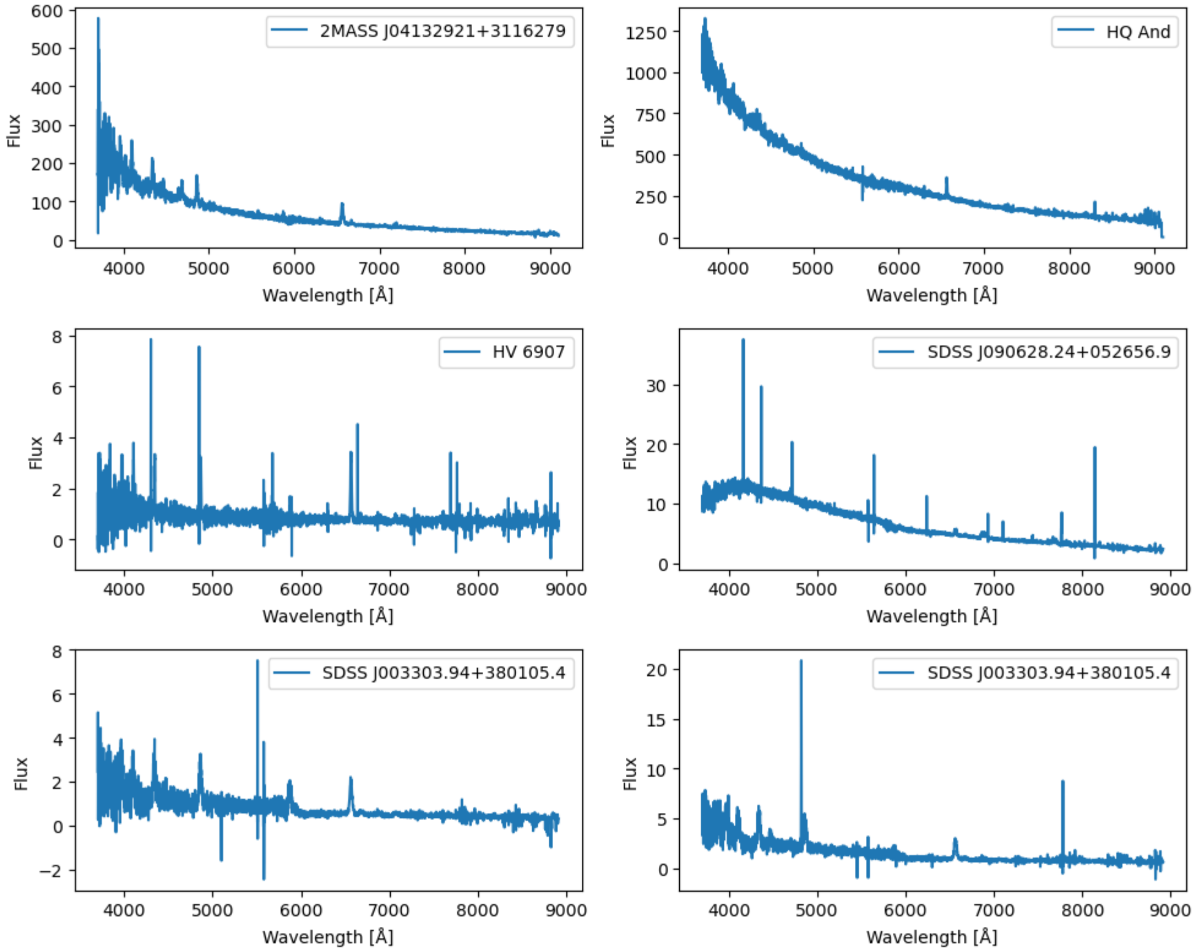

Figure 05: Optical spectra of 2MASS J04132921+3116279 and other cataclysmic variable systems: HQ And, V1434 TAU, SDSS J090628.24+052656.9, and SDSS J003303.94+380105.4.

In summary, V1434 TAU is best classified as a short-period SU UMa-type dwarf nova, with a superhump period below the period gap, strong Balmer emission lines, and a regular outburst recurrence pattern. The absence of He II and the flickering-rich photometric profile indicate a non-magnetic, low-inclination system with a dynamic accretion disk prone to regular instabilities.

SDSS J003303.94 +380105.4

The cataclysmic variable SDSS J003303.94+380105.4 was observed by TESS in Sectors 57 and 84. The light curve from Sector 57 captured a superoutburst, during which I detected a clear superhump signal with a period of 0.073406±0.000005 days. This is consistent with the characteristics of an SU UMa-type dwarf nova. In the quiescent phase, the power spectrum from these observations is dominated by flickering and quasi-periodic oscillations (QPOs). Additionally, there is a periodic power around 0.071123 ± 0.000054 days, which is approximately 3% shorter than the superhump period. This suggests that the 0.071123 day signal is likely the system's orbital period, a behavior typical of quiescent or post-outburst phases in low-inclination systems.

Spectroscopic data from LAMOST, obtained on two consecutive nights (2015-10-16 and 2015-10-17), provides further insight into the system's physical state (Figure 5). Both spectra show a strong prominent Balmer emission line (Hα, Hβ, Hγ, Hδ) (Table 02), which are indicative of an optically thick accretion disk. The strength of the Balmer lines was highest in the first observation, then slightly decreased in the second, suggesting variability in the disk's emission, possibly due to short-term changes in accretion rate or post-outburst cooling.

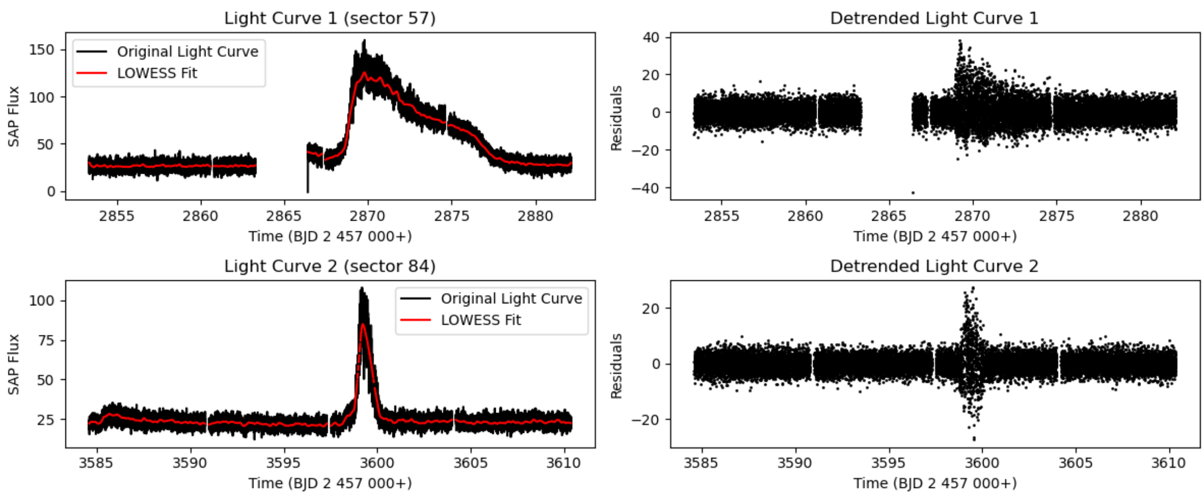

Figure 06: TESS SAP flux light curves and corresponding detrended residuals for SDSS J003303.94 +380105.4 across four observation sectors. The left column shows the original light curves (black) with LOWESS fits (red) for Sectors 57 and 84, respectively. The right column displays the residuals obtained by subtracting the LOWESS fit.

The absence of high-ionization lines, particularly He II, in both spectra suggests that the system does not possess a strong magnetic field. This is consistent with the interpretation of SDSS J003303.94+380105.4 as a non-magnetic CV, aligning with the standard model of SU UMa-type systems. The relatively strong but not extreme Balmer emission and moderately blue continuum support a scenario where the system was in a quiescent or post-outburst state at the time of observation.

In summary, SDSS J003303.94+380105.4 is characterized as a short-period SU UMa-type dwarf nova, exhibiting superhump behavior during outburst, and possessing a non-magnetic, optically thick accretion disk. The photometric and spectroscopic features together indicate a modest mass transfer rate, with no evidence of magnetic accretion processes, consistent with a standard disk-instability-driven evolution.

SDSS J090628.24+052656.9

The cataclysmic variable SDSS J090628.24+052656.9 was observed by TESS in three separate sectors: Sectors 61, 72, and 88 (Figure 07). From the LSP analysis of the light

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curves, I identified consistent periodic signals across all three sectors, with periods measured as 0.144034 ± 0.000030, 0.149240 ± 0.000059, and 0.145539 ± 0.000044 days, respectively. These periods correspond to ~3.45–3.58 hours, placing the system above the orbital period gap (~2–3 hours), a regime typically populated by U Gem-type dwarf novae and nova-like variables.

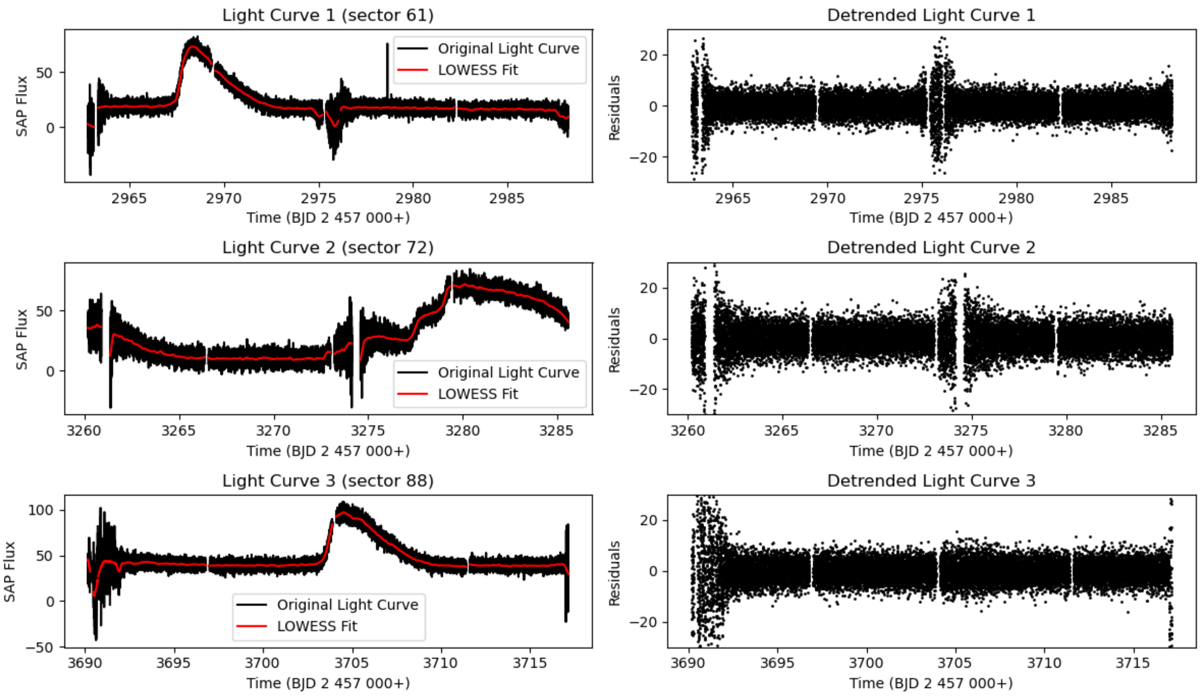

Figure 07: TESS SAP flux light curves and corresponding detrended residuals for SDSS J090628.24+052656.9 across four observation sectors. The left column shows the original light curves (black) with LOWESS fits (red) for Sectors 61, 72, and 88, respectively. The right column displays the residuals obtained by subtracting the LOWESS fit.

The small variations in the detected periods across sectors are within the margin of uncertainty and may reflect orbital modulations, such as ellipsoidal variations or shallow eclipses. Alternatively, these fluctuations could arise from accretion-related variability, such as flickering or possible superhumps, potentially due to a recent outburst or residual disk procession. However, no superoutburst was directly observed in the TESS data, and the light curves are relatively stable with low-amplitude variability, suggesting the system may have been in a quiescent state during the TESS observations.

Spectroscopic data from LAMOST (Figure 05) reveal a smooth, moderately blue continuum, consistent with emission from a hot component, likely a combination of the white dwarf and a cool, quiescent accretion disk. The Hα emission line is the only Balmer line clearly visible, while higher-order Balmer lines and He II are absent (Table 02). This spectral profile implies a low-ionization state, typical of a low mass transfer rate or a cool accretion disk. The dominance of Hα and absence of other emission features support the interpretation that the

system was in a quiescent phase during spectroscopic observation, with minimal high-energy activity or magnetic accretion.
Taken together, the photometric and spectroscopic data suggest that SDSS J090628.24+052656.9 is most likely a U Gem-type dwarf nova observed in quiescence. The system exhibits stable orbital modulation above the period gap, a weakly active accretion disk, and no evidence of strong magnetic fields or recent outburst signatures. Continued monitoring could help confirm the presence of superhumps or outburst cycles and better constrain its orbital parameters.

Table 02: Summary of orbital and superhump periods, and equivalent widths (EWs) of emission lines for the five cataclysmic variables studied. Negative EW values indicate emission. Values are derived from TESS photometry and LAMOST spectroscopy.

Star system	Orbital period (days)	Superhumps period (days)	Hα (Å)	Hβ (Å)	Hγ (Å)	Hδ (Å)	He II (Å)
2MASS J04132921+3116279	0.135350 ± 0.000009	-	-32.83	-14.68	-9.30	-.617	-6.72
HQ And	0.127975 ± 0.000015	0.139809 ± 0.000008	-6.70	-1.07	-0.81	-	-
V1434 TAU	-	0.069724 ± 0.000002	-54.61	-31.50	-20.22	-13.10	-
SDSS J003303.94+380105.4	0.071123 ± 0.000054	0.073406 ± 0.000005	-73.38 -63.73	-52.09 -43.97	-29.94 -23.27	-8.91 -11.87	- -
SDSS J090628.24+052656.9		-	-4.82	-	-	-	-

5 Conclusions or Summary

In this study, I conducted a detailed photometric and spectroscopic investigation of five relatively understudied cataclysmic variable (CV) systems: 2MASS J04132921+3116279, HQ And, V1434 TAU, SDSS J003303.94+380105.4, and SDSS J090628.24+052656.9. These objects were selected based on their availability in both TESS photometric data and LAMOST spectroscopic surveys, providing a valuable opportunity to combine time-domain and spectral diagnostics.
My analysis of TESS light curves employed Lomb-Scargle Periodogram methods to derive precise orbital and superhump periods. Additionally, for 2MASS J04132921+3116279, I applied O–C timing techniques to explore possible orbital evolution, revealing a statistically insignificant but potentially decreasing orbital period. The remaining systems demonstrated

behaviors consistent with their expected CV subtypes, including clear superhump signals during outburst phases in HQ And, V1434 TAU, and SDSS J003303.94+380105.4, as well as periodic modulations consistent with orbital variability in SDSS J090628.24+052656.9.
Spectral analysis from LAMOST focused primarily on Balmer and He II emission line diagnostics, as well as continuum shape. The presence and strength of Hα and other Balmer lines provided insights into the temperature, density, and ionization state of the accretion disks. Notably, 2MASS J04132921+3116279 showed strong He II and Balmer emission, suggesting a high accretion rate and potential magnetic influence possibly an intermediate polar or a nova-like variable in a high accretion state. In contrast, HQ And and SDSS J003303.94+380105.4 displayed strong Balmer lines but lacked He II, pointing to non-magnetic, nova-like or SU UMa-type systems in high or post-outburst states. V1434 TAU and SDSS J090628.24+052656.9 were consistent with quiescent SU UMa-type and U Gem-type systems, respectively, based on their moderate line strengths and absence of high-ionization features.
Overall, my results demonstrate the diversity of accretion behaviors and evolutionary states present within short-period CVs. By combining high-cadence photometric monitoring from TESS with optical spectroscopy from LAMOST, I was able to effectively classify and characterize these systems, some of which have received limited prior attention. This approach illustrates the power of survey synergy in advancing our understanding of accretion physics and orbital evolution in compact binary stars. Continued follow-up—particularly high-resolution spectroscopy and extended photometric monitoring—will be essential for further constraining the physical parameters and evolutionary pathways of these systems.

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