The Astrophysical Journal, 974:130 (7pp), 2024 October 10 https://doi.org/10.3847/1538-4357/ad6f97

The Photometric Study of EX Dra: A Dwarf Nova Exhibiting a Titled and Precessional Disk

Wei Liu[1,2,3,4,5], Sheng-Bang Qian[2,3], Xiang-Dong Shi[4,5], Qi-Bin Sun[4,5], Xiao-Hui Fang[6], and Qi-Shan Wang[6]
[1] College of Physics and Electronic Engineering, Xingtai University, Xingtai 054001, People's Republic of China
[2] Department of Astronomy, School of Physics and Astronomy, Yunnan University, Kunming 650091, People's Republic of China; qiansb@ynu.edu.cn
[3] Key Laboratory of Astroparticle Physics of Yunnan Province, Yunnan University, Kunming 650091, People's Republic of China
[4] Yunnan Observatories, Chinese Academy of Sciences, P.O. Box 110, Kunming 650216, People's Republic of China
[5] University of Chinese Academy of Sciences, No. 1 Yanqihu East Rd., Huairou District, Beijing 101408, People's Republic of China
[6] School of Mathematics, Physics and Finance, Anhui Polytechnic University, Wuhu 241000, People's Republic of China
Received 2024 March 3; revised 2024 August 10; accepted 2024 August 13; published 2024 October 9

Abstract

We present a photometric study of EX Dra, a dwarf nova that has been extensively observed by the Transiting Exoplanet Survey Satellite. The data reveal the occurrence of 20 complete outbursts, exhibiting several intriguing and rare characteristics. The light curves exhibit a distinct superorbital signal with a period of approximately $P_{\rm sor} \sim 4.39(7)$ days, along with a negative superhump showing an approximate period of $P_{\rm nsh} \sim 4.805(1)$ hr, indicating that the accretion disk is tilted and undergoing precession with the period of $P_{\rm sor}$. In addition, the time-varying nature of $P_{\rm sor}$ suggests that the precession period is fluctuating.The eclipsing light minima $O-C$ analysis during quiescence shows an oscillation with period of 3.9(5) days, which is a little shorter than the superorbital period. We contend that this is unlikely to be a sudden alteration of the orbital period, but rather, it is influenced by the tilt and precession of the accretion disk. Notably, we found an amplitude shift in the outburst behavior from 3.5 mag with a periodicity of about 26 days to an amplitude of around 2.5 mag with a periodicity of about 12 days, which persisted for 14 yr before reverting. Furthermore, we have extracted quasiperiodic oscillations in the plateau at the noneclipsed phases, characterized by periods ranging between 37 and 40 minutes.

Unified Astronomy Thesaurus concepts: Cataclysmic variable stars (203); Dwarf novae (418); U Geminorum stars (1732)

1. Introduction

Dwarf novae are semidetached binary systems, comprising a weakly magnetic white dwarf (the primary star) and a late-type main-sequence star (the secondary star). In these systems, the secondary star, having filled its Roche lobe, transfers material onto the white dwarf. This process results in the formation of an accretion disk surrounding the white dwarf (B. Warner 1995). Due to accretion, dwarf novae are much brighter than isolated white dwarfs or red dwarfs. Dwarf novae exhibit unexpected repeat outbursts, and according to outburst profiles, they were classified into three subtypes, which are Z Cam type, U Gem type, and SU UMa type (see also Y. Osaki 1996; J. K. Cannizzo 2000). There are two models proposed to explain these outbursts, the mass transfer instability model (G. T. Bath 1975) and disk instability model (DIM; Y. Osaki 1974; J.-P. Lasota 2001; J. M. Hameury 2020). With the accumulation of observational data, DIM has been widely verified and accepted.

EX Dra (HS 1804+6753) is an eclipsing dwarf nova characterized by an orbital period of 0.209937316 day, positioned above the period gap of cataclysmic variables. The period gap is between 2 and 3 hr, and the number of cataclysmic variables in this range is particularly small. Its minimum brightness in quiescence is 15.2 mag; its maximum brightness in outburst is 12.3 mag. In subsequent studies using spectroscopy and photometry, the binary parameters were obtained, $q = 0.72(\pm0.06)$, $m_1 = 0.75(\pm0.15)M_\odot$, and $m_2 = 0.54(\pm0.1)M_\odot$ (I. Billington et al. 1996; H. Fiedler et al. 1997; R. Baptista et al. 2000). The spectral type of the secondary was determined to be $M1.5(\pm0.5)$ (C. Knigge 2006). It is a deep eclipsing system with an orbital inclination of 85° (R. Baptista et al. 2000). A. W. Shafter & J. N. Holland (2003) analyzed the acquired multicolor light curves in conjunction with a parameter-fitting model, thereby deriving a multitude of useful parameters for the system under investigation.

J. M. C. Court et al. (2020) reported a negative superhump in EX Dra during quiescence with a period of ∼4.81 hr. Furthermore, they also point out that the dwarf nova outbursts of EX Dra are initiated from the inside out, with the accretion disk radius expanding during these events.

Negative superhumps refer to periodic variations in brightness with periods a bit shorter than the orbital period, a phenomenon frequently observed in cataclysmic variables (D. Harvey et al. 1995). The periods of negative superhumps are not strictly constant but exhibit small variations. Negative superhumps are explained to arise in a titled disk precesses with respect to the orbital plane. The titled disk precesses retrogradely such that the same aspect between the disk and the infalling stream of matter repeats on a period slightly less than the orbital period (J. Bonnet-Bidaud et al. 1985; J. Patterson 1999). Later, through simulations, this model was confirmed and refined (e.g., M. A. Wood et al. 2000; M. A. Wood & C. J. Burke 2007; M. A. Wood et al. 2009). However, there is not yet a good understanding of why the disk becomes tilted. J. R. Murray et al. (2002) demonstrate that a dipolar magnetic field centered on the secondary star can excite measurable vertical structure in the accretion disk of a close binary system, leading to a tilted disk. However, again the disk tilt dies away in their simulations because of the inherent symmetry when averaged over several orbits. Instability in the vertical direction can lead to the tilting of the accretion disk. The 3:1 resonance may amplify oscillations of a disk particle not only in the radial direction but also in the vertical direction (S. H. Lubow 1992; J. R. Murray & P. J. Armitage 1998). However, the 3:1 resonance typically occurs in SU UMa–type stars, which are generally found below the orbital period gap. J. Smak (2009) advocated that the stream–disk interaction maintains instability in the vertical direction. M. M. Montgomery & E. L. Martin (2010) proposed that the disk is forced to lean by a kind of buoyancy, called lift, once it is tilted. Superorbital signals are frequently detected in systems exhibiting negative superhumps and are regarded as compelling evidence of a precessing, tilted accretion disk (D. Harvey et al. 1995). The connection between the orbital period ($P_{\rm orb}$), the superorbital period ($P_{\rm sor}$), and the period of negative superhumps ($P_{\rm nsh}$) is often described by the relationship

$$\frac{1}{P_{\rm prec}} = \frac{1}{P_{\rm sor}} = \frac{1}{P_{\rm nsh}} - \frac{1}{P_{\rm orb}}.$$

This formula suggests that the inverse of the precession period ($P_{\rm prec}$), which governs the superorbital modulation, equals the difference between the inverses of the negative superhump period and the orbital period (J. I. KATZ 1973; P. Barrett et al. 1988; D. Harvey et al. 1995).

Quasiperiodic oscillations (QPOs) are a common phenomenon in the light curves of cataclysmic variables (J. Patterson et al. 1977). They are short-timescale modulations in light curves that refer to the luminosity variation with time ranging from 50 to 1000 s (P. A. Woudt & B. Warner 2002). QPOs are difficult to recognize because of their low coherence and short coherence time. In the outbursts of the long-period dwarf nova EM Cyg, QPOs with duration of hundreds of seconds were detected, and these QPOs vanished following the cessation of the outbursts (W. Liu et al. 2021).

EX Dra was classified as a U Gem–type dwarf nova. A. V. Halevin & A. A. Henden (2008) found the outburst cycle switched from 20–25 to 10–15 days on 2003 January, using the data obtained by members of The American Association of Variable Star Observers (AAVSO). What led to this switch is unclear. Years have passed and more photometric data have been accumulated than enough for us to analyze them here again. With the release of photometric data from the Transiting Exoplanet Survey Satellite (TESS) and AAVSO, we are able to analyze the EX Dra outburst light-curve characteristics in more detail.

In this paper, superorbital signal, or precession of disk, is studied. In addition, we explore outburst cycle and amplitude variations of this target using TESS and AAVSO data. Many characteristics of the light curves during outbursts and quiescence are also found.

2. Data Preparation

The main mission of TESS is to search for exoplanets via transit detection, and many superoutbursts of SU UMa stars were observed by this method. The light curves were downloaded from the Mikulski Archive for Space Telescopes (MAST) data archive.[7] All the TESS data used in this paper can be found in MAST: doi:10.17909/jrpc-ww29. TESS divides the sky into 26 sectors, observing the southern ecliptic hemisphere in the first year of mission operation and the northern hemisphere in the second year. It observes a sector of the sky for two spacecraft orbits of approximately 27 days. Every sector has a 1 day gap for transferring data back. The detectors attached to TESS are sensitive to wavelengths ranging from 600 to 1000 nm. The observations of two adjacent sectors are almost continuous except a short gap, and a light curve may consist of multiple consecutive sector observations. EX Dra was monitored photometrically by TESS from 2019 July 19 to 2022 December 22. We selected the simple aperture photometry (SAP) data with the exposure time of 120 and 20 s. The 23 sectors data including 20 complete outbursts (see Figure 1) were obtained.

AAVSO is an international nonprofit organization. Founded in 1911, the organization focuses on coordinating, analyzing, publishing, and archiving variable star observations made largely by amateur astronomers (T. R. Williams & M. Saladyga 2011). The AAVSO creates records that establish light curves depicting the variation in brightness of a star over time. The AAVSO makes these records available to professional astronomers, researchers, and educators. We downloaded all the light curves of EX Dra from AAVSO,[8] and the data span up to 30 yr.

3. The Precessional Disk

3.1. The Superorbital Period

The superorbital signals shown in the light curves of dwarf novae are commonly attributed to the reverse precession of the tilted disk. It is widely accepted that the superorbital period corresponds to the precession period. Superorbital signals seem clearer in high-orbital-inclination dwarf novae than in low-orbital-inclination systems. The superorbital signal, as discovered from the TESS light curve of EX Dra, is distinctly evident during quiescent states but becomes not obvious during outbursts (see Figure 2). We selected the light curves for outbursts 1 through 4. Prior to obtaining the time-resolved power spectra, we removed the light-curve trend in the outbursts using the locally weighted scatterplot smoothing method (for more details, see W. Liu et al. 2024). The results are shown in Figure 2. The results show that the superorbital signal period varies over time, fluctuating around a period of 4.39(7) days. Figure 3 illustrates the light curves during quiescence from BJD 2458942 to 2458954, from which we extracted the primary and secondary light minima as well as maxima, displayed in the middle panel. The primary and secondary minima represent the primary and secondary eclipses, respectively, and we set the primary eclipses to 0 phase. The illustrations of these minima and maxima are marked in Figure 4. The maxima correspond to −0.25 and 0.25 phases. The middle panel of Figure 3 clearly exhibits periodic variations resembling sinusoidal patterns occurring at both primary and secondary light maxima phases. Similar modulation also occurs at secondary light minima; however, its shape deviates from sinusoidal behavior. Notably, no variation is observed at the primary light minimum, when the accretion disk is completely eclipsed by the companion star, suggesting that this periodic modulation originates from the accretion disk itself. By employing the Lomb–Scargle method, we determined a superorbital period of $P_{\rm sor} = 4.39(7)$

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

[8] https://www.aavso.org/

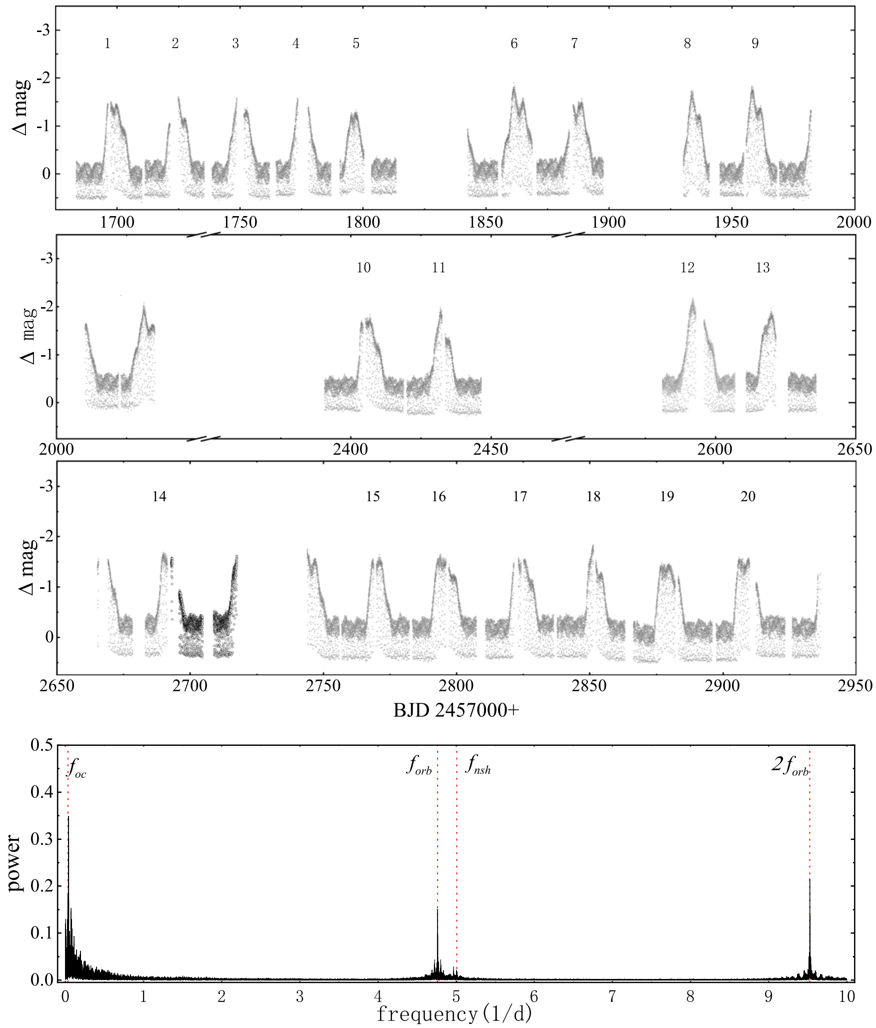

Figure 1. Light curves of EX Dra recorded by TESS. The bottom is the frequency spectrum of the light curves. $f_{\rm oc}$, $f_{\rm orb}$, and $f_{\rm nsh}$ are the frequencies of outburst cycle, orbital period, and negative superhump, respectively.

days from BJD 2458942 to 2458954 in quiescence. Such modulation becomes less apparent in outbursts. J. M. C. Court et al. (2020) reported the observation of negative superhumps in EX Dra with a period of $P_{\rm nsh} = 0.200417$ day, indicating a tilted accretion disk system. The occurrence of negative superhumps is attributed to the combination of orbital motion and tilted disk precession. According to the formula

$$\frac{1}{P_{\rm prec}} = \frac{1}{P_{\rm nsh}} - \frac{1}{P_{\rm orb}},$$

the precession period can be calculated from the orbital period and the period of the negative superhump. We got the negative superhump period of $P_{\rm nsh} = 0.20023(6)$ day from BJD 2458942 to 2458954 in quiescence. The calculated precession period is $P_{\rm prec} = 4.42(3)$ days, which is corresponding to the superorbital period. Using photometric study and the combined model, the radius of the accretion disk in the quiescence and outburst states were constrained to $R_{dq} = 0.16 - 0.32a$ and $R_{do} = 0.31 - 0.36a$ (I. Voloshina et al. 2021), respectively. Where a represents the distance between the two stars, R_{dq} denotes the radius of the accretion disk during its quiescent state, while R_{do} represents the radius of the accretion disk during the outburst. The study by R. Baptista et al. (2000) reports a value of a as $1.61(\pm0.1)\ R_\odot$ and specifies the radius of the companion star, R_2, to be $0.57(\pm0.04)\ R_\odot$. The radius of the companion star can also be converted to $0.35(\pm0.03)a$. Due to the high orbital inclination of 85°, the accretion disk is almost completely eclipsed in quiescence. In outburst states, the accretion disk will appear a little bit when eclipsed. This is in perfect agreement with the observational data from TESS; the eclipsing luminosity is only slightly raised in outburst. The disk is fully eclipsed by the secondary in quiescence.

The accretion disks in dwarf novae are not well understood because it cannot be directly observed. However, some phenomena in the light curves can be used to obtain the status of the accretion disk (D. R. Gies et al. 2013; M. Kimura et al. 2020; M. Kimura & Y. Osaki 2021). Negative superhump in EX Dra during quiescence was found in TESS light curve, which indicates that a titled and precessing disk around the white dwarf. The period modulation of 4.39(7) days that we have identified suggests the precession period of the disk in the EX Dra system. It has no modulation when the accretion disk is eclipsed since the modulation comes from the disk.

3.2. The Observation minus Calculation Analysis

We used observation minus calculation $(O-C)$ analysis to study the periodic changes of the eclipsing time in several

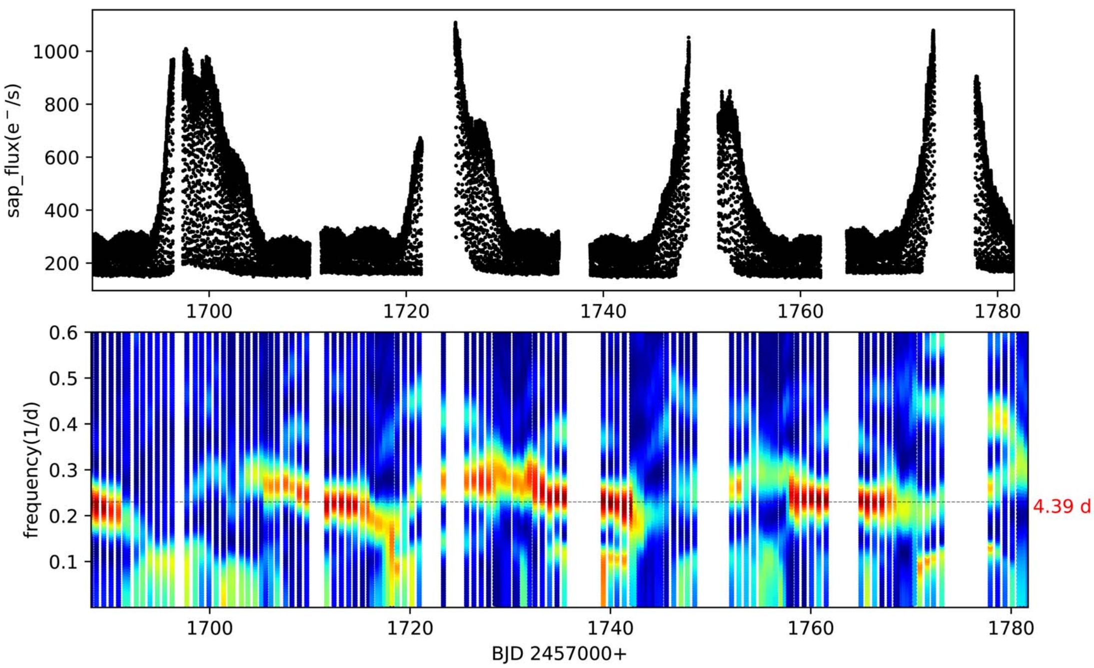

Figure 2. The upper panel exhibits the light curve spanning from outbursts 1 through 4. Meanwhile, the lower panel reveals the corresponding time-resolved power spectrum, wherein the black dashed line denotes the presence of a superorbital signal with a period around 4.39 days.

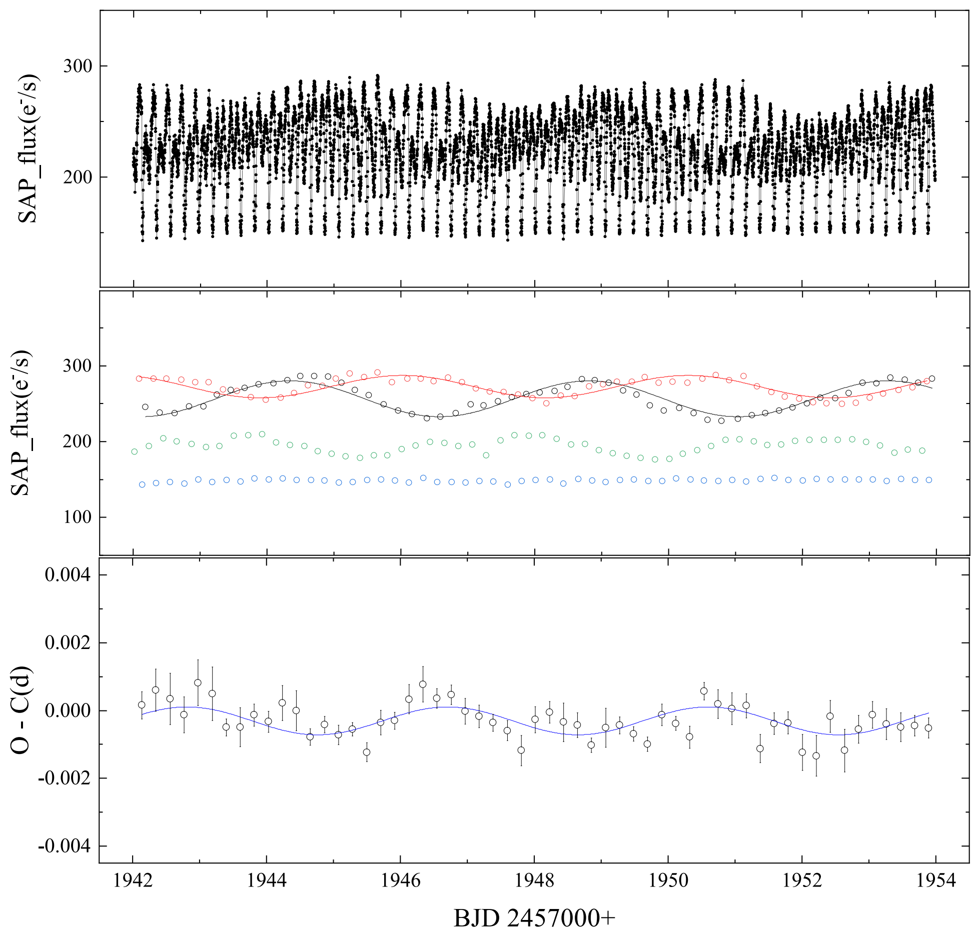

Figure 3. The top panel shows beat in quiescence. The middle panel shows the primary (blue) and secondary (green) light minima and the primary (black) and secondary (red) light maxima in the light curve. The red line and the black line are the fittings to the primary and secondary light maxima, respectively. The bottom panel shows the $O-C$ analysis of the eclipsing times. The blue line is the fitting of the $O-C$ data.

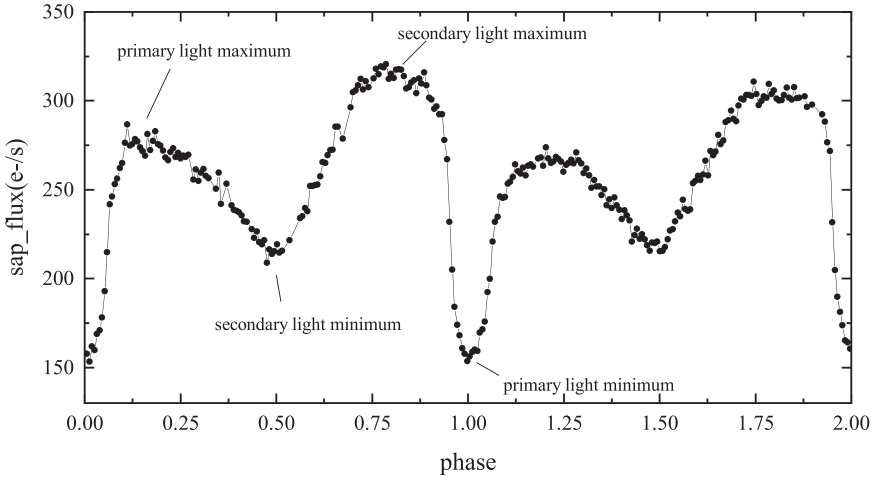

Figure 4. The light curves of two orbital phases. Primary and secondary maxima, as well as primary and secondary minima, are all marked on the light curves.

superorbital periods in quiescence. In an outburst, eclipses are affected by variations in the brightness of the accretion disk, which leads to inaccuracies of eclipsing light minimum times. We chose a high-signal-to-noise-ratio eclipse as the initial epoch of the ephemeris. According to the quadratic polynomial fitting method, the light minima times of eclipses were obtained. According to the orbital period of 0.209937 day, the $O-C$ values were calculated by an ephemeris of

$$T_{\min} = \mathrm{BJD}2458942.139101 + 0.209937 \times E, \quad (1)$$

where BJD 2458942.139101 is the initial epoch and E is the epoch number. The $O-C$ diagram is shown in bottom panel of Figure 3. The $O-C$ curves show a clear sinusoidal variation with a period of 3.9(5) days and an amplitude of about 0.001 day. Interestingly, this $O-C$ curve period oscillation coincides with the phase of the primary light maxima curve (see middle panel of Figure 3). This is similar to the sinusoidal variation in SU UMa (W. Liu et al. 2024) in the superoutburst, UX UMa (E. de Miguel et al. 2016), SDSS J081256.85+191157.8 (Q.-B. Sun et al. 2023) and TV Col (Q.-B. Sun et al. 2024). The $O-C$ oscillation has a relatively short period, indicating that it is unlikely to be due to rapid variations in the orbital period and instead may be associated with some connection to the precession of the accretion disk. The periodic change in the irradiated surface of the secondary star visible to the observer may also contribute to this modulation.

4. The Outburst Characteristics

4.1. The Outburst Cycle

EX Dra is a U Gem–type dwarf nova, just showing normal outbursts with intervals from 10 to 30 days. The data from TESS exhibit 20 complete outbursts. The Lomb–Scargle power spectrum of all TESS light curves (see Figure 1) shows that the frequency of outburst cycle is $f_{oc} = 0.03814$, corresponding to a period of about 26 days and some other peaks corresponding to the timescale range from 22 to 27 days. This indicates that EX Dra switched back to the outburst cycle with a timescale of 20–25 days from 10 to 15 days (A. V. Halevin & A. A. Henden 2008). The previous switch occurred on 2003 January.

To study the period changes of outburst cycles, we have downloaded nearly 30 yr of AAVSO data, spanning from 1995 to the current year. Subsequently, a time-resolved power spectrum was generated and depicted in Figure 5, along with corresponding light curves in the top panel. Despite occasional data gaps leading to some discontinuities in the power spectrum, two distinct outburst cycles are clearly discernible: one period approximately 12 days and another spanning around 26 days. The light curves show that the outburst amplitude has decreased by about 1 mag. Specifically, the quiescence brightness has increased by about 0.8 mag, and the outburst brightness has decreased by about 0.2 mag. In 2017 January, the outburst switched from low-amplitude high frequency to high-amplitude low frequency. Therefore, the switching lasts about 14 yr.

We found that the averaged optical flux during the periods of both short-outburst intervals and the long-outburst intervals were essentially equal to 14 mag. This indicates that the rate of material transfer might not have undergone any change (M. Kimura et al. 2021). What factors are responsible for this switching remain unclear at present. The possible reasons are the change in the viscosity of the quiescent disk or the change in the overflow rate of the gas stream from the secondary star (M. Kimura & Y. Osaki 2023).

4.2. The QPOs

In the plateau of outbursts, distinct QPOs are shown in the light curves. To get a more accurate oscillation profile, we selected a sector of TESS data with an exposure time of 20 s. The light curves of three orbital periods in outbursts and quiescence were selected and are shown in the top and middle parts of Figure 6. The figure clearly demonstrates the association between QPOs and the orbital phase, with no detection of QPOs during eclipses, and the QPOs cease with the end of outbursts. The Lomb–Scargle method was employed to identify frequency signals of QPOs from the selected light curves. Specifically, we observed periods of 37.3, 40, and 37 minutes for these QPOs, respectively. We find that QPOs are consistently present during all outbursts, indicating that their occurrence is not random but rather implies the presence of a specific underlying mechanism. These findings suggest that certain activities occurring on the accretion disk during outbursts are responsible for generating these QPOs. Although there are slight variations in both frequency and amplitude among different orbital periods, QPOs have amplitudes of

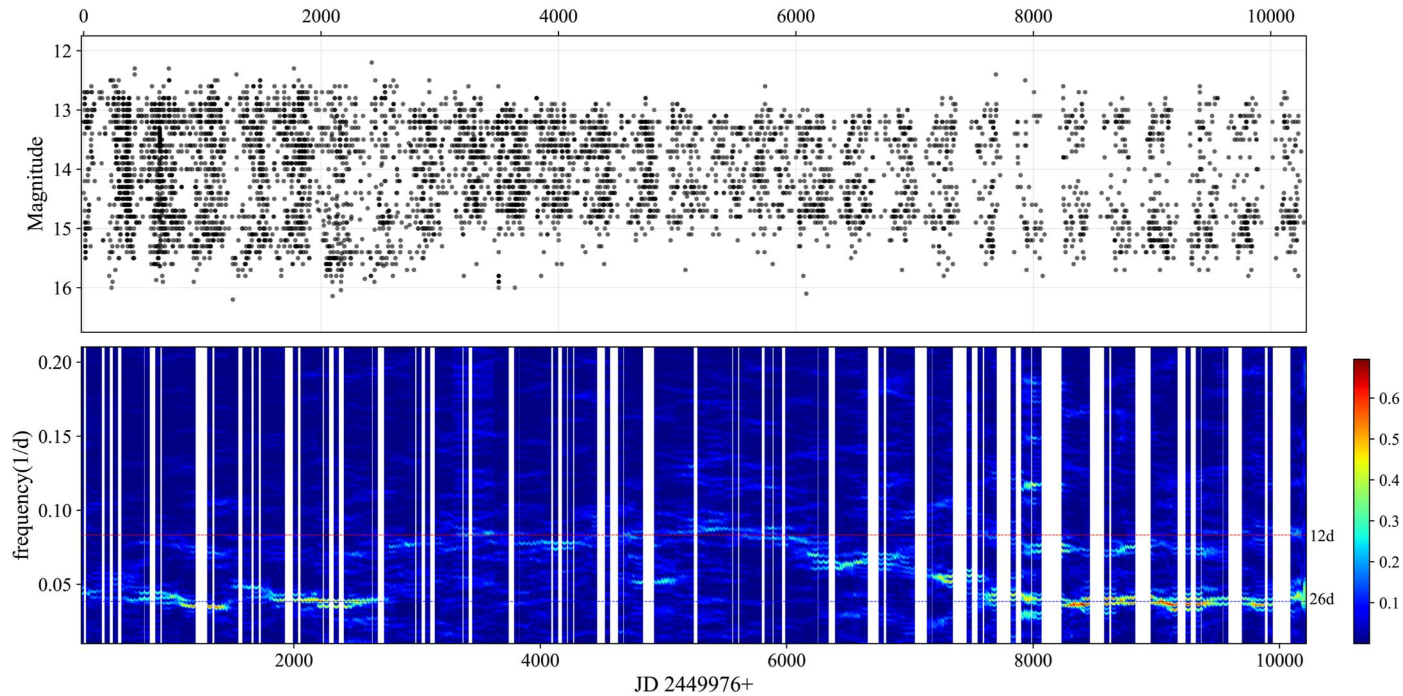

Figure 5. The time-resolved power spectrum shows that the outburst cycle switched from approximately 26 days to 12 days and that on BJD 2459976, it switched back.

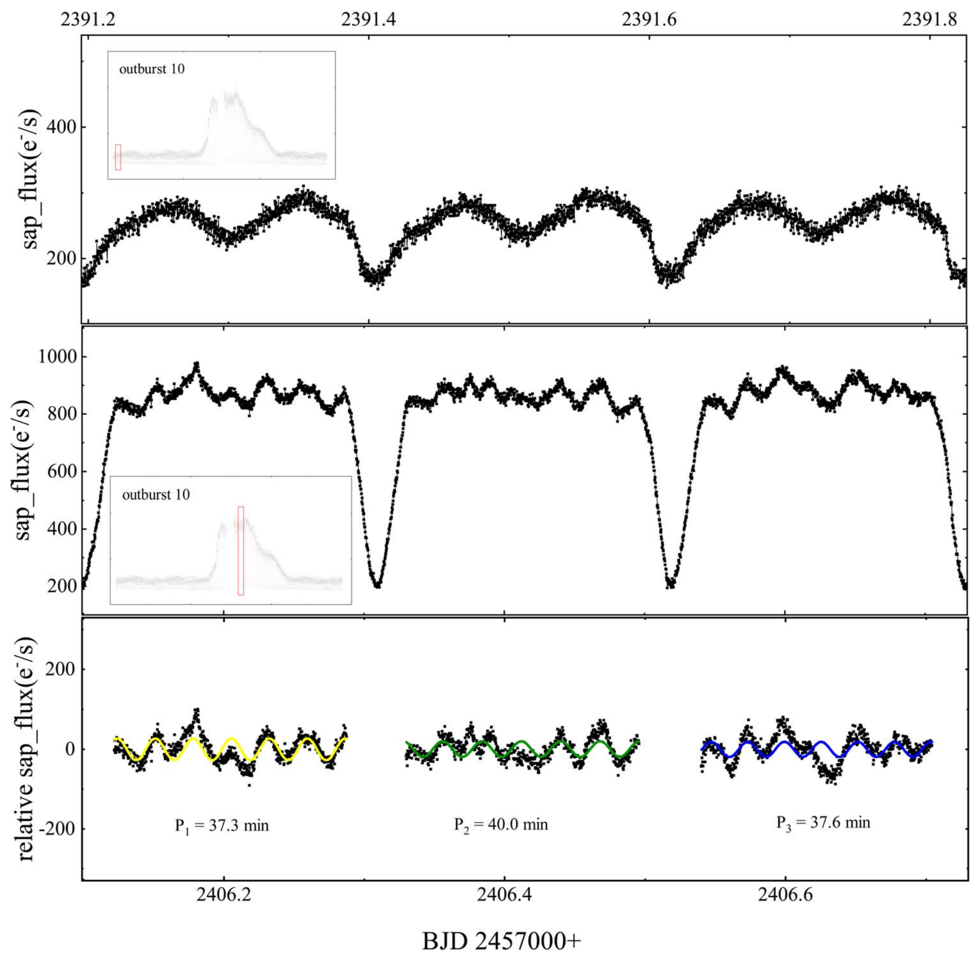

Figure 6. The top panel shows light curves of three orbital periods in quiescence. It corresponds to the position of the red box of outburst 10 in the top panel. The middle panel shows light curves of three orbital periods in the plateau. It corresponds to the position of the red box of outburst 10 in the middle panel. The bottom panel shows the light curve with eclipsing profile removed; the yellow, green, and blue lines refer to the fit to QPOs. Three QPO frequencies were found, with periods of 37.3, 40, and 37.6 minutes, respectively.

about $80e^{-}/s$. Such phase-associated QPOs have also been found in EM Cyg (W. Liu et al. 2021).

QPOs in cataclysmic variables are diverse in nature and can be produced by multiple mechanisms, making it difficult for them to be explained with a single physical mechanism. For example, B. Warner (1995) noted that the longest QPO periods are close to the rotation period at the outer edge of the accretion disk in CVs, while J.-P. Lasota et al. (1999) suggested that QPOs in the dwarf nova WZ Sge are associated with thermal spots at the edge of the accretion disk, and all QPOs may be caused by oscillations in the inner accretion disk, including the presence of turbulence on the accretion disk (D. Moss et al. 2016).

B. W. Carroll et al. (1985) and S. H. Lubow & J. E. Pringle (1993) analyzed the pulsation of the accretion disk and suggested that QPOs might be generated by nonradial oscillation of the accretion disk itself. During quiescence, when the luminosity of the accretion disk is low, any resulting changes in luminosity are subtle. However, during outbursts when the accretion disk becomes brighter, these changes become more pronounced and manifest as QPOs.

5. Conclusion

The long-term light curves of EX Dra obtained from TESS exhibit multiple outbursts, revealing various characteristics during these events. The outbursts display quasiperiodicity with a cycle of approximately ∼26 days. The orbital period and negative superhump signals also were shown in the power spectrum (see Figure 1). We performed an analysis of the light curve to investigate the superorbital signal, which may offer potential evidence suggestive of accretion disk precession. The periodic variations in the primary light maxima, secondary light maxima, and secondary light minima are noteworthy. The constancy of the primary light minima may suggest that the variations originate from the accretion disk. The time-resolved power spectrum (Figure 2) shows that during the outbursts, the superorbital signal becomes not obvious. The precession period of the accretion disk is estimated to be approximately 4.39 days with an uncertainty of 0.07 days. In addition, we found that the superorbital signal period is variable, especially during outbursts, fluctuating at around 4.39 days. The $O-C$ curve exhibits oscillations with a period of 3.9(5) days, and the phase of the primary light maximum curve is almost the same. This target showcases a highly unusual, outburst-alternating behavior. From the analysis of AAVSO observational data, we uncovered that the outburst pattern shifted from episodes of approximately 3.5 mag increases, recurring every 26 days, to those of 2.5 mag increments with a shorter recurrence interval of roughly 12 days. This latter pattern persisted consistently for a 14 yr duration before reverting to the original state. What exactly triggers this transition remains unclear at present. QPOs emerge outside eclipse phases during outbursts, exhibiting a period of approximately 40 minutes and an amplitude of $80\,e^{-}/s$, suggesting a probable link to activities taking place within the accretion disk.

Acknowledgments

This work is supported by National Key R&D Program of China (grant No. 2022YFE0116800), the National Natural Science Foundation of China (Nos. 11933008 and 12103084), the basic research project of Yunnan Province (grant No. 202301AT070352), and the Natural Science Foundation of Anhui Province (2208085QA23). This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST). Funding for the TESS mission is provided by the NASA Science Mission Directorate. We acknowledge with thanks the variable star observations from the AAVSO International Database contributed by observers worldwide and used in this research.

ORCID iDs

Wei Liu https://orcid.org/0000-0002-0690-3273
Xiang-Dong Shi https://orcid.org/0000-0002-5038-5952
Qi-Bin Sun https://orcid.org/0000-0003-0516-404X
Xiao-Hui Fang https://orcid.org/0000-0002-4023-9310
Qi-Shan Wang https://orcid.org/0000-0003-3886-3883

References

Baptista, R., Catalan, M. S., & Costa, L. 2000, MNRAS, 316, 529
Barrett, P., O'Donoghue, D. D., & Warner, B. 1988, MNRAS, 233, 759
Bath, G. T. 1975, MNRAS, 171, 311
Billington, I., Marsh, T. R., & Dhillon, V. S. 1996, MNRAS, 278, 673
Bonnet-Bidaud, J., Motch, C., & Mouchet, M. 1985, A&A, 143, 313
Cannizzo, J. K. 2000, NewAR, 44, 41
Carroll, B. W., McDermott, P. N., Savedoff, M. P., van Horn, H. M., & Cabot, W. 1985, ApJ, 296, 529
Court, J. M. C., Scaringi, S., Littlefield, C., et al. 2020, MNRAS, 494, 4656
de Miguel, E., Patterson, J., Cejudo, D., et al. 2016, MNRAS, 457, 1447
Fiedler, H., Barwig, H., & Mantel, K. H. 1997, A&A, 327, 173
Gies, D. R., Guo, Z., Howell, S. B., et al. 2013, ApJ, 775, 64
Halevin, A. V., & Henden, A. A. 2008, IBVS, 5833, 1
Hameury, J. M. 2020, AdSpR, 66, 1004
Harvey, D., Skillman, D. R., Patterson, J., & Ringwald, F. A. 1995, PASP, 107, 551
KATZ, J. I. 1973, NPhS, 246, 87
Kimura, M., & Osaki, Y. 2021, PASJ, 73, 1225
Kimura, M., & Osaki, Y. 2023, PASJ, 75, 250
Kimura, M., Osaki, Y., & Kato, T. 2020, PASJ, 72, 94
Kimura, M., Yamada, S., Nakaniwa, N., et al. 2021, PASJ, 73, 1262
Knigge, C. 2006, MNRAS, 373, 484
Lasota, J.-P. 2001, NewAR, 45, 449
Lasota, J.-P., Kuulkers, E., & Charles, P. 1999, MNRAS, 305, 473
Liu, W., Qian, S.-B., Zhi, Q.-J., et al. 2021, MNRAS, 505, 677
Liu, W., Shi, X.-D., Fang, X.-H., & Wang, Q.-S. 2024, NewA, 106, 102129
Lubow, S. H. 1992, ApJ, 401, 317
Lubow, S. H., & Pringle, J. E. 1993, ApJ, 409, 360
Montgomery, M. M., & Martin, E. L. 2010, ApJ, 722, 989
Moss, D., Sokoloff, D., & Suleimanov, V. 2016, A&A, 588, A18
Murray, J. R., & Armitage, P. J. 1998, MNRAS, 300, 561
Murray, J. R., Chakrabarty, D., Wynn, G. A., & Kramer, L. 2002, MNRAS, 335, 247
Osaki, Y. 1974, PASJ, 26, 429
Osaki, Y. 1996, PASP, 108, 39
Patterson, J. 1999, in Disk Instabilities in Close Binary, ed. S. Mineshige & J. C. Wheeler (Tokyo: Universal Academy Press), 61
Patterson, J., Robinson, E. L., & Nather, R. E. 1977, ApJ, 214, 144
Shafter, A. W., & Holland, J. N. 2003, PASP, 115, 1105
Smak, J. 2009, AcA, 59, 121
Sun, Q.-B., Qian, S.-B., Zhu, L.-Y., et al. 2023, MNRAS, 526, 3730
Sun, Q.-B., Qian, S.-B., Zhu, L.-Y., Liao, W.-P., Zhao, E.-G., et al. 2024, ApJ, 966, 83
Voloshina, I., Khruzina, T., & Metlov, V. 2021, The Golden Age of Cataclysmic Variables and Related Objects V, Vol. 2–7 (Palermo: Proceedings of Science), 10
Warner, B. 1995, Cataclysmic Variable Stars, Vol. 28 (Cambridge: Cambridge Univ. Press)
Williams, T. R., & Saladyga, M. 2011, Advancing Variable Star Astronomy: The Centennial History of the American Association of Variable Star Observers (Cambridge: Cambridge Univ. Press)
Wood, M. A., & Burke, C. J. 2007, ApJ, 661, 1042
Wood, M. A., Montgomery, M. M., & Simpson, J. C. 2000, ApJL, 535, L39
Wood, M. A., Thomas, D. M., & Simpson, J. C. 2009, MNRAS, 398, 2110
Woudt, P. A., & Warner, B. 2002, MNRAS, 333, 411