THE ASTROPHYSICAL JOURNAL, 399:680–685, 1992 November 10

TWO UNUSUAL CATACLYSMIC VARIABLES AT HIGH GALACTIC LATITUDE: CP ERIDANI AND AL COMAE

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Received 1991 December 2; accepted 1992 May 19

ABSTRACT

We present time-series photometry of two faint, interacting binary stars at high Galactic latitude: CP Eridani and AL Comae Berenices. We also present spectroscopy of CP Eri. CP Eri has a long-lived photometric periodicity near 28 minutes. Its spectrum has lines of helium that are sometimes in emission and sometimes in absorption; there are no lines of hydrogen in the spectrum. We identify CP Eri as a binary star consisting of a pair of white dwarfs undergoing mass transfer. AL Com has an unstable, high-amplitude photometric modulation with a period between 87 and 90 minutes. The previously identified photometric period at 41 minutes is also unstable. Some of the properties of AL Com are similar to the dwarf nova WZ Sge and others are similar to the intermediate polar EX Hya, but overall AL Com is unlike any other well-studied cataclysmic variable.

Subject headings: binaries: close — novae, cataclysmic variables — stars: individual (CP Eridani, AL Comae) — stars: white dwarfs

1. INTRODUCTION

Cataclysmic variables (CVs) are highly evolved binary stars undergoing mass transfer from a late-type secondary that fills its Roche lobe onto a white dwarf primary. The accretion takes place through either an accretion disk or a magnetically focused accretion column or a combination of the two. Interacting binary white dwarfs (IBWDs) are similar to CVs but have a low-mass white dwarf as secondary. Reviews of the literature on these objects may be found in la Dous (1990) and Patterson (1984).

We have been engaged in a program to measure the properties of faint CVs at high Galactic latitude to determine whether there are differences between Population I and Population II CVs. As part of this program we have collected time-series photometric data to establish the orbital periods and the flickering properties of these stars. The stars are usually too faint to observe with conventional photometers on the 2–3 m telescopes available to us. We have, therefore, used CCDs instead of photomultiplier tubes as detectors because of their greater sensitivity. In addition, since CCDs are imaging devices, photometric conditions are not necessary for the observations if comparison stars are available, and we can use a higher fraction of the telescope time scheduled to us.

This paper presents results for two stars from our sample: AL Com and CP Eri. They were initially selected for their variability, faintness and high Galactic latitudes, making them likely candidates for Population II CVs.

AL Com first attracted close attention when discovered in outburst at 14th magnitude by Rosini in 1962 (Bertola 1964). It faded back to its quiescent brightness fainter than $\sim 19\ m_{pg}$ in 60 days, with a deep and short-lived minimum ~ 20 days after maximum. Because of its outburst and because it had a featureless blue spectrum during the outburst, AL Com has been classified as a dwarf nova. Five other outbursts are known, yielding a recurrence time of 325 days (Kholopov & Efremov 1976). Time-series CCD photometry by Howell & Szkody (1987) showed that the light curve at minimum light has a large amplitude variation (0.4 mag) with a period near 40 minutes. Because of this short period, they suggested that AL Com might be either a DQ Her star or a double degenerate system such as AM CVn (Solheim et al. 1984). However, neither DQ Her stars nor the suspected double degenerate systems are known to have dwarf nova outbursts with amplitudes as large as 6 mag. Szkody et al. (1989) published further time-series CCD photometry in which they again found a strong modulation near 40 minutes. The spectrum of AL Com at minimum light shows Hα and Hβ in emission (Mukai et al. 1990). This disqualifies AL Com as an IBWD since the spectra of IBWDs are dominated by helium lines in either absorption or emission and totally lack hydrogen lines. Antipova (1987) and O'Donoghue et al. (1991) have included AL Com in their discussions of SU UMa stars, which are dwarf novae with superoutbursts interspersed with normal outbursts.

We present time-series CCD photometry of AL Com from three observing seasons. In the latter two seasons the light curve was modulated by a high-amplitude periodicity near 90 minutes. The pulse structure at this frequency was highly variable, changing substantially within a few hours. The 40 minute oscillation found by Howell & Szkody (1987) is also present in our observations. It is not a harmonic of the longer periodicity.

CP Eri was one of five faint, blue, variable stars at high Galactic latitude listed by Luyten & Haro (1959), who reported observing it at 17th magnitude, ~ 2.5 mag brighter than it was on the POSS plates. The light curve of CP Eri published by Szkody et al. (1989) showed a 0.2 mag increase in brightness over 2.5 hr and some possible rapid flickers with amplitudes of 0.2–0.4 mag. Howell et al. (1991) later found a periodicity near 28 minutes in the light curve and suggested that the star is an intermediate polar.

We present time-series CCD photometry of CP Eri confirming the presence of a periodicity at 1724 ± 4 s (28.6 minutes) with a complex and variable harmonic structure. Spectra of the star show a pure helium line spectrum on a blue continuum. The helium lines are in absorption during the bright state and in emission during the faint state. Hydrogen is entirely absent. These characteristics are similar to those of the IBWDs V803

Cen (O'Donoghue, Menzies, & Hill 1987; O'Donoghue & Kilkenny 1989) and CR Boo (Wood et al. 1987).

2. TIME-SERIES PHOTOMETRY WITH A CCD PHOTOMETER

For our study of faint cataclysmic variables one of us (TMCA) has written a software package called CHRONOS designed specifically for the collection of time-series photometry of stars with CCD detectors. A description of an early version of CHRONOS may be found in Abbott & Opal (1988).

We used CHRONOS to run TI 800 × 800 frame-transfer CCDs and Tektronics 512 × 512 CCDs. When observing with the TI CCDs, we used the frame-transfer capability to minimize dead time between exposures. The Tektronics CCDs, while not capable of frame transfer operation, are quieter and cosmetically cleaner, and therefore produce somewhat better light curves. We reduced the dead time for these devices by reading out only those lines in the CCD that contained useful data. CHRONOS reduces image data and produces approximate light curves in real time, but the image data are also recorded on disk, allowing the light curves to be reduced more accurately later. Timing is maintained by synchronizing the host computer's clock with Coordinated Universal Time at the beginning of each run. The clock drifts by no more than 2 s over the course of our longer runs.

In developing CHRONOS our primary goal was to produce a program that reduces the vast quantities of data obtained by time-series imaging to a light curve with the minimum difficulty. We have, therefore, restricted ourselves to simple aperture photometry for extracting the brightness of stars. The apertures used are circular; counts in pixels that lie on the edge of the aperture are weighted by the fraction of the pixel which lies within the aperture. The local sky brightness is measured in an annular region surrounding the program star's aperture.

A wide range of aperture and sky annulus radii will yield light curves of sufficient quality to permit the observer to monitor the observing conditions and the gross behavior of the program star. However, choosing the optimum radii is not a straightforward task and the choice must be made after the observing run is over. Because the program star is usually variable, the noise present in its light curve must be deduced from the behavior of comparison stars also within the field of view of the CCD. The final reduction of the data is, therefore, performed off-line, after the end of the observation.

The data reduction proceeds as follows. First, the sky annulus for each star is selected to cover as large an area as possible, but not so large that it is contaminated by other stars in the field or biased by cosmetic and flat-fielding defects. Occasionally, another star lies so close to the star of interest that it unavoidably contaminates the local sky estimate. This is true for much of our data on AL Com, which has a slightly brighter companion $\sim 3''$ to the southeast. In this case, we measured the sky in a square region $\sim 10''$ away from AL Com.

Once the sky has been estimated for each star, we must select an aperture to extract the stellar brightnesses. We apply apertures with a range of radii to the comparison stars, producing a series of light curves for each comparison star, one light curve for each aperture radius. The effects of variable atmospheric extinction are eliminated by dividing each light curve by the light curve of one of the brighter companion stars produced with an aperture of the same radius. The result, for each aperture, is a set of flat, differential light curves. We can measure the noise in each of these curves, extrapolate to the brightness of the program star and, therefore, determine the aperture size that maximizes the signal to noise ratio of its light curve.

Ideally, the noise in the program star should be estimated from a comparison star that has the same brightness. The close companion to AL Com, 3″ to the southeast, while inconvenient to the sky measurements, was only slightly brighter than AL Com throughout our observations. We therefore used this star to estimate the error in the observations of AL Com.

If a star of approximately the same brightness of the program star is not available within the field of view, it is necessary to extrapolate from stars of different brightness. Clearly, the more comparison stars that are available, the more reliable the result will be.

Unfortunately, CP Eri was the brightest star in its field by a considerable margin, and we deduced an approximate noise in its light curve by linear extrapolation from fainter stars. The extrapolation is not particularly accurate, but can be used as an indicator to deduce a near-optimum aperture size.

We use the same aperture radius for all stars throughout a run. If different aperture sizes are used for different stars, trends are observed that arise from variable seeing and transparency. A complete description of our data reduction methods and a comparison to more traditional techniques of time-series photometry is in preparation.

3. CP ERIDANI

3.1. *Observations*

The observing log for photometry of both CP Eri and AL Com is given in Table 1. Most of the observations were made on the McDonald Observatory 2.1 m telescope using a focal reducer (Opal & Booth 1990) and a Tektronics 512 × 512 CCD. The exceptions were the run of 1989 May 9, which used the TI2 800 × 800 CCD at the Cassegrain focus of the 2.1 m telescope, and the run of 1989 October 24, which used the same CCD at the broken-Cassegrain focus of the 2.7 m telescope. Whenever possible, we correct for variable atmospheric extinction by using comparison stars in the field. Since CP Eri is in a relatively sparse field, it was not possible to obtain suitable comparison stars in data obtained without the focal reducer. For these runs we were assured of photometric conditions by observers using standard photometers on other telescopes at McDonald Observatory. Runs obtained with the focal reducer on the 2.1 m telescope all have multiple comparison stars.

We observed CP Eri without a filter in order to maximize the signal-to-noise ratio. The bandpass of the instrument was, therefore, largely defined by the response of the CCD. In the case of the 1990 data, this was a thin, antireflection coated Tektronix 512 × 512 device, a "blue" CCD. The two light curves obtained in 1990 September are shown in Figure 1.

CP Eri varied significantly during the run on 1990 September 26, declining by $\sim 20\%$ in brightness. In addition, a power spectrum of the light curve reveals a periodicity near 28 minutes and a complex set of harmonics. There are no other periodicities in the data. CP Eri increased slightly in brightness during the run on 1990 September 27. The same 28 minute oscillation is present but at higher amplitude and with a slightly different harmonic structure. Since there is significant power in the harmonics, we elected to use the periodogram period-finding technique of Warner & Robinson (1972) to determine the precise value of the 28 minute period. In this technique the data are folded over a range of preselected periods to generate a set of average pulse shapes. A discriminant is selected to find the most likely pulse shape and, therefore, the best estimate of

TABLE 1

PHOTOMETRY OF AL COMAE AND CP ERIDANI

UT Date	UT Start	HJD Start 2,447,000 +	Object	Sampling Interval (s)	Sample Length (frames)	Telescope (m)
1989 May 9	03:01:10	655.6294	AL Com	120	115	2.1
1989 Oct 24	09:03:02	823.8804	CP Eri	120	79	2.7
1990 Apr 21	04:54:10	1002.7090	AL Com	180	83	2.1
1990 Apr 23	06:01:00	1004.7553	AL Com	180	67	2.1
1990 Apr 24	04:03:10	1005.6734	AL Com	180	101	2.1
1990 Sep 26	08:24:30	1160.8545	CP Eri	60	211	2.1
1990 Sep 27	08:21:00	1161.8521	CP Eri	60	205	2.1
1991 Feb 17	08:00:30	1304.8384	AL Com	180	58	2.1
1991 Feb 18	08:28:30	1304.8579	AL Com	180	75	2.1
1991 Feb 22	08:43:50	1309.8687	AL Com	180	72	2.1
1991 Apr 9	02:46:20	1355.6137	AL Com	180	128	2.1
1991 Apr 11	03:33:00	1357.6531	AL Com	180	69	2.1
1991 Apr 12	04:55:00	1358.7010	AL Com	180	64	2.1
1991 Apr 15	02:39:10	1361.6155	AL Com	180	150	2.1

the period. The discriminant we used is the total power in the pulse, i.e., the mean square excursion from the mean brightness of the star. This period finding technique works well on signals with complex pulse shapes because it adds the power in the harmonics to the power in the fundamental to determine the best period.

Combining the data of the two nights, we found a period of 1724 ± 4 s (Fig. 2), where the error has been estimated from the width of the peak in the periodogram. More conventional Fourier analysis yields similar but less accurate results, with no evidence for any periodicities in the data other than this one and its harmonics. Figure 3 shows a Fourier amplitude spectrum of both nights of data on CP Eri. The fundamental frequency given by the periodogram technique is marked along with the positions of the first seven harmonics.

The same 28 minute variation is also present in the data of 1989 October 24. These data were taken without comparison stars and, hence, we are unable to assign a formal error to the observations. However, the detection is significant and demonstrates the long-lived nature of the periodicity.

We measured the spectrum of CP Eri on 1990 October and December 21 (UTC) using the Imaging Grism Instrument (Hill & Stockton 1992) mounted at the f/9, bent-Cassegrain focus of the McDonald 2.7 m reflector. This grism spectrometer is a simple, high-throughput, red-sensitive instrument employing a thinned, back-side illuminated, 800×800 pixel TI CCD as the detector. These observations are summarized in Table 2.

The spectra were extracted in the VISTA environment using Horne's (1986) optimal extraction package, wavelength calibrated with a neon lamp and flux-calibrated against the spectrophotometric standard star BD +40°4032 (Stone 1977). A second-order polynomial fit to the positions of the calibration lines was used to define the wavelength scale. The lack of neon emission lines in the blue part of the spectrum makes the wavelengths shortward of the 5577 Å night sky line somewhat uncertain, with the potential error being as large as 30 Å (two resolution elements) at the end of the spectrum.

The spectrum of 1990 October 20 is shown in Figure 4*a* and has been smoothed with a 2 pixel FWHM Gaussian resulting in a resolution of ~20 Å. The spectrum was obtained under conditions of variable cloudiness and poor seeing, and required a total integration time of 90 minutes. The object was in a low state at this time, although the conditions were too poor to allow a precise measurement of its brightness. A faint, broad emission feature that we identify as He I λ5876 is visible in the spectrum. Apart from another possible emission feature at He I λ5015, the spectrum is otherwise featureless and blue. The slight downturn in the spectrum at the extreme blue end is most likely caused by an error in flux calibration at the edge of the detector.

The December spectrum was obtained by D. Wills under better conditions. At this time CP Eri was substantially brighter and had a magnitude of $V = 16.5$ from the flux calibrated

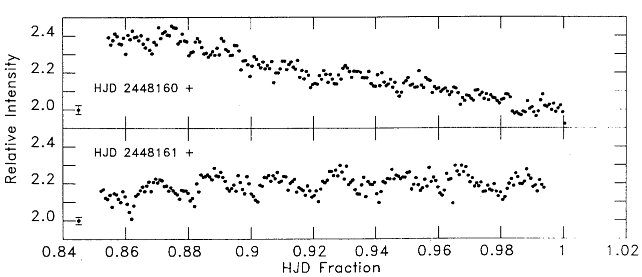

FIG. 1.—Time-series CCD photometric light curves of CP Eri for the nights of 1990 September 26 (*upper curve*) and 27 UT (*lower curve*). The ordinate scale is in units of intensity relative to a nearby star. The 2 σ error bar shows the error deduced from the interpolation scheme described in the text.

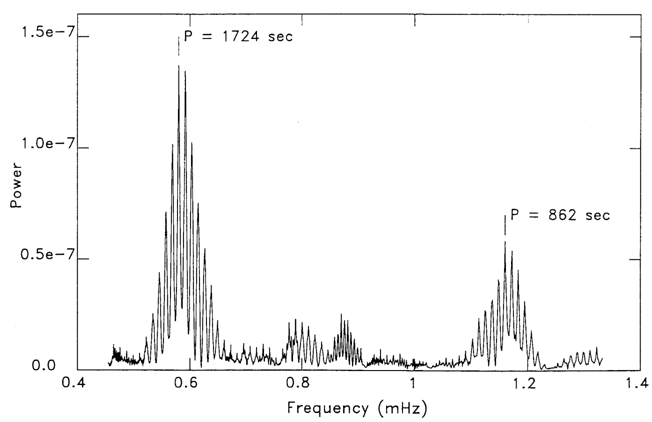

FIG. 2.—A periodogram of light curves of Fig. 1. The ordinate scale is in arbitrary units proportional to power. The highest peak and its first harmonic are marked with ticks.

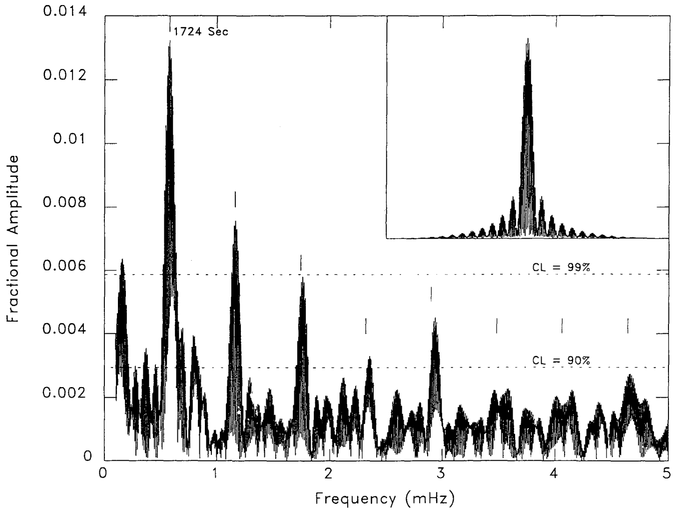

FIG. 3.—An amplitude spectrum of the light curves of Fig. 1. The most likely period as determined from the periodogram of Fig. 2, and its harmonics are marked with ticks. Ninety percent and 99% levels of confidence in period detection are indicated by the dashed lines. Inset is the spectral window of the observations.

spectrum (Fig. 4*b*). The spectrum shows broad, shallow absorption lines of He I at 4921 Å, 5015 Å, and 5876 Å, but is otherwise featureless and blue. The FWHM of the absorption lines, corrected for the instrumental resolution is ~50 Å (2500 km s^{-1}). The width of the He I λ5876 emission in the October spectrum is also consistent with this value.

3.2. *Discussion*

The properties of CP Eri are similar to the properties of interacting binary white dwarfs. Four other IBWDs are already known: CR Boo (=PG 1346+082; Wood et al. 1987), GP Com (Nather, Robinson, & Stover 1981; Smak 1975), V803 Cen (O'Donoghue, Menzies, & Hill 1987; O'Donoghue & Kilkenny 1989) and AM CVn (Solheim et al. 1984). All IBWDs have two properties: they have short periods—from 2790 s for GP Com to 1011 s for AM CVn—and they have spectra with broad lines of helium and no lines of hydrogen. GP Com has been unambiguously identified as a pair of white dwarfs with an orbital period of 2790 s undergoing mass transfer, as demonstrated by the presence of an S-wave in its spectrum (Nather, Robinson, & Stover 1981). Although it has not been demonstrated conclusively that the other three are binaries, there is much indirect evidence for the binary white dwarf model with mass transfer, and the model is widely accepted.

CP Eri is most similar to V803 Cen and CR Boo. Its dominant period is 1724 s as compared to 1611 s in V803 Cen and 1490 s in CR Boo. The light curve of CP Eri, like that of CR Boo and V803 Cen, shows a complex harmonic structure, with a pulse shape that can change significantly from one night to

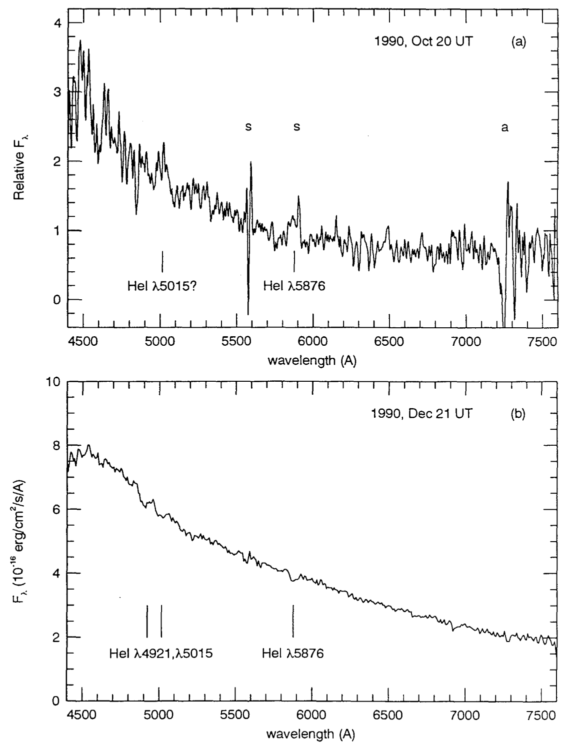

FIG. 4.—Spectra of CP Eri. (*a*) Taken under poor conditions, the star appeared to be in a low state at the time of observation, note the faint but broad emission lines of He I. (*b*) Taken under more favorable conditions, CP Eri was at magnitude $V = 16.5$, note the broad absorption of He I. Residual night sky emission features are indicated by "s," and H_2O absorption by "a."

the next. The dominant periods in CR Boo and V803 Cen are not strictly periodic and both show higher frequency oscillations that are not harmonics of the dominant period. Whether CP Eri also displays these features is unclear from the present data. Further observations to look for them would be worthwhile.

Both V803 Cen and CR Boo show large variations in brightness with amplitude of up to ~4 mag on time scales of a few days. The variations of CR Boo may be quasi-periodic. CP Eri also shows large-scale variations: we have observed it at 16.5 mag, and other observers have found it at magnitudes 17.0, 19.5 (Luyten & Haro 1959 and POSS blue plate), 19.7 (Howell et al. 1991), and 17.8 (Szkody et al. 1989).

Like V803 Cen and CR Boo, CP Eri shows broad, weak absorptions lines of helium when in a bright state and weak emission lines of helium when in a faint state. In all three stars, these lines are superposed over a blue continuum. Finally, and crucially to the interacting binary white dwarf model, the spectrum of CP Eri does not have any lines of hydrogen. Given all these similarities and the absence of an inconsistency, the classification of CP Eri as a fifth IBWD appears secure.

TABLE 2

SPECTROSCOPY OF CP ERI

UT Date (1990)	Exposure Time (minutes)	Spectral Coverage (Å)	Dispersion (Å $pixel^{-1}$)	Resolution (Å)	Conditions
Oct 20	90	4400–7600	4	18	Poor
Dec 21	45	4400–7600	4	18	Photometric

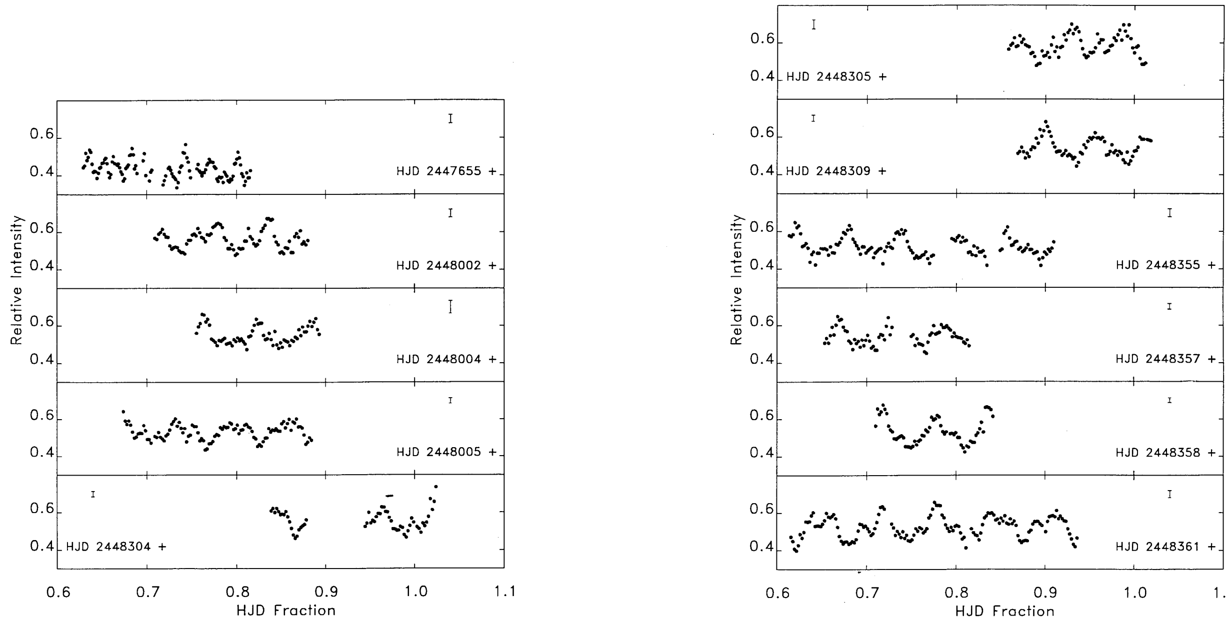

FIG. 5.—Light curves of AL Com; from top to bottom (UT dates): (*a*) 1989 May 9, 1990 April 21, 23, and 24, and 1991 February 17, (*b*) 1991 February 18 and 22, 1991 April 9, 11, 12, and 15. All light curves are plotted on the same scale. The ordinate scale is in units of intensity relative to a well-sampled star in the field. The 2 σ error bars show the error deduced from the interpolation scheme described in the text.

4. AL COM

4.1. *Observations*

We obtained data on AL Com in 1989, 1990, and 1991. Sample light curves are shown in Figure 5. As noted by other observers (Howell & Szkody 1991), the pulse structure is highly variable, so much so that the modulation near 90 minutes that is strongly present in the 1990 and 1991 data is entirely absent in the 1989 data. Significant changes in the shape of the modulation can also appear within a single run as can be seen in the 7.5 hr run of 1991 April 15 (HJD 2,448,361 in Fig. 5).

From a Fourier analysis of the data obtained in 1991 April (Fig. 6), when we obtained the most data in the shortest time (20.55 hr of observations from four observing runs spread over 6 nights), the most likely periods are 89.6 minutes with 24 hr aliases at 95.6 and 84.4 minutes, and 40.8 minutes with aliases at 42.0 and 39.7 minutes. To check this result, we constructed synthetic light curves including these 89.6 and 40.8 minute periodicities with the same sampling intervals and noise properties as deduced from the comparison star. The same Fourier analysis procedure applied to this synthetic data produced an amplitude spectrum of a very similar structure to that for AL Com, with no shifting of the highest peaks or of the power between aliases. We also generated synthetic light curves incorporating periods at 42 and 84 minutes and found the derived amplitude spectrum to be quite different to that obtained from the observational data. We are confident that the 24 hr aliases in our data at 84.4 and 42.0 minutes do not represent the true period and its first harmonic, and that the two strongest periodicities present in the data do not have any simple harmonic relationship to one another. This result is contrary to that of Howell & Szkody (1991) who found the longer periodicity to be at 84 minutes, exactly twice the periodicity found in their earlier observations. However, these data cover a much shorter time-base than our own and are correspondingly more difficult to interpret given the highly variable pulse shape.

Amplitude spectra of the light curves from 1991 February and 1990 April show peaks at 41.0 and 40.8 minutes, respectively, but the low-frequency peak is less repeatable, being found at 87.3 and 87.2 minutes at these times. In both cases, the change in periods is greater than would be expected from the noise in the light curves, and we suggest that neither represents a signal of constant frequency and amplitude.

The amplitude of the peak found near 20 minutes is also highly variable. Its amplitude was large in data from 1989 (in

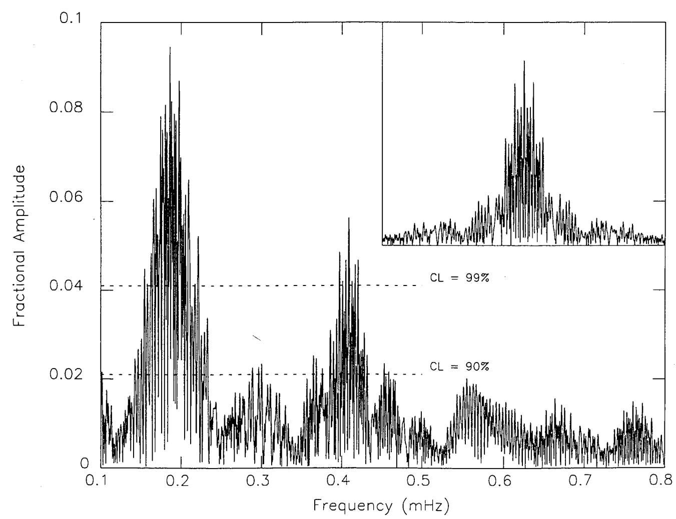

FIG. 6.—An amplitude spectrum for AL Com using the data obtained in 1991 April. Ninety percent and 99% levels of confidence in period detection are indicated by the dashed lines. Inset is the spectral window of the observations.

the data of 1989 May 9 herein and Szkody et al. 1990) but small in 1990 and 1991.

4.2. *Discussion*

The photometric behavior of AL Com is complex and variable. The 90 minute period is variable in frequency and amplitude, although our data allow for the existence of an underlying more stable period with large phase jitter. The 41 minute period also appears to vary in frequency and amplitude, but the variation is much smaller. The 20 minute periodicity, previously of high amplitude, is only marginally detectable in most of our data.

The standard model for hydrogen-dominated cataclysmic variables has a minimum orbital period of 60–75 minutes (Rappaport, Joss, & Webbink, 1982). As the period of the system decreases toward this value, the mass of the secondary decreases and its thermal time scale lengthens. Eventually the mass transfer time scale becomes shorter than the thermal time scale of the secondary, which is then driven out of thermal equilibrium. Because it is not in thermal equilibrium the radius of the secondary is greater than the radii of both main-sequence stars and hydrogen degenerate stars with the same mass. The secondary therefore has a minimum radius and the system has a minimum period. The exact value of this minimum period depends on the details of the model, but is certainly greater than 41 minutes, so the 41 minute period in AL Com cannot be the orbital period. There is no indication of periodicities longer than 90 minutes. Consequently, the 87–90 minutes period is more likely to be the orbital period of the system and we identify it as such.

The short orbital period and high-amplitude eruptions of AL Com invite comparison to the extreme SU UMa star WZ Sge. WZ Sge has an orbital period of 81.63 minutes (Robinson, Nather, & Patterson 1978) and has shown high-amplitude outbursts, one with an unusual 3 mag dip in its light curve during the decline (Patterson et al. 1981) much like the dip in AL Com's outburst of 1961 (Bertola 1964). The structure of WZ Sge's light curve is also erratic and displays a double-hump with humps of variable amplitude. Such behavior in AL Com could explain the apparent absence of the 87–90 minute periodicity in data from 1989 and earlier. If the two humps have the same amplitude, the periodicity at the orbital period disappears and only a periodicity at half the orbital period is present. The light curve from 1989 is too short to allow us to distinguish between the first harmonic of the orbital period and the 41 minute oscillation.

Nevertheless, no SU UMa star has a persistent, high-amplitude period in its light curve in addition to the orbital period and therefore the classification of AL Com as an extreme SU UMa star remains suspect.

The multiperiodic nature of AL Com also suggests a comparison to the eclipsing intermediate polar EX Hya. The light curve of EX Hya is modulated at two periods, 98 and 67 minutes. The period at 98 minutes is the orbital period and the period at 67 minutes has been identified as the spin period of a magnetic white dwarf (e.g., Siegel et al. 1989). The inner edge of the accretion disk in EX Hya is disrupted by the magnetic field of the white dwarf and matter is accreted onto the magnetic poles through asymmetric accretion columns. It is tempting to conclude that AL Com must also be an intermediate polar, since the spin period of its white dwarf would provide a covenient source for the 41 minute period. However, the observed instabilities in the supposed spin and orbital periods render this conclusion suspect. It is true that the observed orbital period of EX Hya is not constant: Siegel et al. (1989) observed the center of optical eclipse to wander by ± 20 s as a function of the 67 minute period and explained the phenomenon in terms of an eclipsed source locked to the white dwarf rotation and located quite close to its surface. Nevertheless, this variation is far smaller than the variation of the 90 minute period in AL Com.

Given that the 41 minute periodicity is not an harmonic of the 87–90 minute periodicity, we cannot agree with Howell & Szkody's (1991) suggestion that AL Com is a magnetic system where the white dwarf has switched from two active accretion poles to just one, as often seen in AM Her stars.

A further problem with classifying AL Com as an intermediate polar is that no intermediate polar is known to have dwarf nova outbursts as large as those of AL Com. DQ Her, on the other hand, has undergone a nova explosion (e.g., la Dous 1990), but most intermediate polars have no outbursts at all.

In summary, although AL Com has characteristics in common with both extreme SU UMa stars and intermediate polars, it also displays behavior which is inconsistent with either class. The identification of the star as a cataclysmic variable seems secure but AL Com is an otherwise unique object.

We are grateful to Derek Wills for obtaining a spectrum of CP Eri on 1990 October 20, We would like to thank Don Winget and Janet Wood for valuable discussion. We acknowledge the encouragement and support of the late Chet B. Opal, to whose memory this paper is dedicated.

REFERENCES

Abbott, T. M. C., & Opal, C. B. 1988, in Instrumentation for Ground-Based Optical Astronomy: Present and Future, ed. L. B. Robinson (New York: Springer), 386
Antipova, L. I. 1987, Ap&SS, 131, 453
Bertola, F. 1964, Ann d'Astrophys., 27, 298
Hill, G. J., & Stockton, A. N. 1992, in preparation
Horne, K. 1986, PASP, 98, 609
Howell, S. B., & Szkody, P. 1987, PASP, 100, 224
———. 1991, Inf. Bull. Var. Stars, No. 3653
Howell, S. B., Szkody, P., Kreidl, T. J., & Dobryzycka, D. 1991, PASP, 103, 300
Kholopov, P. N., & Efremov Y. N. 1976, Variable Stars, 20, 277
la Dous, C. 1990 in Cataclysmic Variables and Related Objects, NASA/CNRS Ser. on Nonthermal Phenomena in Stellar Atmospheres, ed. M. Hack (Washington DC: NASA), 14
Luyten, W. J., & Haro, G. 1959, PASP, 71, 469
Mukai, K., et al. 1990, MNRAS, 245, 385
Nather, R. E., Robinson, E. L., & Stover, R. J. 1981, ApJ, 244, 269
O'Donoghue, D., Chen, A., Marang, F., Mittaz, S., Laing, J. D., Winkler, H., & Warner, B. 1991, preprint
O'Donoghue, D., & Kilkenny, D. 1989, MNRAS, 236, 319
O'Donoghue, D., Menzies, J. W., & Hill, P. W. 1987, MNRAS, 227, 347
Opal, C. B., & Booth, A. J. 1990, Proc. SPIE, 1235, 263
Patterson, J. 1984, ApJS, 54, 443
Patterson, J., McGraw, J. T., Coleman, L., & Africano, J. L. 1981, ApJ, 1067
Rappaport, S., Joss, P. C., & Webbink, R. F. 1982, ApJ, 254, 616
Robinson, E. L., Nather, R. E., & Patterson, J. 1978, ApJ, 219, 168
Siegel, N., Reinsch, K., Beuermann, K., van der Woerd, H., & Wolff, E. 1989, A&A, 225, 97
Smak, J. 1975, AA, 25, 227
Solheim, J. E., Robinson, E. L., Nather, R. E., & Kepler, S. O. 1984, A&A, 135, 1
Stone, R. P. 1977, ApJ, 218, 767
Szkody, P., Garnavich, P., Howell, S. B., & Kii, T. 1990, in Accretion-powered Compact Binaries, ed. C. W. Mauche (Cambridge Univ. Press), 251
Szkody, P., Howell, S. B., Mateo, M., & Kreidl, T. J. 1989, PASP, 101, 899
Warner, B., & Robinson, E. L. 1972, MNRAS, 159, 101
Wood, M. A., Winget, D. E., Nather, R. E., Hessman, F. V., Liebert, J., Kurtz, D. W., Wesemael, F., & Wegner, G. 1987, ApJ, 313, 757