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E2003+225: A 3^h42^m AM HERCULIS TYPE BINARY SYSTEM

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ABSTRACT

The bright soft X-ray source E2003+225, originally discovered by the *HEAO 1* low-energy detectors, has been found to be a new AM Herculis type binary. The optical counterpart shows a rich emission spectrum of He II, He I, and H as well as circular and linear polarization. Larger polarization in the near-infrared than in the ultraviolet argues for its origin as high harmonic cyclotron emission. Optical photometry, polarimetry, spectroscopy, and the X-ray light curves are all consistent with an orbital period of $222^m.51$, the longest period known for AM Herculis systems, and only the second on the long side of the 2–3 hour cataclysmic variable period gap.
Subject headings: polarization — stars: binaries — stars: individual — X-rays: binaries

I. INTRODUCTION

Close binary systems containing an accreting magnetic white dwarf and a low-mass companion (AM Herculis type binaries) are interesting observational targets because of their dramatic and complicated variations in the X-ray and optical spectral regions. They are equally interesting from a theoretical standpoint because the magnetic field's interaction with accreting matter is manifested through directly observable consequences, particularly through polarization effects.

As recently as 1981, only four AM Herculis type binaries were known. In the last 2 years, this number has grown to nine, largely as the result of optical identification of X-ray sources. All of these systems (with the exception of AM Her, $P = 186^m$) have periods between 81^m and 115^m.

We report here the initial observations of a tenth AM Herculis system, E2003+225, first announced in *IAU Circular* No. 3733 (Nousek *et al.* 1982), which has the longest period yet known. The system was identified at the Black Moshannon Observatory 1.6 m reflector of Pennsylvania State University during a spectroscopic survey of optical candidates in the 1′ radius error circle resulting from *Einstein Observatory* X-ray images. The *Einstein* images were obtained as part of a Guest Investigator project to identify bright soft X-ray sources first discovered by the *HEAO 1* A-2 low-energy detectors (LEDs; Nugent *et al.* 1983). Subsequent high-speed photometry using the 0.9 m reflector at Kitt Peak yielded a period of 3^h42^m. Detection of circular and linear polarization using the Steward 2.3 m reflector confirmed the identification of E2003+225 as an AM Herculis type system.

The subsequent sections discuss the X-ray observations (§ II), the optical spectroscopy (§ III), and the polarimetry and photometry (§ IV), and consider the system geometry and emission mechanisms (§ V).

II. X-RAY

a) HEAO 1 A-2 LED Observations

E2003+225 was first detected by the *HEAO 1* A-2[4] LEDs in the 0.15–0.5 keV band and cataloged as H2005+22 (Nugent *et al.* 1983). The *HEAO 1* LEDs were collimated proportional counters which scanned the celestial sphere along lines of constant ecliptic longitude once every 33 minutes. Their sensitivity extended from 0.15 to 2.8 keV, with fields of view of $\sim 1°.5$ and $2°.8$ FWHM along the scan direction, and $2°.95$ FWHM perpendicular to the scan direction (Rothschild *et al.* 1979).

E2003+225 was observed by *HEAO 1* in the fall of 1977 and spring of 1978. Light curves in the 0.15–0.28 keV band

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[4] The A-2 experiment on *HEAO 1* is a collaborative effort led by E. Boldt of the Goddard Space Flight Center (GSFC) and G. Garmire of Pennsylvania State University (PSU), with collaborators at GSFC, PSU, the Jet Propulsion Laboratory, and the University of California, Berkeley.

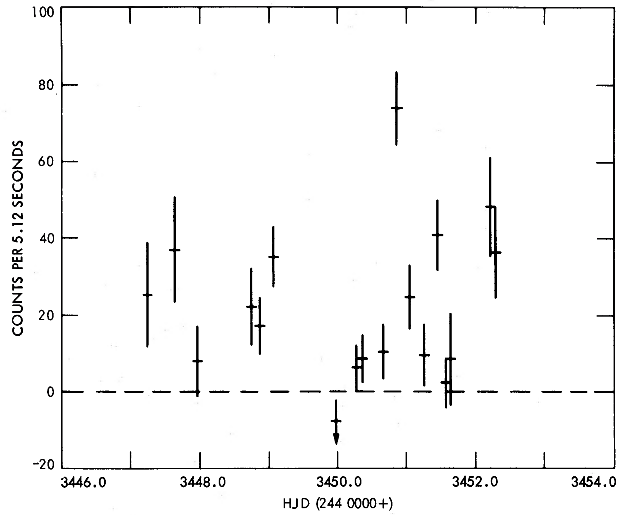

FIG. 1*a*

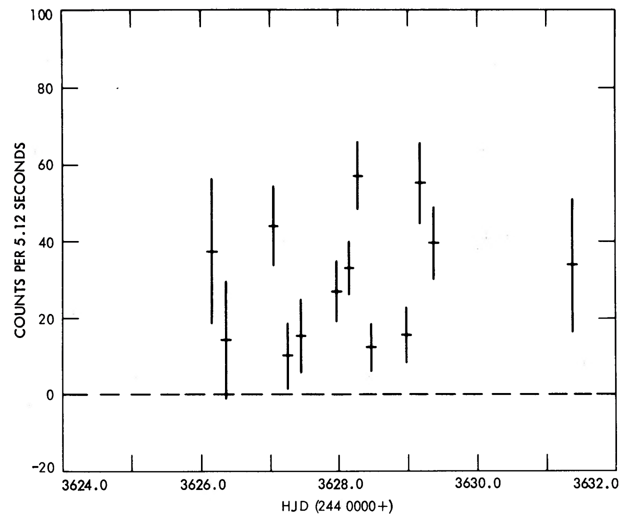

FIG. 1*b*

FIG. 1.—(*a*) Soft X-ray (0.15–2.8 keV) intensity of E2003+225 observed by *HEAO 1* LEDs in the fall of 1977. (*b*) Same as (*a*), but for spring of 1978.

were derived by R. A. S. and P. C. A. from single scans and corrected for source offset from the scan plane. These are given in Figures 1*a* and 1*b*. These figures show that the source is highly variable, often within a day. Both the fall and spring data sets are inconsistent with a single count rate, with a reduced χ^2 value of 5.39 per degree of freedom (18 points) and 3.24 per d.o.f. (13 points) for the fall and spring transits respectively.

X-ray pulse-height spectra were derived for both the fall and spring data. These spectra were fitted to both blackbody and exponential plus Gaunt factor models corrected for interstellar absorption using standard χ^2 fitting procedures. The pulse-height data indicate an extremely soft spectrum, with no evidence for X-rays above 0.5 keV. However, the statistical accuracy of the data allows large ranges of temperature and column density (Fig. 2).

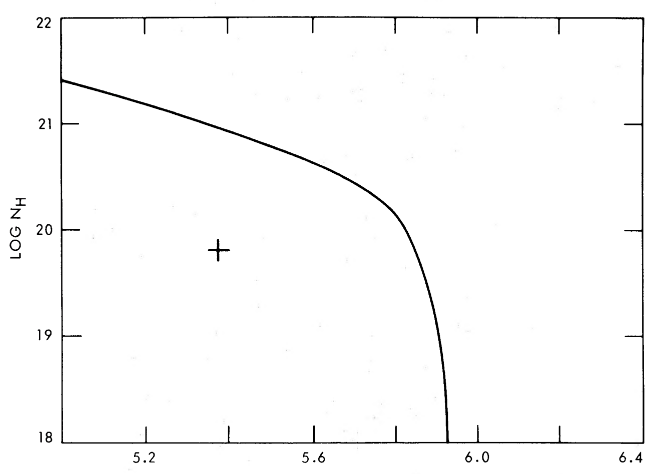

FIG. 2.—Boundary of blackbody model parameter space consistent (at 90% confidence level) with *HEAO 1* and *Einstein* X-ray spectra of E2003+225. Cross marks the location of the best fit model.

If a blackbody spectrum is appropriate, as is expected for the X-ray–heated poles of a magnetic white dwarf in an AM Herculis type system (see § V), we derive a best fit temperature of $T \sim 2 \times 10^5$ K. Temperatures above 10^6 K yield fits below the 90% confidence level. For the best fit blackbody model, we derive an incident flux (<0.5 keV) at Earth of $1.7 \pm 0.6 \times 10^{-11}$ ergs cm^{-2} s^{-1} for the fall data and $2.3 \pm 0.4 \times 10^{-11}$ ergs cm^{-2} s^{-1} for the spring data. It should be noted that the flux estimates are heavily weighted toward scan observations of E2003+225 at or near maximum X-ray flux.

b) *Einstein Observatory*

Three observations with the imaging proportional counter (IPC) aboard the *Einstein Observatory* were conducted as part of a Guest Investigation by Gordon Garmire and J. A. N. during 1981 April 11–12 to position more precisely the *HEAO 1* source H2005+22. Three observations were required because the *HEAO 1* source error box was much wider than the ~75′ width of an IPC field. The dominant source found in these fields was named E2003+225, following the convention for *Einstein* sources. The average source intensity was 1.4×10^{-11} ergs cm^{-2} s^{-1}, and the best fit blackbody spectrum temperature is 2.6×10^5 K, so similar to the values for H2005+22 as to leave little doubt it is the same source.

E2003+225 happened to fall in the overlap region of two successive IPC fields, which provide a total observation length of 562^m, during which usable data intervals totalled 281^m. Unfortunately, being near the edge of both fields makes determination of the IPC gain extremely difficult. Accordingly, we allowed the assumed gain to vary by ±10% in the spectral fitting. The resulting spectral parameters (Fig. 2) are quite similar to those found by *HEAO 1* 3 years earlier. Data collected by the monitor proportional counter (MPC) sensitive to 1–10 keV showed no evidence for a source, consistent with the very soft spectrum of E2003+225.

An X-ray light curve covering ~2.25 consecutive 3^{h}42^m (§ IV) periods was derived from the two IPC fields. The X-ray intensity (Fig. 3) shows strong variations, from $\lesssim$0.01 to 2

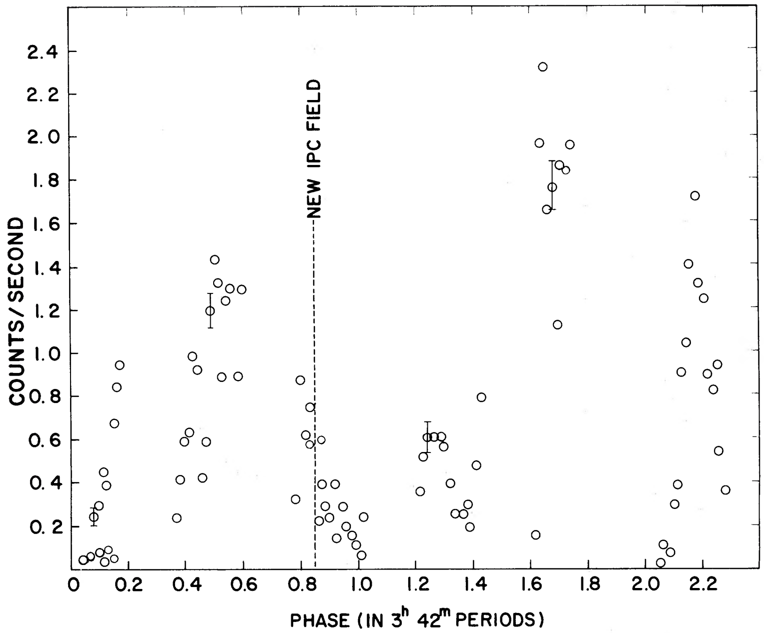

FIG. 3.—Soft X-ray (0.14–4 keV) intensity of E2003+225 observed by *Einstein Observatory* on 1981 April 11 UT. Data for the second IPC observation have been scaled upward by 1.384 to compensate for the relative telescope vignetting factors. The phase has been calculated from an orbital period of 222ᵐ51 with an arbitrary phase zero at the start of the X-ray observation (HJD 2,444,705.62518).

counts s^{-1}, over the observations, as well as short time-scale flickering, varying by approximately a factor of 2 in 50 s. To combine the IPC observations, a relative normalization factor of 1.384 has been applied to the second data set. This factor reflects the differential telescope vignetting resulting from the change in off-axis angles between the two observations. An additional correction might be required if the detector gain varies significantly between the locations of the two observations, producing a change in the number of X-ray events lost below the lower level electronic discriminator. This correction is small, however, because the count rate shows no large change across the boundary of the two data sets. Although in the first IPC field the ribs supporting the IPC window may have partially occulted E2003+225, the qualitative behavior of the second IPC field does not change and the aspect solutions for the satellite were stable. Therefore, it appears that most of the X-ray modulation observed in E2003+225 is intrinsic.

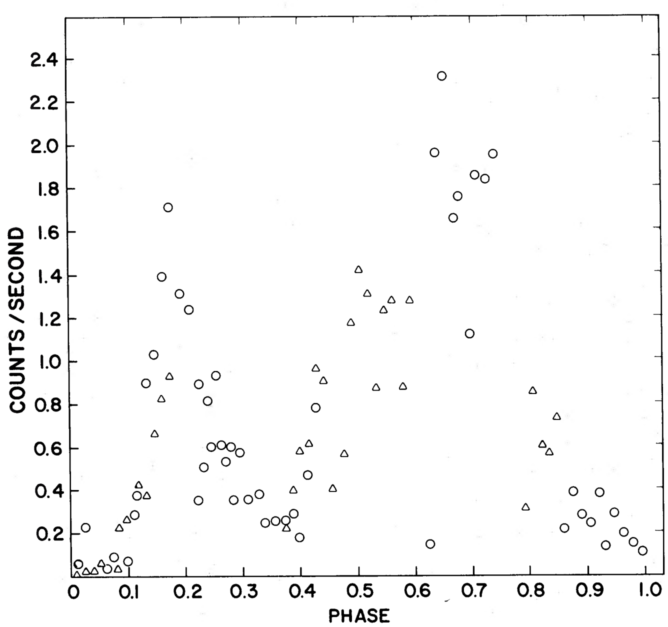

FIG. 4.—Soft X-ray light curve of E2003+225 folded over in same phase as in Fig. 3.

The X-ray light curve in Figure 3 has been labeled in units of the phase starting at an arbitrary zero point at the beginning of the IPC observation and using a period of 222ᵐ51 from the linear polarization. Several characteristics of the light curve repeat on this period, particularly the dramatic intensity increase at phases 0.0–0.2 which is repeated at 2.0–2.2, and at 0.4 repeated at 1.4. In detail, the X-ray intensity is not identical from cycle to cycle, but a repeating double-humped structure does appear (Fig. 4). Fourier analysis of the photon arrival times showed no periodic modulation over time scales ranging from 1.5 s to 3000 s.

III. SPECTROSCOPY

Following the initial discovery of the emission-line optical counterpart (Fig. 5) on 1982 June 25, six additional nights in July and August were devoted to spectroscopy on E2003+225 by J. A. N. and L. O. T. using the Black Moshannon 1.6 m telescope and the fiber-coupled SIT spectrograph (Ramsey, Nations, and Barden 1981). Observations were made using either a resolution of 17 Å with integrations of 600 s, or a resolution of 2 Å with integrations of 2000 s.

In Figure 6 we display the sum of 16 spectra obtained in the low-resolution mode on 1982 August 18. The spectrum is rich in strong emission lines, with He II λ4686 of comparable

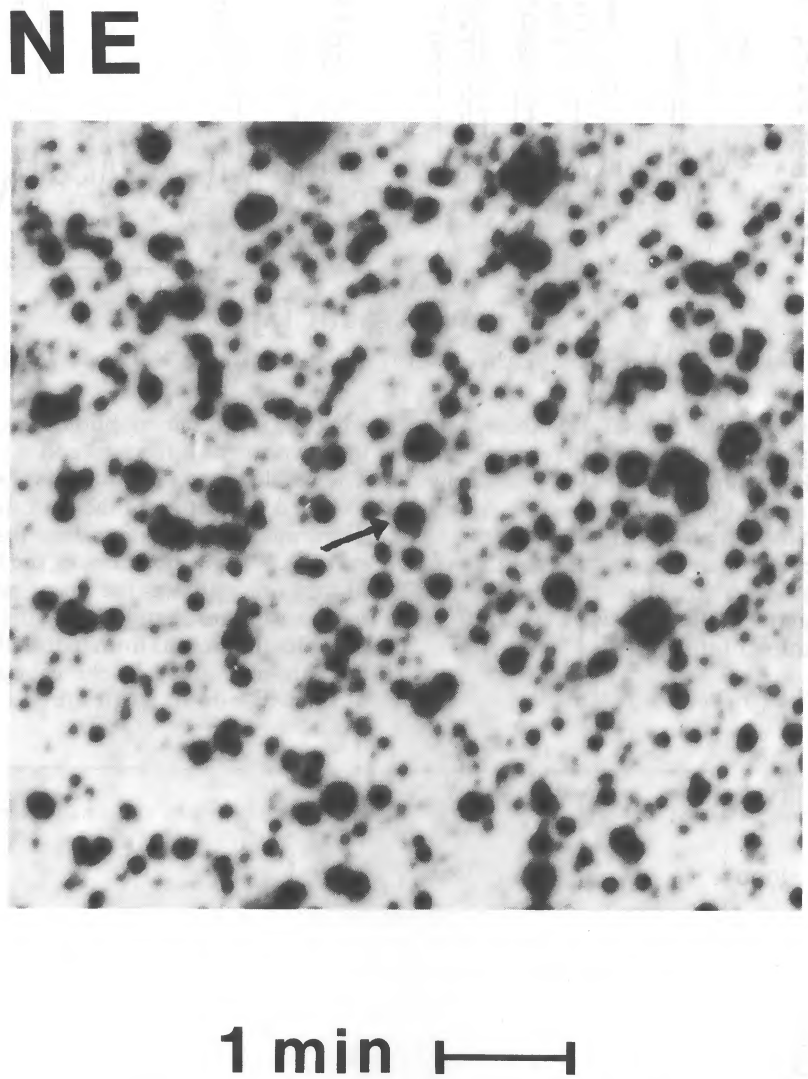

FIG. 5.—Finding chart for E2003+225 (R.A. [1950] = 20ʰ03ᵐ30ˢ.7, decl. [1950] = 22°31′28″); Palomar Sky Survey E Plate

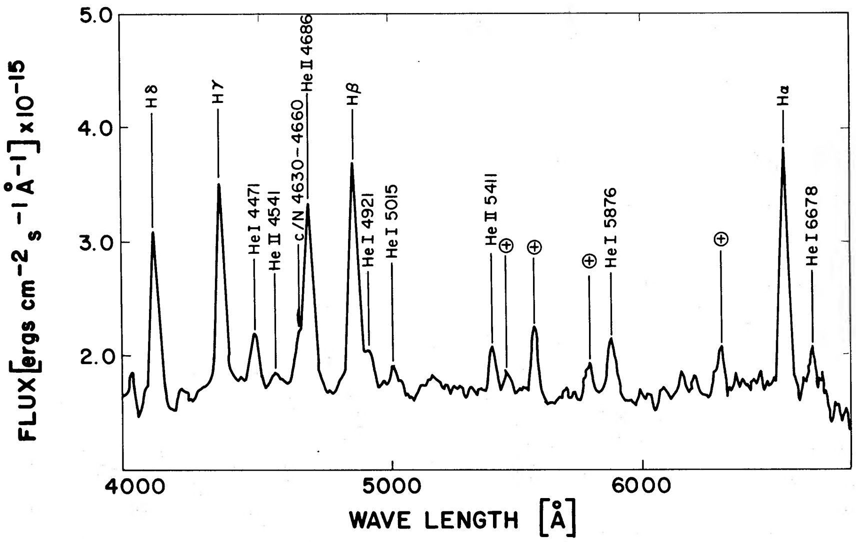

FIG. 6.—Optical spectrum of E2003+225 at 17 Å resolution taken on 1982 August 18 UT

strength to Hβ, and exhibits a shallow Balmer decrement, very similar to the high-state spectra of other AM Herculis type stars (Bond and Tifft 1974; Stockman *et al.* 1977; Schneider and Young 1980; Liebert *et al.* 1982). The mean equivalent widths and relative line intensities are given in Table 1.

Analyzed separately, these observations reveal both wavelength shifts and intensity variation. The variations of the centroid of He II λ4686 and Hβ (Fig. 7) were fitted to a circular orbit velocity equation of the form

$$V = K \sin(\phi - \phi_0) + \gamma$$

where K is the semiamplitude, ϕ_0 the phase for zero-crossing in the positive direction, and γ the average radial velocity. The results are summarized in Table 2.

A striking feature of the fits is that γ is large, ~ 500 km s^{-1}. The semiamplitude is similar to that seen in other AM Herculis systems. Within uncertainties, the Doppler zero crossing occurs at the same phase as the linear polarization pulse (§ IV). The most natural explanation for this large value of γ is that the Doppler shift results from the infall velocity along the accretion column, modulated by the change in line-of-sight projection as the white dwarf rotates (§ V).

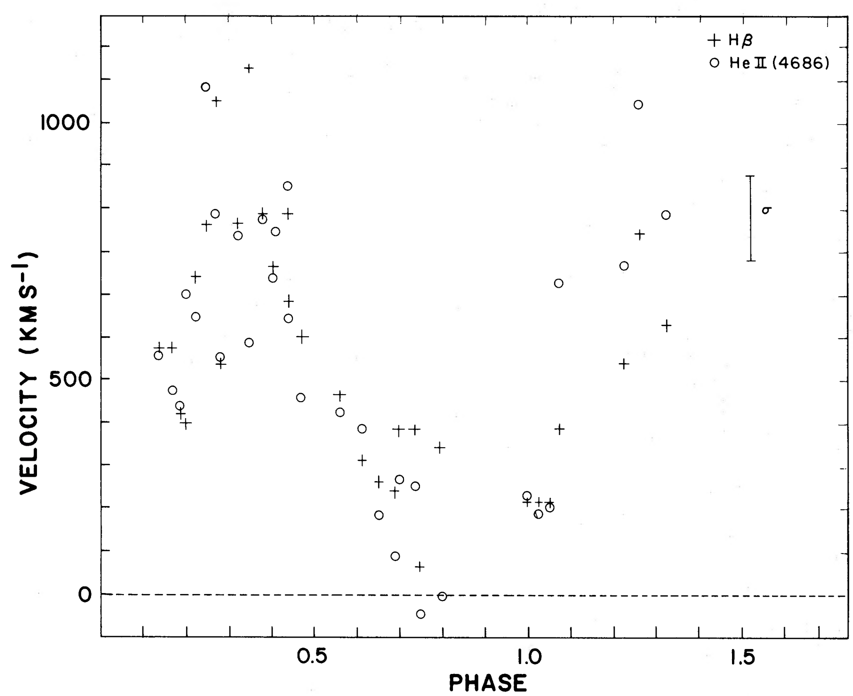

FIG. 7.—Centroid of Hβ and He II λ4686 lines plotted against linear polarization phase

TABLE 1

Equivalent Widths and Relative Intensities

Feature	λ (Å)	Equivalent Width (Å)	Relative Intensity
Hδ	4101	17	91
Hγ	4340	30	103
He I	4471	4	28
He II	4541	1	4
He II	4686	30	96
Hβ	4861	33	100
He I	5876	3	34
Hα	6563	47	121
He I	4921	0.2	1
He I	5015	1	7

The higher resolution observations are compromised by the long exposure times during which temporal variations smear out the spectral features. Still, the profiles do reveal narrow "peak" components and broad "base" components seen in other AM Herculis systems (Crampton and Cowley 1977; Greenstein *et al.* 1977; Leibert *et al.* 1982). The line intensities show dramatic variations, almost disappearing near phase 0 and 0.5.

IV. PHOTOMETRY AND POLARIMETRY

a) *High-Speed Optical Photometry*

High-speed optical photometric observations of E2003+225 were obtained by H. E. B. and A. D. G. on the nights of 1982 September 19, 20, 21, and 24 (U.T.). The no. 2, 90 cm reflector at Kitt Peak National Observatory was used with the two-star photometer and reduction techniques described by Grauer and Bond (1981). E2003+225 was monitored with an unfiltered EMI 9840 photomultiplier, giving a broad-band blue response from the atmospheric cutoff to about 6000 Å. Integration times of 3–5 s were used. The photometer's second photomultiplier was used for simultaneous observations of the comparison star BD +22°3927, located 44^s east and 3'.2 south of the variable. Division by the comparison-star measures was used to remove effects of atmospheric extinction from the variable-star data. All four nights were of photometric quality. One *UBV* measurement of the comparison star yielded $V = 9.74$, $B-V = 0.24$, and $U-B = 0.11$. In order to convert the variable-star data to blue magnitudes, we assumed the comparison star to have $m_{\rm blue} = 9.98$.

TABLE 2

Parameters of Emission-Line Centroid Variation

Line	λ	K (km s^{-1})	ϕ_0	γ (km s^{-1})
Hα	6563	274	0.142	358
Hβ	4861	369	0.145	538
Hγ	4340	378	0.113	316
He II	4686	376	0.071	491

The photometric observations showed that the orbital period is near 3^h42^m. Figure 8 shows a light curve obtained over one complete orbit, on 1982 September 20. The data have been smoothed by summing the original 4 s integrations into 8 s bins. Aside from the obvious orbital modulation of about 0.7 mag, the observations show short time-scale flickering, with amplitudes of up to 0.2 mag, which became most obvious during the light curve maximum. The flickering, although not of large amplitude when compared with other AM Herculis systems, seems unusually rapid. Notice that the sharp event just after the beginning of the run lasted less than 1 minute.

Figure 9 shows a portion of the light curve obtained on 1982 September 19. (A *UBV* measurement at the beginning of this run gave $V = 14.86$, $B-V = 0.12$, and $U-B = -0.94$.) Here, as in all of our blue light curves, E2003+225 shows a gradual decline to a fairly flat-bottomed minimum that lasts for about 0.15 of the orbital period. However, at the beginning of the minimum there is a sharp dip lasting nearly 1 minute. This dip was seen on only two of the four nights. A similar transient dip is seen in VV Pup (Warner and Nather 1972).

Over the four nights of photometric observation, we obtained a total of 10.8 hours of data. Every orbital phase was covered on at least two nights. In order to suppress the flickering activity, we have combined all of our data into a mean light curve, which is shown in Figure 10. The 8839 individual integrations have been sorted into 100 equally spaced phase bins, using the ephemeris for the linear polarization pulses given in § IV*b*.

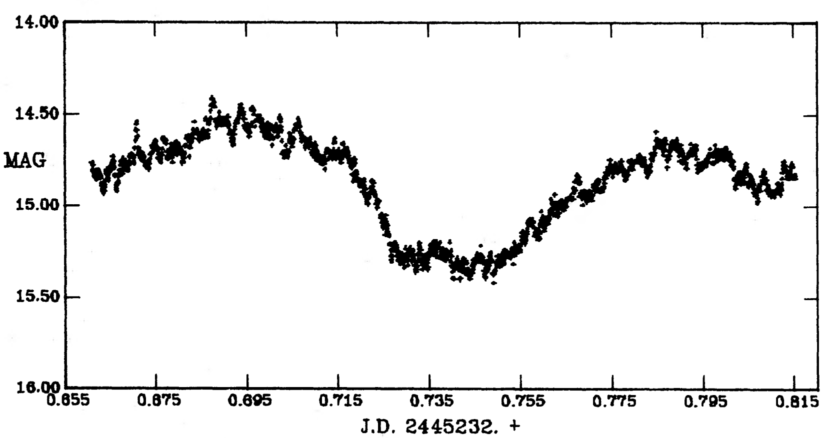

Fig. 8.—Light curve of E2003+225 on 1982 September 20. Broad-band blue magnitudes are plotted against heliocentric Julian Date. The time resolution is 8 s, and one complete orbit of the binary is covered.

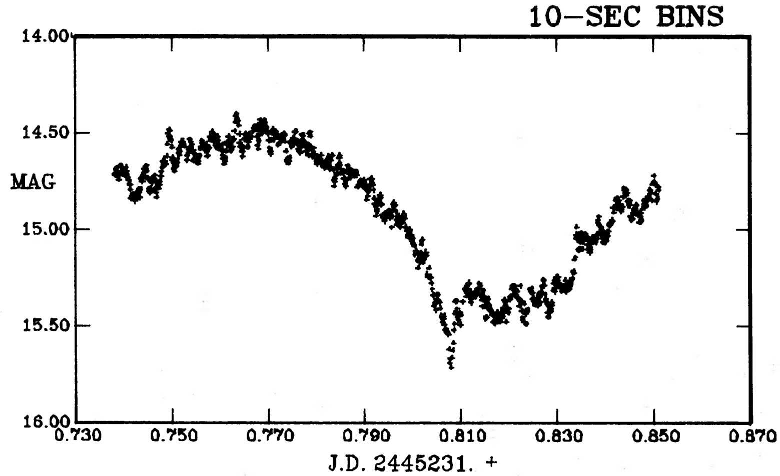

FIG. 9.—Blue light curve of E2003+225 on September 19, with 1 s integrations. The time resolution is 10 s. Note the brief, sharp dip at the beginning of the broad light minimum.

The mean light curve is remarkably similar to those of 2A0311−227 = EF Eri (Bond, Chanmugam, and Grauer 1979), and AN UMa (Krzeminski and Serkowski 1977), showing a deep minimum beginning near polarization phase 0.4, and a shallower minimum beginning near phase 0.8.

b) *Polarization*

Linear and circular polarization measurements of E2003+225 were made by G. D. S., G. J. H., and S. T. on 1982 September 21–25, October 11–15, and December 13–15 with the Steward Observatory 1.5 m and 2.3 m reflectors. The instruments used were the "Minipol" (Frecker and Serkowski 1976) and the similar, but more modern, "Two-Holer" polarimeter/photometer of G. D. S.

As in most AM Her systems, one linear polarization pulse is detected per 3^h42^m period. However, unlike the rapid polarization spikes seen in other AM Her systems, the linear polarization pulses of E2003+225 are fairly broad (Fig. 11*a*), lasting approximately 40 minutes (18% of the period). They are also quite weak, with a peak value $P \approx 2\%$ in the white-light ($\lambda\lambda$3200–8600) spectral bandpass used. During the pulse, the position angle declines at a rate of $\sim 0^\circ\!.8$ per minute, with a mid-pulse value of $\theta = 160°$.

The nonzero off-pulse linear polarization seen in Figure 11*a* is largely the result of measurement uncertainty ($\sim 0.3\%$ in an individual 2 minute sampling interval) which is always positive in polarimetric data. However, residual real polarization must be present even during off-pulse times, as the position angles seem to roughly track the trend set up during the pulses. This residual linear polarization may indicate the presence of a second, weak polarization pulse (Nousek *et al.* 1982), but at present our data are inconclusive.

Seven linear polarization pulses spanning an interval of 1515 orbits have been observed. An ephemeris based on these data, and referenced to zero phase at midpulse, is:

$$\mathrm{HJD} = \underset{\pm 4}{2445234.8348} + \underset{\pm 3}{0.1545252}E\ .$$

The accuracy of this ephemeris is sufficient to determine zero phase for the optical spectroscopic observations, but not back to the X-ray observations.

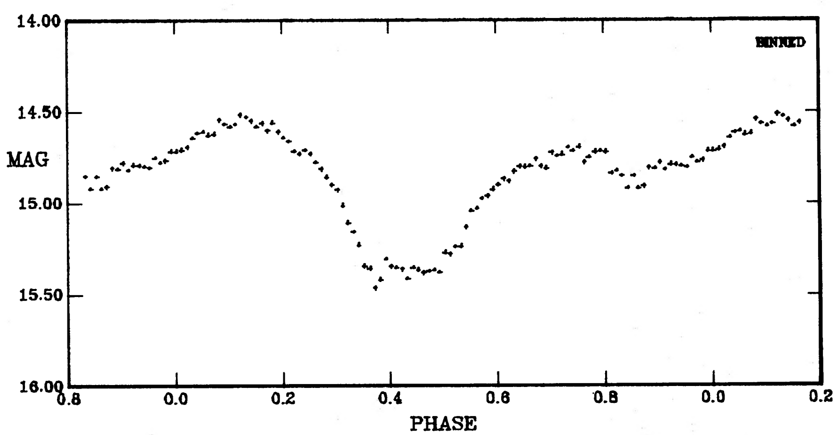

FIG. 10.—Mean blue light curve of E2003+225. We have sorted 10.8 hours of data into 100 equally spaced phase bins, using the ephemeris HJD 2,445,235.835+0.154522E, which gives times of the linear polarization pulses.

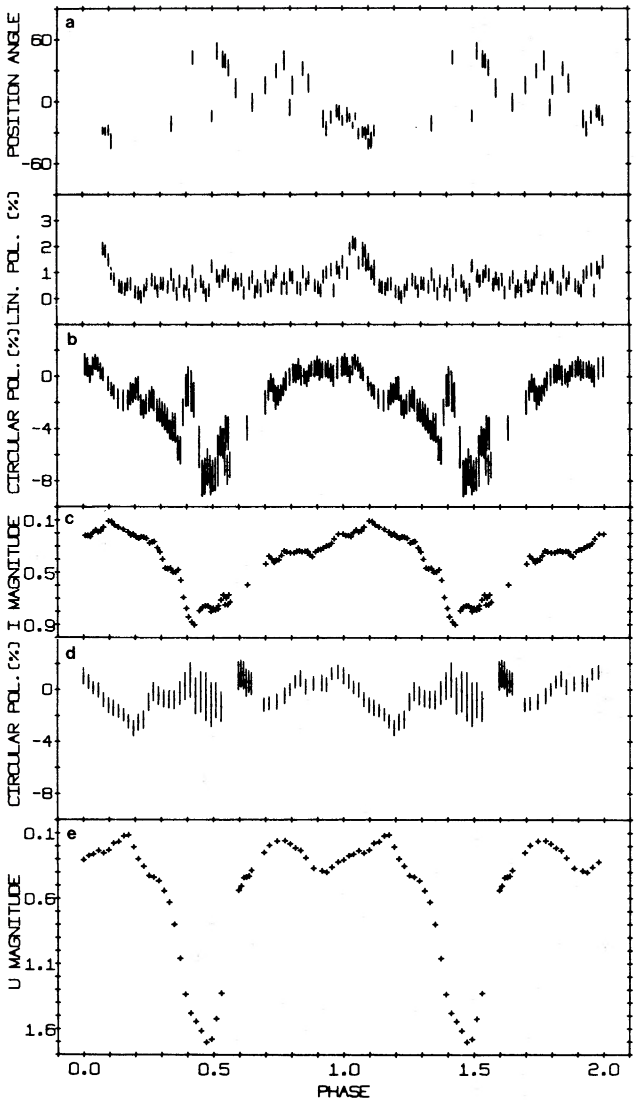

FIG. 11.—(*a*) Linear polarization variation in position angle and amount plotted against linear polarization phase; (*b*) circular polarization variation in the *I* band plotted against linear polarization phase; (*c*) *I* band intensity variations acquired simultaneously with data shown in (*b*); (*d*) Same as (*b*), but for the *U* band; (*e*) *U* band intensity variations acquired simultaneously with data shown in (*c*).

Circular polarization measurements were performed in two bands with the Minipol polarimeter: U ($\lambda_{\rm eff} \sim 3650$ Å), and I ($\lambda_{\rm eff} \sim 8000$ Å). The variation in the U band is similar to that seen in white light (Fig. 10). Polarization in each band and infrared photometry obtained with the polarimetry are shown in Figure 11 folded on the $222^{\rm m}.51$ period. The degree of polarization is much larger in the I band than in the U band, reaching maxima of 7.5% and 2% respectively. However, the light curve amplitude shows reversed behavior, with variations of 0.7 and 1.6 mag, respectively.

The circular polarization of E2003+225 resembles AM Her in showing primarily negative values. One zero crossing of circular polarization (positive-to-negative) is accompanied by the linear polarization pulse, a trait common among these systems. During the following period of strong circular polarization, the I band variation is quite smooth and symmetric about the peak at $\Phi = 0.5$. The only departure is a glitch at $\Phi = 0.4$ which coincides with the sharp photometric dip described in § IV*a*. The origin of this feature is addressed in § V.

V. DISCUSSION

Our observations have confirmed the identification of E2003+225 as an AM Her binary. The general model for these systems includes a low-mass red dwarf orbiting a rotationally locked, strongly magnetic white dwarf primary which is accreting matter in a quasi-radial accretion column. In the following discussion, we attempt to explain the behavior of E2003+225 in terms of a geometric model of this type. We conclude by addressing the salient difference of this object, its long period, and suggest the value of further observations of the system in improving our understanding of the AM Herculis phenomenon in general.

a) *System Geometry*

In the simplest and best understood AM Herculis system, CW 1103+254, the linear polarization pulse coincides with the disappearance of circular polarization at the end of the bright phase (Stockman *et al.* 1983; Schmidt, Stockman, and Grandi 1983). Since a pulse occurs only when the accretion column is nearly perpendicular to our line of sight, a pulse will be observed from a radial column when the accretion shock crosses the limb. A precipitous decline in brightness results from the ensuing self-eclipse.

In E2003+225, the presence of a very weak and diffuse linear polarization pulse, roughly centered on maximum light, implies that the column never rotates completely out of sight, but merely grazes the limb, as in AN UMa, EF Eri (2A 0311−227), and PG 1550+191. The pulse's maximum strength, when compared to the linear polarization behavior of AM Her systems with known geometries, suggests that the magnetic pole of E2003+225 is tilted $\sim 75°$–$85°$ from our line of sight at pulse center. A comparison of the observed position angle variation with predictions for various geometries (Stockman 1977; Chanmugam and Dulk 1981; Meggitt and Wickramasinghe 1982) then reveals that the geometry of E2003+225 can be characterized by an orbital inclination $46° < i < 74°$ and a stellar latitude of the accreting magnetic pole in the range $63° < \Delta < 80°$. With this perspective, our line of sight is never aligned with the funnel to better than $\sim 30°$, and we do not see the effects of cyclotron beaming which are so vivid in PG 1550+191 (Liebert *et al.* 1982).

For line emission in a radial accretion funnel with the above geometry, we would expect to see nearly zero radial velocity at the time of the linear polarization pulse and maximum redshift when the funnel is best directed along our line of sight ($\Phi = 0.5$). The observations confirm this behavior, with no significant radial velocity at $\Phi \approx 0.85$ and sinusoidal variations to a maximum radial velocity $v_{\rm max} \approx 900$ km s^{-1} one-half orbit later. It is interesting to note that the implied infall velocity $V = V_{\rm max} \csc (i + \Delta) \approx 1200$ km s^{-1} is quite similar to the 1000 km s^{-1} deduced for the bulk of line emission from CW 1103+254 (Schmidt, Stockman, and Grandi 1983).

An intriguing aspect of the optical observations of E2003+225 is the glitch in brightness and sharp polarization change at $\Phi = 0.4$. Since the amplitude of this feature in the

I band ($\sim$0.2 mag) is about twice that seen in the U band, and a simultaneous reduction in I band circular polarization is also seen, a brief eclipse of the cyclotron region is indicated. Its duration, $\sim$10 minutes or $\Delta\Phi \sim 16°$, is consistent with the angular occulting diameter of the secondary ($\sim$30° for a 0.45 $M_\odot$, 0.43 $R_\odot$ secondary and a 0.5 $M_\odot$ white dwarf primary, Whyte and Eggleston 1980), the orbital inclination would then be forced to the upper limit permitted by our measurements. Support for an eclipse by the secondary is provided by the fact that the emission lines, too, disappear briefly near this time (§ III). As the glitch precedes the transit of the pole across the stellar meridian by $\Delta\Phi \approx 0.1$, the secondary and main body of the accretion funnel must *lead* the pole in its orbit by $\sim$36°, opposite to the sense suggested in CW 1103+254 (Schmidt, Stockman, and Grandi 1983). An alternative mechanism is an eclipse by the accretion column itself, but this possibility changes none of our above statements regarding the system geometry.

The transient sharp dip observed in the white-light photometry near $\Phi = 0.4$ is more puzzling. Its brief duration, $\sim$1 minute, and presence in only two of four observations at this phase make purely kinematic explanations difficult. Warner and Nather (1972) explain similar dips in the light curve of VV Pup as movement of the accretion spot leading to variable self-eclipsing. That explanation fails here because the minimum emission-line Doppler shift and sharp circular polarization change also occur at phase 0.4, implying that the accretion column is not near the limb and ruling out self-eclipsing. We have no completely satisfactory explanation, but point out that the time scale of this dip is comparable to the flickering activity. Perhaps the transient dip appears when a flickering minimum coincides with the normal phase 0.4 eclipse.

The U band light curve is explained as simple thermal radiation from the hot spot, in which the primary eclipse, phase 0.4–0.5 is due to the secondary/accretion column, and the secondary minimum, phase 0.9–1.1, results from the hot spot grazing over the limb. The I band light curve is dominated by radiation coming from the edges of the accretion column and is more highly polarized. The asymmetry in the I band light might result from curvature in the column, or asymmetries in the accreting flux.

The X-ray data cannot be assigned a linear polarization phase until further observations better refine the period. In terms of the optical model just discussed, the two minima in the *Einstein* data separated by 0.4 periods is intriguing. These X-rays are very soft and presumably originate in the "hot spot" at the base of the accretion column. The first minimum, at the arbitrary X-ray phase 0–0.1 in Figure 5, is deeper, consistent with nearly total eclipse. During the second minimum, near X-ray phase 0.35, there still is residual X-ray flux coming from the system. Thus we might suppose that the deep X-ray eclipse occurs when the hot spot is eclipsed (polarization phase 0.45) and the secondary minimum results from the obscuration of the hot spot as it passes near the limb (polarization phase 0.9). With this choice of phasing, the X-ray light curve resembles an exaggerated U band light curve.

If the X-ray emitting region is eclipsed, the X-ray data should show a change in spectrum unless the eclipse is by a very thick absorber. The primary minimum at phase $\sim$0.0 is so deep that no flux remains to compute a spectral hardness. The secondary minimum shows a ratio of soft X-rays ($E < 0.7$ keV) to hard X-rays ($E > 2.0$ keV) which stays at 0.5 ± 0.1 during secondary minimum, 0.38 ± 0.07 before minimum, and 0.43 ± 0.03 during maximum. For a source this soft, however, the IPC measurement of harder X-rays is illusory. The IPC energy resolution is only $\Delta E/E \sim 120\%$ at 0.25 keV, so for a source with $T \lesssim 10^6$ K nearly all the events recorded in the IPC, regardless of pulse height, were produced by X-rays with $E \sim 0.1$ keV. Absorbing material in front of the source will very rapidly decrease the detected flux but only imperceptibly change the detected spectrum.

Finally, what does the discovery of a long-period AM Herculis type system tell us? Of ten such systems known, eight have periods below 2 hours, and, now, two above 3 hours. This period distribution resembles dwarf novae, suggesting that AM Herculis systems are just a subset of dwarf novae containing strongly magnetic white dwarfs.

As the longest period AM Herculis system, E2003+225 provides a test for theoretical models. For example, recently Lamb *et al.* (1983) have suggested that the synchronous rotation of the white dwarf in these systems is brought about by magnetohydrodynamic torques in the intersystem plasma. The strength of this torque is a strong function of orbital separation, and Lamb *et al.* predict that systems with periods longer than $\sim 3^h$ may not be strictly phase locked.

If the optical drop in brightness $\Phi = 0.4$ is due to an eclipse of the accretion column by the secondary star, then E2003+225 can provide a strong test of the degree of phase locking. This drop will move with respect to the rest of the light curve if the rotation is not locked to the orbit. The current data show no evidence for lack of rotation synchronism, but a systematic search covering more periods and using the I band should be undertaken.

A possible correlation between period and frequency of low states (times of reduced mass transfer) is suspected. AM Her ($P \sim 3^h$) has low states recurring roughly every year; the short-period systems have low states recurring less frequently. Long-term, regular monitoring of E2003+225 for transitions to the low states would test this correlation.

Radio emission has recently been detected from AM Her (Dulk, Bastian, and Chanmugam 1983). This emission is believed to come from intrasystem material. The same search has failed to detect other AM Herculis type systems. If the radio scales with the volume of the system, then E2003+225 is an ideal candidate for future radio searches.

In summary, the discovery of E2003+225 has expanded the class of AM Herculis systems and presents an important object for future optical, radio, ultraviolet, and X-ray studies.

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