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THE DISCOVERY OF 2.93 HOUR PERIODIC INTENSITY DIPS FROM X1323–619¹

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ABSTRACT

We report on a 30 hr duration *EXOSAT* observation of the low-mass X-ray binary X1323–619. The 1–8 keV light curve obtained with the medium-energy instrument (ME) shows irregular intensity dips that recur every 2.93 hr as well as type 1 X-ray bursts. During the 50 minute duration dips the intensity declines to ~50% of its unaffected value. The dip and burst-free ME spectrum of X1323–619 is similar to that of other X-ray burst sources, being fit by a power-law model with energy index 0.5. In addition, considerable low-energy absorption, equivalent to 4×10^{22} H atoms cm^{-2} is required. Spectral changes observed during dipping intervals are consistent with absorption by material with a wide range of abundances. The absence of eclipses of the X-ray source by the companion star implies that the absorbing material responsible for the dipping activity must be located more than 10° above the orbital plane. X1323–619 is not detected with an *EXOSAT* low-energy imaging telescope, consistent with the high column density to X1323–619 measured with the ME. On the basis of spectral and positional similarities, an unusually hard source seen in earlier *Einstein* observations is identified with X1323–619. From an analysis of the burst properties we constrain the distance of X1323–619 to be between 10–20 kpc.

Subject headings: stars: individual (X1323–619) — X-rays: binaries

I. INTRODUCTION

A significant fraction of low-mass X-ray binaries (LMXRB) exhibit periodic dips in their X-ray intensity which repeat with the orbital period of the system (see, e.g., White and Mason 1985; Mason 1986; Parmar and White 1988). These dips are believed to be caused by periodic obscuration of a central point-source by azimuthal structure located at the outer edge of an accretion disk. This structure probably results from an interaction between the gas stream from the companion and the disk. The long continuous observations afforded by the *EXOSAT Observatory* has greatly increased the number of LMXRB known to exhibit periodic dips. The observation of periodic eclipses as well as dips from the transient system EXO 0748–676 have both confirmed that the mean dip recurrence interval reflects the underlying orbital period and revealed complex spectral and temporal changes during dipping intervals (Parmar *et al.* 1986). Observations of X1254–690 (Courvoisier *et al.* 1986), X1916–053 (Smale *et al.* 1988), X1624–490 (Watson *et al.* 1985) and X1755–338 (White *et al.* 1984; Mason, Parmar, and White 1985) have shown a great variety in dip properties, both from the same system and for the class as a whole. The depth and orbital phase of the dips, and even the presence of dips at orbital phases seemingly unconnected with the interaction of the gas stream, can all vary on a wide range of time scales.

Prior to the *EXOSAT* observation of X1323–619 reported here, little was known about this weak (~3 UFU) unidentified source, which appears in the fourth *Uhuru* and the third *Ariel V* catalogs as 4U 1323–62 and 3A 1322–616, respectively (Forman *et al.* 1978; Warwick *et al.* 1981). Although not in the

HEAO 1 A-1 catalog (Wood *et al.* 1984), X1323–619 was detected during *HEAO 1 A-2* scanning observations (R. Mushotzky 1988, private communication). *EXOSAT* was used to observe X1323–619 on 1984 February 11 for 4 hr during which a type 1 X-ray burst and a ~50 minute duration X-ray intensity dip were detected (van der Klis *et al.* 1984, 1985a). In order to see if the dipping activity was periodic a further observation of X1323–619 was made in 1985 February. In this paper we present a detailed analysis of this second, 30 hr duration observation in which a further six X-ray bursts and 10 complete intensity dips were observed. The discovery of periodic dips from this observation was first reported in van der Klis *et al.* (1985b).

II. RESULTS

The region of sky containing X1323–619 was observed with the *EXOSAT Observatory* between 1985 February 11 18:46 UT and February 13 04:41 UT. The observation was continuous, except for an interruption between 1985 February 12 02:52 to 03:39 UT when the *EXOSAT* onboard computer was reconfigured. We report on data obtained with the medium-energy instrument (ME; 1–15 keV; Turner, Smith, and Zimmermann 1981), and a channel multiplier array detector behind an imaging telescope with a 3000 Å Lexan filter (CMA; 0.04–2.0 keV; de Korte *et al.* 1981). The ME was used in a configuration that gave one 128 channel pulse-height-analyzer spectrum every 10 s and simultaneously count rates integrated between 1.5–5.0 keV and 5.0–11.0 keV every 0.031 s. The 10 s accumulation time of the ME spectra was chosen to provide the most reliable means of background subtraction (Parmar 1984) even though this provides insufficient temporal resolution for a time resolved spectral study of the X-ray bursts. Apart from an interval of 1.5 hr on 1985 February 12,

¹ Partially based on observations made at the European Southern Observatory, La Silla, Chile.

FIG. 1.—The 1–8 keV ME light curve of X1323–619 plotted with a time resolution of 360 s

when the offset angle was reduced (see § II[c]), four of the eight ME detectors were offset by 2° to provide a simultaneous monitor of the background counting rate. During the rest of the observation the positions of the two half-arrays were interchanged approximately every 8 hr, and all ME count rates given in this paper refer to four argon detectors observing the source.

Figure 1 shows the ME 1–8 keV light curve plotted with a time resolution of 360 s. Six X-ray bursts are visible, as well as 10 complete intensity dips. The dips have an average duration

of 50 minutes and recur with a period of 2.932 ± 0.005 hr. During the dips the X-ray intensity varies irregularly with a minimum of $\sim 50\%$ of the average value outside of the dips. Figure 2 shows the folded light and hardness ratio curves with the bursts excluded. The hardness ratio increases at phases where dips are present.

The above period and 1σ uncertainty were obtained by estimating the times corresponding to the center of each dip from template fits and by fitting the resulting arrival times to a linear relation with cycle number. The solar-system barycentric

FIG. 2.—The 1–8 keV folded light and hardness ratio curves of X1323–619 with the bursts excluded. The hardness ratio is the counts in the 4–8 keV band divided by those between 1–4 keV. Phases at which dips occur are visible as increases in hardness ratio.

time of the center of the first dip that was fully observed is JD 2,446,108.428 $\pm$ 0.001, where the quoted 1 σ uncertainty is dominated by the difficulty in determining the dip center in the template profile. This ephemeris cannot be uniquely extrapolated back to the dip observed 1 yr earlier during the 1984 February 11 observation. Depending on the number of intervening cycles the average period is 2.932128 ± 0.000002 hr (1 σ), or $n \times 0.000977$ hr smaller or larger; where n is an integer with $|n| \leq 2$ (3 σ confidence). The confidence limits quoted for the periods assume that the shape of the light curve did not vary during the observations. The fit to the arrival times determined during the 1985 February 11–13 observation has a χ^2 of 7.2 for 7 dof, indicating that any such variations must have been small. However, no such independent check is available for the extrapolation back to the 1984 observation.

The ME spectrum of X1323–619 obtained from intervals well clear of any dipping or bursting activity is shown in Figure 3. The total accumulation time is 12 hr, and the average 1–10 keV count rate 5.27 ± 0.04 counts s^{-1} . The spectrum can be adequately represented by both thermal bremsstrahlung and power-law models, with χ^2 's per degree of freedom (dof) of 51/32 and 43/32, respectively. The best-fit thermal bremsstrahlung model gives a temperature of 26^{+14}_{-6} keV with an equivalent hydrogen column density, N_H , of $(3.5 \pm 0.5) \times 10^{22}$ atoms cm^{-2} . The best-fit power-law model gives an energy spectral index, α , of 0.53 ± 0.07 , with $N_H = (4.0 \pm 0.3) \times 10^{22}$ atoms

cm^{-2} . All spectral uncertainties are given at 90% confidence corresponding to a minimum $\chi^2 + 2.7$ for one parameter of interest. Including a narrow emission line at 6.5 keV in the power-law model does not produce a significantly better fit and gives a 90% confidence upper limit of 85 eV. For a line with a full width at half-maximum (FWHM) of 1 keV the upper limit is 125 eV. Assuming that the observed low-energy absorption is caused by cold interstellar material with solar abundances gives a 0.1–10 keV persistent flux from X1323–619 of 1.7×10^{-10} ergs cm^{-2} s^{-1} , which corresponds to a luminosity of 2×10^{36} ergs s^{-1} at a distance of 10 kpc.

a) Energy Dependence of the Dips

The spectral evolution of the dips seen from EXO 0748–676, X1254–690 and X1916–053 have been studied in detail by Parmar *et al.* (1986), Courvoisier *et al.* (1986), and Smale *et al.* (1988), respectively. The spectral changes observed during dipping intervals cannot be well described by a simple increase in the column density of cold absorbing material with normal abundances. High-quality spectra obtained from these sources indicate the presence of a soft-excess during dipping intervals (i.e., more counts are observed at low energies than predicted by the above model). In all cases, where sufficient counts are detected, significantly better fits are obtained using a two-component model first proposed by Parmar *et al.* (1986). Here, both components have the same spectral index or tem-

FIG. 3.—The ME spectrum of X1323–619 obtained from dip and burst free intervals. The observed spectrum is shown as crosses and the best-fit power-law model as a histogram. The fit parameters are given in the text.

TABLE 1
DIP SPECTRAL ANALYSIS

COUNT RATE (counts s ⁻¹)	TIME ^a (minutes)	MODEL ^b	SPECTRAL PARAMETERS			
			a_1	a_2	N_H^c	χ^2/dof
3.44 ± 0.07.....	297	1	0.0160 ± 0.0010	...	7.6 ± 0.7	37/25
		2	0.011 ± 0.002	0.005 ± 0.003	12 ± 5	32/24
2.42 ± 0.10.....	137	1	0.0140 ± 0.0015	...	11.0 ± 1.5	17/19
		2	0.0120 ± 0.0025	0.002 ^{+0.003} _{-0.002}	13.5 ^{+9.5} _{-3.0}	16/18
1.32 ± 0.43.....	5	1	0.014 ± 0.005	...	14 ± 8	7.7/4

NOTE.—All uncertainties are 90% confidence.

^a Accumulation interval of spectrum.

^b The fitted function are $a_1 E^{-1.53} \exp[-N_H \sigma(E)]$ photons cm⁻² s⁻¹ (model 1) and $\{a_1 \exp[-N_H \sigma(E)] + a_2 \exp[-4.0 \times 10^{22} \sigma(E)]\} E^{-1.53}$ photons cm⁻² s⁻¹ (model 2). The value of α of 0.53 and the low-energy absorption of 4×10^{22} H atoms cm⁻² in model 2 are those appropriate to dip and burst free intervals, E is energy in keV and $\sigma(E)$ the absorption coefficients of Morrison and McCammon 1983.

^c In units of 10^{22} atoms cm⁻².

perature as during unaffected intervals, but only one component undergoes extra absorption. An interpretation of such a spectrum is that two emission regions are being observed, one of which is extended and only partially obscured during dipping intervals. Alternatively, such a spectrum could result from the obscuration of a single emission region by material with a low metallicity. In this case, the ratio of energy independent to energy dependent flux reduction allows an estimate of the number of electrons compared to the number of atoms that are capable of photoabsorbing in the X-ray waveband to be made.

A two-component spectral study of the X1323-619 dips is not so restrictive as in the cases discussed above because the ME count rate from this source is a factor ~ 10 smaller than that from the other dipping sources. In order to estimate the abundance of the absorbing material three intensity-selected dip spectra, corresponding to shallow, intermediate, and deep-dipping intervals were accumulated (Table 1). Satisfactory fits were obtained to all three dip spectra, using a power-law model with α fixed at the best-fit value obtained during dip and burst free intervals of 0.53 and by allowing N_H to vary. As in the case of the other dips sources a soft excess is present in some of the X1323-619 dip spectra. The two-component model of Parmar *et al.* (1986) was fitted to the dip spectra and gave a small reduction in χ^2/dof (from 37/25 to 32/24) for the spectrum accumulated during intervals of shallow dipping activity. The two component fits to the spectra accumulated during intervals of intermediate and deep dipping activity show no significant improvement over the single component

fits. These fits show similar trends in absorbing column and normalization with dip depth, albeit with much larger uncertainties, as in other dip sources. Following the technique described in Mason, Parmar, and White (1985) we find from the two-component fits that the abundance of the absorbing material is between a factor 15 deficient to a factor 2 overabundant compared to solar material.

b) X-Ray Bursts

The intervals between X-ray bursts varied from 318 to 326 minutes, corresponding to an average burst frequency of 0.18 burst hr⁻¹. The evolution of the burst properties was studied by fitting a blackbody model to background subtracted burst spectra accumulated every 10 s (Table 2). The 10 s time resolution means that the initial burst phases and peaks are not fully resolved, and so the peak fluxes, f_p , can only be regarded as lower limits to the corresponding true quantities. For an assumed distance of 10 kpc the apparent blackbody radius in the burst tails is $(5.3 \pm 0.8)(\xi_b)^{1/2}$ km, where ξ_b is the anisotropy factor of the burst emission (Sztajno *et al.* 1987; see also Lapidus and Sunyaev 1985; Fujimoto 1988). There was no evidence for a change in blackbody radius during the bursts. Using the thermal bremsstrahlung model for the persistent emission, the ratio of the persistent flux between the bursts to that emitted during the bursts, α' , is $(79 \pm 4)\xi_p/\xi_b$, with ξ_p being the anisotropy factor of the persistent emission. Because of the uncertain burst peak luminosities the decay times cannot be reliably inferred from the spectral evolution of the bursts. However, the average burst rise time (defined as the interval

TABLE 2
BURST PROPERTIES

Burst Onset (1985 UT)	t_{rec}^a (s)	$f_p(0.1-20 \text{ keV})^b$ (10^{-9} ergs cm ⁻² s ⁻¹)	$E_b(0.1-20 \text{ keV})^c$ (10^{-7} ergs cm ⁻²)	α'^d	r_{bb}^e (10^5 cm)
Feb 11 23:12:08.....	> 15968	2.61 ± 0.25	0.72 ± 0.06	> 64	5.3 ± 1.2
Feb 12 04:32:10.....	19202	2.13 ± 0.25	0.69 ± 0.05	82	4.5 ± 1.0
Feb 12 09:51:08.....	19138	3.05 ± 0.41	0.70 ± 0.06	79	5.1 ± 1.3
Feb 12 15:09:42.....	19114	2.27 ± 0.17	0.67 ± 0.05	83	5.2 ± 1.6
Feb 12 20:34:33.....	19491	2.25 ± 0.17	0.74 ± 0.05	76	7.0 ± 1.3
Feb 13 02:01:18.....	19605	3.17 ± 0.33	0.78 ± 0.05	73	4.8 ± 1.1

^a Interval since last burst.

^b Observed peak flux during a 10 s interval, the true peak flux is a factor ~ 2 higher.

^c Integrated burst flux.

^d Calculated using a thermal bremsstrahlung model for the persistent flux. The anisotropy of the burst and persistent emission are assumed to be the same.

^e Apparent blackbody radius in the burst tail 30-50 s after burst onset assuming a distance of 10 kpc.

between burst onset and peak intensity) and decay time (the interval between the burst peak and when the intensity has fallen to $1/e$ of its peak value) were estimated from the high-time resolution data in the 1.5–11.0 keV energy range to be 4.0 ± 0.6 s and 12.5 ± 1.6 s, respectively. There is no evidence for double peaked profiles in the high-time resolution data, as would be expected from bursts undergoing radius expansion (Lewin *et al.* 1976; Hoffman, Cominsky, and Lewin 1978; Grindlay *et al.* 1980; Tawara *et al.* 1984; Lewin, Vacca, and Basinska 1984; Vacca, Lewin, and van Paradijs 1986; Haberl *et al.* 1987; Murakami *et al.* 1987).

A comparison of the evolution of the burst flux from the X1323–619 bursts with those from X1608–52 (Gottwald *et al.* 1987b) and X1705–44 (Gottwald *et al.* 1987a) which had similar decay times, indicates that due to the 10 s time resolution of our data the above analysis underestimates the burst peak fluxes by a factor of ~ 2 . Thus, the average measured peak flux of $(2.6 \pm 0.4) \times 10^{-9}$ ergs cm $^{-2}$ s $^{-1}$ probably corresponds to a true peak flux of $\sim 5 \times 10^{-9}$ ergs cm $^{-2}$ s $^{-1}$. It is unlikely that the burst peak luminosity reached the Eddington luminosity since there is no evidence for radius expansion (see above), and so we can only set an upper limit to the distance, d , of a $1.4 M_{\odot}$ neutron star with radius 10^6 cm (taking into account gravitational redshift) of

$$d \lesssim 1.5 \times 10^{-3} [(1 + X)^{-1} \xi_b^{-1}]^{1/2} (f_q^{-1})^{1/2} \text{ kpc},$$

where f_q is in ergs cm $^{-2}$ s $^{-1}$. For a hydrogen abundance, X , between 1 and 0, the distance to X1323–619 is $\lesssim (15-20)(\xi_b^{-1})^{1/2}$ kpc.

A lower limit to the distance of X1323–619 may be obtained by combining the relation of van Paradijs, Penninx, and Lewin (1988) with the observed properties of the bursts. These authors find that γ , the ratio of the observed persistent flux to the net peak flux of bursts with radius expansion (i.e., the flux corresponding approximately to the Eddington luminosity) is dependent on both the burst decay time, τ and on α' . For X1323–619 we find $\alpha' = 79 \pm 4$ and $\tau = 12.5 \pm 1.6$ s which gives $\gamma = 0.02-0.08$. For an Eddington luminosity of $(1.6-2.6) \times 10^{38}$ ergs s $^{-1}$ (where the limits correspond to hydrogen and helium rich material, respectively) this gives a persistent luminosity for X1323–619 of $3.2 \times 10^{36} \xi_p$ to $2.1 \times 10^{37} \xi_p$ ergs s $^{-1}$. This is a factor $1\xi_p-6\xi_p$ higher than the observed value for a distance of 10 kpc, and therefore constrains the distance to be $\gtrsim 10$ kpc. Combining this with the upper limit derived above gives a distance for X1323–619 of 10–20 kpc.

c) Position

During the EXOSAT observation the data from the CMA were searched for the presence of a point-source close to the positions of X1323–619 given in Warwick *et al.* (1981) and Forman *et al.* (1978). Since no such source was detected, a procedure to determine the position of X1323–619 using the nonimaging ME instrument was carried out. In this section we discuss this procedure and its application to the X1323–619 observations. In order to obtain a more accurate position for X1323–619, we compare the source properties derived from the ME with those of the point-sources detected after the observation in the CMA data and in earlier *Einstein* observations.

The position of X1323–619 was estimated using ME data obtained between 1985 February 12 13:30 and 15:12 UT. During this interval the pointing direction of four of the ME

detector's was changed in 15' steps so that X1323–619 was visible in both the 45' FWHM FOVs of these and the aligned detectors. Six different offset angles were used. Since the ME offset drive mechanism moves each pair of detectors in a different direction this results in 12 different offset pointing directions. For each pointing direction, the ratio of counts observed in the offset detectors to those observed in the aligned detectors can be calculated. An additional uncertainty of 0.5 counts s $^{-1}$ was added quadratically to the uncertainties derived from counting statistics in order to account for systematic uncertainties in background subtraction. The count rate ratios were then compared with predicted values, derived assuming only one contributing source within the FOV and using the collimator profiles given in Gottwald (1984). A best-fit position of R.A. $13^{\text{h}}24^{\text{m}}23^{\text{s}}$, Decl. $-61^{\circ}57'4''$ (with an equivalent 90% confidence uncertainty radius of 8') was found by minimizing the χ^2 statistic. Figure 4 shows this uncertainty region, along with the 90% confidence uncertainty regions for X1323–619 of Warwick *et al.* (1981) and Forman *et al.* (1978) obtained with nonimaging instruments on the *Ariel V* and *Uhuru* satellites, respectively.

The high column density in the direction of X1323–619 and the lack of sensitivity above ~ 2 keV of the CMA, means that the count rate predicted in this instrument on the basis of the X1323–619 ME spectrum obtained from dip and burst free intervals is only $(5.6 \pm 1.2) \times 10^{-4}$ counts s $^{-1}$. This is below the 3σ detection level of a point source in the central region of the CMA of 6.7×10^{-4} counts s $^{-1}$ and explains the faintness (or absence) of X1323–619 in the CMA. The CMA image obtained by accumulating data from the entire observation was searched for the presence of point sources using a position dependent point-spread function. Three sources, labeled F, G, and H in Figure 4 were detected, and their properties are summarized in Table 3. The count rate from source H is $(3.7 \pm 0.4) \times 10^{-3}$ counts s $^{-1}$. This source lies within the ME uncertainty region and close to that of Forman *et al.* (1978), but its count rate is too low to search for evidence of dips in its light curve. Sources F and G have count rates of $(3.2 \pm 0.2) \times 10^{-2}$ counts s $^{-1}$ and $(3.8 \pm 0.5) \times 10^{-3}$ counts s $^{-1}$, respectively. Both sources lie outside all three nonimaging uncertainty regions and so neither is likely to be associated with X1323–619.

The imaging proportional counter (IPC) on the *Einstein Observatory* registered X-rays with energies up to ~ 4 keV and so was much more sensitive to highly absorbed sources than the CMA. During an IPC exposure of the X1323–619 field on 1980 August 20, between 00:54 and 03:37 UT, a total of six sources were detected (labeled A, B, D, E, I, and J in Fig. 4). In addition, during an earlier high-resolution imager (HRI) observation, on 1980 August 18 between 11:56–12:24 UT, one additional source (labeled C), as well as two of the sources (D and E) seen in the IPC exposure, were detected. The locations and count rates of these sources are given in Table 3 along with the hardness ratios of the sources detected in the IPC. As source C was seen in the HRI but not in the IPC it is unlikely to be X1323–619, since the IPC is significantly more sensitive to highly absorbed sources than the HRI. Of the sources detected in the CMA, source F lies close to one of the IPC detector window supports and was not detected by the IPC, while the other two (G and H) lie outside the FOVs of both the IPC and HRI. Folding the ME spectrum for X1323–619 obtained from dip and burst free intervals through the IPC spectral response gives a predicted (0.2–3.9 keV) count rate of 0.256 counts s $^{-1}$

FIG. 4.—The part of the sky containing X1323–619. The non-imaging uncertainty regions for X1323–619 of Warwick *et al.* (1981), Forman *et al.* (1978), and that obtained using the ME are indicated by 3A, 4U, and EXOSAT/ME, respectively. The sources detected in the imaging *Einstein* and *EXOSAT* observations are labeled A–J (Table 3).

TABLE 3
POINT SOURCES IN THE REGION OF X1323–619

SOURCE	INSTRUMENT	SOURCE CENTROID ^a		R_b	COUNT RATE ^c ($\times 10^{-3}$) s ⁻¹	HARDNESS RATIO ^d
		R.A.	Decl.			
A	IPC	13 ^h 22 ^m 10 ^s	–61°57′42″	40	7.7 ± 2.3	20 ± 90
B	IPC	13 22 54	–61 45 16	50	7.6 ± 2.5	0.9 ± 0.7
C	HRI	13 23 09.34	–62 11 48.5	7.0	8.0 ± 2.8	...
D	HRI ^e	13 23 16.78	–61 52 35.7	2.5	16.0 ± 4.0	26.5 ± 7.7
E	HRI ^e	13 23 23.68	–62 07 00.3	4.0	6.0 ± 2.4	1.4 ± 1.2
F	CMA	13 24 01.7	–62 22 09	20	32.3 ± 2.3	...
G	CMA	13 24 01.7	–61 36 58	10	3.8 ± 0.5	...
H	CMA	13 24 15.1	–61 51 33	10	3.7 ± 0.4	...
I	IPC	13 24 28	–62 03 53	50	9.6 ± 2.4	1.1 ± 0.6
J	IPC	13 25 32	–61 38 45	40	21.9 ± 4.1	1.9 ± 0.8

NOTE.—Source D is likely to be X1323–619 (see text).

^a Epoch 1950.

^b 90% confidence uncertainty radius in arc seconds.

^c Integrated between 0.2–3.9 keV, 0.04–2.0 keV and 0.1–3.9 keV for the IPC, CMA, and HRI, respectively.

Note that the count rates from different instruments cannot be compared directly.

^d IPC counts between 0.9–3.9 keV divided by those between 0.2–0.9 keV.

^e Source was also detected in the IPC from which the hardness ratio is obtained.

FIG. 5.—A red-sensitive finding chart for source D obtained using the 1.5 m Danish telescope at the European Southern Observatory, a CCD detector, and a Z band filter. The exposure time is 20 minutes. The region within the $1' \times 1'$ square box in the upper panel is shown enlarged in the lower panel. The circle denotes the HRI uncertainty region for source D.

and a hardness ratio (counts in the 0.9–3.9 keV band divided by those between 0.2–0.9 keV of 16.5. Examination of Table 3 shows that only IPC sources A and D have hardness ratios consistent with that predicted. Source A is extremely faint with a count ratio of 20 ± 90 and lies outside all the nonimaging uncertainty regions and is therefore unlikely to be X1323-619. Source D is the brightest of the IPC sources with a 0.2–3.9 keV count rate of 0.225 ± 0.009 counts s^{-1} and a hardness ratio of 26.5 ± 7.7 . Both these values are in good agreement with those predicted on the basis of the ME spectrum. In addition, source D lies within both the *EXOSAT* ME uncertainty region and that of Forman *et al.* (1978). The best position for source D is obtained using the HRI and is R.A. $13^h23^m16^s.78$, Decl. $-61^\circ52'35''.7$ (epoch 1950, with a 90% uncertainty radius of $2''.5$). Source B also lies within two nonimaging uncertainty regions but the hardness ratio of 0.7 ± 0.9 is inconsistent with that predicted from the ME spectrum.

Of the 10 sources detected by imaging observations of the X1323-619 field only source D has a count rate and hardness ratio consistent with those predicted using the ME spectrum of X1323-619. In addition, the position of source D is consistent with two of the three nonimaging uncertainty regions for X1323-619. Thus, on the basis of these similarities it is highly probable that source D is that seen in the ME and is therefore X1323-619. Figure 5 shows a finding chart for source D with the HRI uncertainty region indicated. Examination of the IPC light curve of source D shows no obvious evidence for the presence of dips similar to those seen in the ME, although the noncontinuous *Einstein* observation and relatively low IPC count rate means that such dips could easily be missed. However, the IPC light curve of source D binned in 100 s intervals does show some evidence for variability, with a χ^2 of 179 for 54 dof when tested against the hypothesis of a constant source.

III. DISCUSSION AND CONCLUSIONS

The detection of type 1 X-ray bursts and periodic dips in X-ray intensity from X1323-619 characterize this system as a LMXRB. The dips recur every 2.93 hr and have a duration of

50 minutes. Observations of dip sources that show X-ray eclipses (e.g., EXO 0748-676, Parmar *et al.* 1986) or optical variations associated with either the changing aspect of an asymmetric accretion disk or the X-ray heated atmosphere of the companion (e.g., X1254-690, Motch *et al.* 1987), indicate that the dip recurrence intervals closely reflect the underlying orbital period. Thus, the orbital period of X1323-619 is almost certainly 2.93 hr. In the case of X1323-619, the lack of X-ray eclipses or an optical modulation means that the orbital phase of the dips is unknown. However, by analogy with other dip sources it is probable that the dips are caused by obscuration of the central point source by material located at the rim of the accretion disk in the region where the gas stream from the companion impacts the disk.

The absence of eclipses allows us to place a constraint on the vertical extent of the structure responsible for the dips. Assuming that the companion fills its Roche lobe and the $M_x/M_c < 0.8$ (where M_x is the mass of the compact object and M_c the mass of the companion) then combining Kepler's third law with the Roche geometry (e.g., Paczyński 1971) gives $M_c = 0.33 M_\odot$ for a 2.93 hr orbital period. From an analysis of the 1–8 keV light curve we can exclude the possibility of eclipses of the X-ray source by the companion star lasting longer than 10 s. If the companion obeys the main-sequence mass-radius relation of Whyte and Eggleton (1980) then the lack of eclipses implies that the system inclination must be less than 75° . If the companion is no longer assumed to be on the main sequence, but has the minimum possible mass for nondegeneracy ($0.085 M_\odot$), then the system inclination must be less than 80° . Thus, the material responsible for the dipping activity must be located at least 10° from the orbital plane.

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