events of comparable luminosity from the vicinity of LMC X-4 and these may be related to the four outbursts reported here.

I thank G. F. Carpenter of Birmingham University and P. J. N. Davison for useful discussions.

N. E. WHITE

*Mullard Space Science Laboratory,*
*University College London,*
*Holmbury St Mary,*
*Dorking, Surrey, UK*

Received 10 October; accepted 3 November 1977.

1. Sandaleak, N. & Philip, A. G. D. *IAU Circ.* No. 3023 (1977).
2. Chevalier, C. & Ilovaisky, S. A. *Astr. Astrophys.* **59**, L9 (1977).
3. Giaconni, R. *et al. Astrophys. J.* **178**, 281 (1972).
4. White, N. E., Davison, P. J. N. & Carpenter, G. *IAU Circ.* No. 3100 (1977).
5. White, N. E. & Carpenter, G. *Mon. Not. R. astr. Soc.* (submitted).
6. Epstein, A. *et al. Astrophys. J.* **216**, 103 (1977).

# A search for rapid optical periodicities from Cyg X-1

ACCORDING to the most widely accepted model of the X-ray source Cyg X-1, the X rays are produced in a gas disk surrounding and accreting into a black hole with a mass of about $10M_\odot$. The accretion disk is maintained by matter transferred from the binary companion of Cyg X-1, the blue supergiant HDE226868. The X-ray luminosity of Cyg X-1 is known to vary randomly on a wide range of time scales, from many days to a few milliseconds, with the shortest of these time scales corresponding to the dynamical time scale of the innermost stable orbit around the black hole[1,2]. The optical luminosity of the Cyg X-1 system is also known to vary on time scales of days[3], but only one case of extremely rapid optical variability has been reported[4,5]. The properties of the rapid variations were most unusual. The variations were transient and were detected only four times, but they occurred sufficiently frequently that three of these detections occurred during the total of only 2 h of observations accumulated by Auriemma *et al.* in July 1975[4,5]. The variations were nearly periodic, with periods of 83.53 ms, 83.71 ms, 83.59 ms, and with $|\Delta P/P| \sim 2\times10^{-4}$. The periodicities were long lived, lasting at least 6 min and probably over 10 min, so that the pulse trains consisted of over 4,000 pulses. The amplitudes of the pulses were large, up to 0.042 mag. No comparable behaviour has been detected in the X-ray light curve of Cyg X-1, and it is far from clear that this behaviour is consistent with our present conceptions of accretion disks. Thus, the detections of these pulses, if confirmed, would be of some importance since they would require a revision of the models for Cyg X-1. Therefore, we have taken an extensive set of observations of Cyg X-1 with the purpose of detecting additional examples of the rapid periodicities.

The data were acquired using one or other of the high-speed photometers mounted on the 0.76 m, 0.92 m, or 2.08 m telescopes at McDonald Observatory. Our observational technique consisted of acquiring individual 10-min long light curves of HDE-226868. The light curves were taken through a wide variety of filters, most notably the Johnson U, B, and V filters, the Strömgren v filter, and a 30 Å filter centered on the $\lambda$4,686 Å line of He II. Each of the light curves was tested for the presence of periodicities at the time it was observed. Our technique for testing for periodicities has already been described in detail[6]. Briefly, for a sinusoidal signal, the test is equivalent to calculating the power spectrum of the light curve, but because of limitations on computer memory and speed, the spectrum is calculated only for a restricted range of frequencies. For Cyg X-1, we chose a frequency range of 11.718 to 12.216 Hz. This frequency range is centred on, and is a factor of nearly 20 greater than the range of the frequencies detected by Auriemma *et al.* We accumulated over 90 h of light curves spaced over 65 nights in September to November 1976 and in May to October 1977. With the exception of a few observations heavily contaminated by clouds, the maximum amplitude of any possible periodic signal during this time was 0.0029 mag, which is more than a factor of 10 less than the amplitude of the variations detected by Auriemma *et al.* With no exceptions, the power at all frequencies in the tested range was always consistent with white noise.

There are several ways to account for the difference between our results and those of Auriemma *et al.* Cyg X-1 could have changed its properties between 1975 and 1976 so that the periodicities are no longer present or occur far less often. The variations could have been present during our observations, but with periods outside the range of periods we tested. It is also possible that the periodicities detected by Auriemma *et al.* were spurious and of instrumental origin.

E. L. ROBINSON
R. E. NATHER
J. AFRICANO
B. SMITH

*McDonald Observatory and Department of Astronomy,*
*University of Texas,*
*Austin, Texas 78712*

Received 11 October; accepted 3 November 1977.

1. Boldt, E., Holt, S., Rothschild, R. & Serlemitsos, P. *Proc. Calgary Conference on X-rays in Space* (1974).
2. Oda, M., Doi, K., Ogawara, Y., Takagishi, K. & Wada, M. *Astrophys. Space Sci.* **42**, 223 (1976).
3. Walker, E. N. *Goddard Symp. X-ray Binaries* 521 (1975).
4. Auriemma, G. *et al. Nature* **259**, 27 (1976).
5. Auriemma, G., Cardini, D., Costa, E., Giovannelli, F. & Ranieri, M. *Goddard Symp. X-ray Binaries* 485 (1975).
6. Nather, R. E. Robinson, E. L., Van Citters, G. W. & Hemenway, P. D. *Astrophys. J. Lett.* **211**, L125 (1977).

# Quasi-periodic fluctuations in electron content during a partial solar eclipse

CHIMONAS and Hines[1,2] have suggested that a solar eclipse might generate gravity waves in the atmosphere. During solar eclipse the localised cooling of the atmosphere in the lunar shadow causes an energy imbalance and the shadow moving at supersonic speed across the Earth's surface could be a continuous source of gravity waves propagating to great distances in the atmosphere. These quasi-periodic wave perturbations in the ionospheric electron density, caused by the coupling between the ionised and the neutral particles, have been detected by various investigators[3–5] at middle and high latitude stations away from the path of the eclipse shadow. Hajkowicz[6] has reported the observation of perturbations of quasi-periods of less than 2 min, after the October 1976 eclipse. We report here the observation of quasi-periodic fluctuations in Faraday rotation angle $\Omega$ and the 1 MHz modulation phase delay $\varphi$ of 40 MHz transmissions from ATS-6 geosynchronous satellite recorded at Trivandrum (dip 0°57′S, geographical longitude 76°57′E) during the partial solar eclipse on 29 April 1976. $\varphi$ directly gives columnar electron density integrated along the radio ray path from the satellite to the receiver; whereas $\Omega$ gives columnar integrated electron density only up to an altitude of 2,000 km because of the weightage by the component of the geomagnetic field along the ray path. For ATS-6 to Trivandrum ray path geometry, a change of 10° in $\Omega$ will be produced by a change of $0.47\times10^{16}$ el. m$^{-2}$ of electron (el.) content. In contrast to this, 10° change in $\varphi$ will be produced by a change of $0.34\times10^{15}$ el. m$^{-2}$. The accuracy of measurement of both $\Omega$ and $\varphi$ is better than 1°.

On 29 April 1976 the solar eclipse, as seen from the 300 km altitude point on the ATS-6 to Trivandrum ray path, began at 1718h (all times are IST); maximum obscuration of about 20% of the solar disk was at 1802 h; the end of the eclipse was at 1843 h and the sunset time was 2003 h. The values of $\Omega$ and $\varphi$ recorded on 29 April 1976 between 1420 h and 1830 h were scaled at intervals of 2 min. The differences between the data and the 10-min moving averages which contain all fluctuations with quasi-periods less than 50 min are plotted against time in Fig. 1; separately for