phase precede the initiator AUG codon.

To conclude, we note that *tof* mRNA, like the P_{rm} mRNA, also begins with an AUG. This similarity may not be entirely fortuitous. It is in keeping with the abovementioned symmetry of the entire O_R region and with the fact that *tof* product, like the *c*I product, acts as a repressor, albeit a weak one. Its sites of action, like those of the *c*I repressor, are O_L where it performs the eponymous function of turning off the *N* operon, and O_R, where it turns off transcription of P_{rm} and of P_R and hence its own transcription[19]. In short, the *tof* product may formally be considered a mini version of the *c*I repressor. In the *tof* mRNA, however, the initial AUG is not the start of translation because it is followed two triplets later by a UAA codon in phase.

We thank T. Bickle and P. Schedl for discussions and criticism. This work was supported in part by a grant from the Swiss National Foundation for Scientific Research.

Received May 6; accepted June 16, 1976.

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letters to nature

The second highly polarised radio outburst in Cygnus X-3

WE detected a second outburst with a high degree of linear polarisation from Cyg X-3 in August 1975, following the alert by Kawajiri[1]. The first such outburst was observed in May 1974 (refs 2 and 3). Here we report observations of both polarised outbursts as well as of an unpolarised outburst in January 1975. At 8 GHz the observed polarisation position angle was the same for both polarised outbursts. The Faraday rotation measure associated with the source is much larger than previously reported[2]. We suggest that the orientation of the magnetic field in the source and the rotation measure are both stable with time. In addition, we find that the highly polarised outbursts decay significantly more slowly than the unpolarised outbursts.

All measurements were made with the University of Michigan 85-foot paraboloid operating at frequencies of 8 and 14.5 GHz. The equipment and on-off observing techniques used at 8 GHz have been described previously[4–6]. Similar equipment and techniques were used at 14.5 GHz. All the observations were made with linear polarimeters except for those made at 8 GHz on May 26 and June 2, 1974 and on August 27–28, 1975, which were obtained with a single-horn circular polarimeter. Observations of Cyg X-3 were alternated with observations of the standard sources Cyg A or DR21 to determine the flux density calibration. Daily averages of the data for the polarised outbursts are presented in Table 1. The total flux density measurements have been corrected for confusion effects by the addition of 0.071 Jy at 14.5 GHz and the subtraction of either 0.73 or 0.49 Jy at 8 GHz for observations made with the linear or circular polarimeters respectively. The standard errors include the statistical noise and the uncertainties in the antenna gain and telescope pointing.

The total and polarised flux densities for August and September 1975 are displayed in Fig. 1. Only the decay phase of the outburst was observed. Observations[7] at 5 GHz indicate that the maximum flux density occurred on August 22 or 23, 2 or 3 d before our measurements began. From August 26 to September 3, the decay of the total flux density at 8 GHz was exponential with time. The line through the 8-GHz data points is a least squares fit to the data from August 26–27 to September 1–2 and represents an e-folding time of 86±1 h. The 14.5-GHz data are consistent with the same exponential decay rate. The spectral index from 14.5 to 8 GHz during the exponential decay remained at $\alpha = -0.65 \pm 0.06$ where $\alpha = (\Delta \log S_\nu / \Delta \log \nu)$. The same spectral index appears to fit the data at 5 GHz (ref. 7) which indicates that the source was transparent above 5 GHz from August 24 to September 5. After September 3 the rapid exponential decay ceased and the total flux density slowly and irregularly declined until September 20. By September 10 the flux density seems to have been nearly the same from 5 GHz to 14.5 GHz, coresponding to a spectral index $\alpha \sim 0$.

Table 1 Flux density and linear polarisation variations with time

Date	(UT)	S_ν(Jy)	P(%)	Position angle (degrees)
		8.0 GHz		
1974				
May	26.5	4.18±0.35	9.7±0.8	80±2
June	2.4	1.70±0.35	7.0±1.8	87±7
1975				
August	25.3	7.34±0.12	5.8±0.5	75±2
	26.3	6.32±0.14	7.6±0.7	80±2
	27.1	5.48±0.08	8.4±0.5	80±2
	28.1	4.25±0.18	8.4±0.5	86±2
	29.0	3.21±0.09	11.6±1.6	83±4
September	2.1	1.04±0.03	12.5±2.7	87±6
	3.0	0.90±0.06	17.1±5.1	97±7
	5.2	0.46±0.04	8.6±9.5	
	8.1	0.54±0.04	19.8±7.0	83±7
	10.1	0.36±0.08	23.4±14.8	84±16
	11.0	0.47±0.06	18.4±14.6	88±14
	17.1	0.27±0.05	25.6±18.5	143±18
		14.5 GHz		
1975				
August	27.2	3.69±0.25	12.6±2.1	146±5
	28.2	2.65±0.13	17.4±2.5	154±4
	29.3	2.04±0.16	17.7±4.9	145±7
September	3.1	0.64±0.07	27.9±14.9	151±19
	9.1	0.58±0.10	22.2±15.3	2±23
	12.0	0.33±0.11	15.3±28.8	

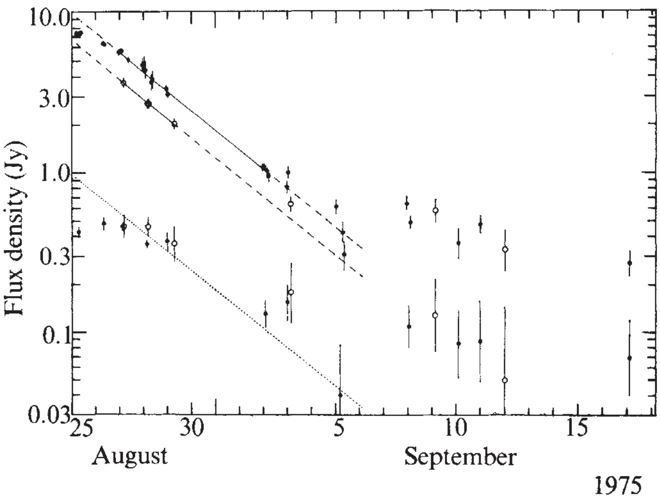


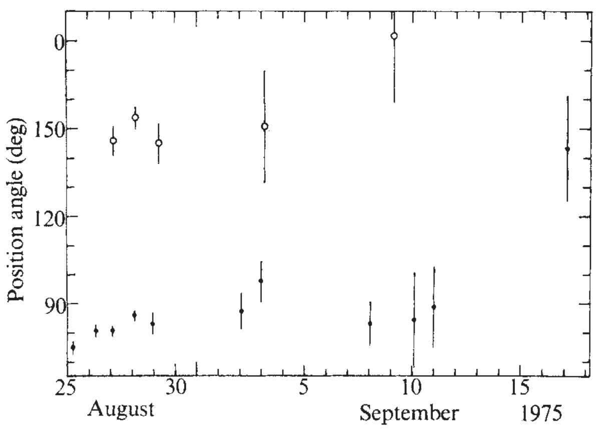
Fig. 1 Semilog plot of total and polarised flux density against universal time at 8.0 (●) and 14.5 (○) GHz for Cyg X-3. The total flux density measurements in the upper portion of the plot are 40-min averages of the data. The polarised flux density measurements in the lower portion are daily averages. The two lines through the total flux density measurements are fits to an exponential decay with time for the data where the lines are solid. The dotted line through the polarised flux density measurements represents a constant 10% degree of linear polarisation for the exponential decay of the total flux density at 8 GHz.

It has been noted that the decay of the first September 1972 outburst evolved from an exponential to a power-law time dependence with the exponential phase lasting longer at higher frequencies[8]. The same phenomenon may have occurred during this outburst. The irregular flux variations and the apparent change in the spectral index indicate, however, that renewed injection or acceleration of particles may have obscured the decay of the outburst after September 3. Hence, fits to the data extending after September 3, such as the one made at 5 GHz (ref. 7) may not give a true indication of the decay process.

No circular polarisation was detected in either polarised outburst. A 2σ upper limit of 0.5% for the degree of circular polarisation was obtained on August 27–28, 1975. Our measured degree of circular polarisation of 0.4±0.4% for the May 1974 outburst agrees with the upper limit of 0.5% obtained by Seaquist *et al.*[2].

During the August 1975 outburst the degree of linear polarisation increased to > 10% at both frequencies, as illustrated in Fig. 1. The level of polarisation at 8 GHz is comparable to that observed by us and by Seaquist *et al.*[2] during the May 1974 outburst. Although the total flux density was already decreasing when we started observing on August 25, 1975, the polarised flux density did not begin to decrease until August 27. The increase in the degree of polarisation with time, and the fact that the degree of polarisation was significantly higher at the higher frequency (14.5 GHz) are both similar to the pattern observed during the May 1974 outburst[2,3].

Fig. 2 Linear polarisation position angle against universal time at 8.0 (●) and 14.5 (○) GHz. The points represent daily averages of the data.



The position angles of the linear polarisation for the August 1975 outburst are shown in Fig. 2. The average position angle observed at 8 GHz from August 25 to September 3 of 81.1±1.0° is the same within uncertainties as the value of 80.5±2.2° observed by us for the May 1974 outburst. The position angle may have changed at 8 GHz by ~ 10° during the 1975 outburst. The average position angle observed at 14.5 GHz was 150±3°. If the difference in position angle is caused by Faraday rotation, the rotation measure must be at least $-1{,}265\pm56$ rad m^{-2}. This value is more than twelve times that derived from data at the frequencies 2.7 and 8.1 GHz (ref. 2). Observations at 4.2 GHz for the May 1974 outburst[3] also indicate that the original determination of the rotation measure was too small because of the $n\pi$ ambiguity in the amount of rotation at 2.7 GHz. The excellent agreement of the observed position angles for the two polarised outbursts strongly suggests that the rotation measure and intrinsic position angle were the same for both outbursts. If the position angles of the two outbursts were completely independent, the probability that the difference would be not more than 0.6° is 0.7%. The probability that the difference would be not more than the quadratically summed error of 2.4° is 2.7%. We have fitted the observed position angles from both outbursts together and find that a rotation measure of $-1{,}233\pm10$ rad m^{-2} is consistent with all the data. The intrinsic position angle of the linear polarisation was 0±3°.

The stability of the 8-GHz polarisation position angle during the outbursts and between the first outburst and the second indicates that most of the Faraday rotation must occur in a region which is unaffected by the evolution of the outbursts. It is extremely unlikely that the rotation measure within the expanding emitting region would be the same for two separate bursts or that the internal rotation measure would not change as the emitting region expanded. The region producing the observed Faraday rotation could be either the long path through the Galaxy between Cyg X-3 and the Earth or a volume around Cyg X-3 in which material has accumulated from previous activity in the source. The sign of the rotation measure is the same as that observed for other sources in the Cygnus direction through the Galaxy, although the magnitude is much larger[9,10]. If the distance to Cyg X-3 is taken as 11 kpc (refs 11 and 12), the observed rotation measure could be produced by an average longitudinal component of the magnetic field of 10^{-6} gauss and an average electron density of 0.14 cm^{-3}. These are reasonable values, especially since the source is located on the far side of the Cyg X complex of H II regions.

The similar degrees of polarisation and the agreement between the polarisation position angles for the two outbursts suggest that the structure of the magnetic field in Cyg X-3 was the same for both outbursts. The periodicity observed in the radio[6,8], infrared[13] and X-ray[14] emissions indicates that Cyg X-3 is a rotating or revolving system with a period of 4.8 h. The absence of large changes in the polarisation position angle data indicates that the magnetic field in the emitting region is oriented near a direction parallel or perpendicular to the angular momentum axis of the object.

Since the intrinsic position angle of the linear polarisation produced in an optically thin source is perpendicular to the transverse projection of the magnetic field, the axis of

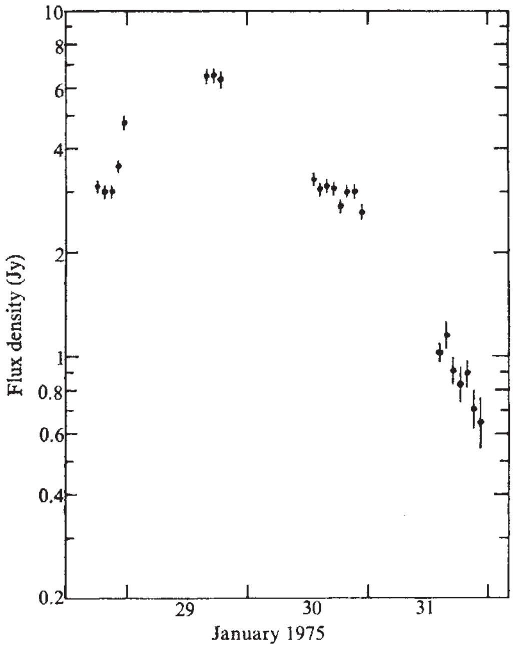


Fig. 3 Semilog plot of total flux density against UT at 8.0 GHz for Cyg X-3. The points represent 40-min averages of the data.

rotation or revolution of the system should be near a position angle of 0° or 90°. Any model for the radio emission from this source, especially those involving expansion where the particles control the magnetic field[15,16], must explain the observed stability of the field structure.

Observations at 8 GHz of an unpolarised outburst in Cyg X-3 during January 1975 are shown in Fig. 3. The average degree of linear polarisation from our 23 measurements was $1.3\pm0.5\%$ at a position angle of $66\pm12°$. The characteristic time for the decay of the total flux density was ~27 h which is similar to the decay times found for the other unpolarised outbursts[5,17]. It is noteworthy that the two highly linearly polarised outbursts have decayed significantly more slowly than all the other observed outbursts, of which four are known to have been unpolarised[2,6,18,19].

If there is a correlation between the decay rate and the existence of linear polarisation, it is an important feature which must be explained by any model for the radio outbursts in Cyg X-3. For instance, there is a natural correlation between the decay rate and the amount of linear polarisation if the absence of polarisation in the unpolarised events is caused by Faraday depolarisation and the energy losses of the radiating particles arise from thermal bremsstrahlung. This energy loss mechanism has been suggested to explain the exponential nature of the decay[5]. The difference in the amount of thermal matter required for polarised and unpolarised outbursts is much larger, however, than the difference required to explain the different decay rates. On the other hand, it is not obvious why a correlation between the decay rate and the state of polarisation would exist for expanding source models in which the energy losses are due to adiabatic expansion[15] or to both adiabatic expansion and synchroton radiation[16]. Source models for Cyg X-3 must account for the smaller degree of polarisation at lower frequencies during the polarised outbursts. For example, the ratio of the degree of polarisation at 8 GHz to that at 14.5 GHz was 0.54 ± 0.06. It has been suggested that this depolarisation effect arises from Faraday depolarisation[2]. This explanation is, however, hard to reconcile with the stability of the polarisation position angle observed at 8 GHz.

We thank F. T. Haddock, T. V. Seling, G. E. Latimer and K. G. Holmes for making these observations possible. This research was supported by grants from the NSF.

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Received June 8; accepted June 22, 1976.

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Competition of neutrino and gravitational radiation in neutron star formation

WE look here into the possibility that neutrino radiation (rather than gravitational radiation) may be the dominant way by which non-radial pulsations are damped out in a collapsing star. If true, such a result implies that estimates and hopes to detect gravity waves from supernovae explosions may have been overly optimistic.

It has been known for some time that neutron stars and black holes are probably the collapsed central remnants of a supernova explosion. These objects presumably originate from the collapse of the cores of sufficiently massive ($M\gtrsim7M_\odot$) stars[1], following the cessation of thermonuclear burning. Although at the present no completely consistent detailed theory exists showing exactly how the collapse of the core and the subsequent supernova explosion take place, there does exist a general model[2] for the final stages of stellar evolution and supernovae explosions. According to this, the electrons' of a sufficiently massive stellar core, due to the high density and temperature, get absorbed by the protons, through $p+e^-\rightarrow n+\nu$. At the same time, huge numbers of neutrinos, resulting from this and other thermal processes (pair annihilation, plasma decay, bremsstrahlung) (refs 3 and 4) are emitted, taking away most of the gravitational energy of the collapse. These neutrinos possibly drive the ejection of the overlying stellar mantle, while the neutron-rich core further collapses to a condensed remnant.

The leftover remnant is of very high density (10^{14}–10^{15} g cm^{-3}) and its radius will eventually be only a few times its Schwarzschild radius. This implies that general relativistic effects may be important in situations involving neutron stars. In particular, the possibility of gravitational radiation emission from non-radially pulsating neutron stars has been extensively examined and it has been shown that gravitational waves can carry away the pulsational energy, thus damping out the star's oscillations. (Such non-radial pulsations presumably might occur during the collapse and formation of the neutron star.) Some workers have estimated[5] that the energy emitted in gravitational radiation in such an event would be sufficient to trigger existing or future gravitational radiation detectors. Consequently one might expect detectable gravitational wave pulses to be associated with supernovae explosions from the non-radial pulsations of the newly formed neutron stars.