LETTERS TO NATURE

PHYSICAL SCIENCES

Detection of Radio Emission from Cygnus X-1

THE X-ray source Cyg X-1 is known to be highly variable and recently has been found to pulsate with a period of 73 ms (ref. 1). Here we report the detection of its radio counterpart at a frequency of 1,415 MHz.

Two sets of observations at 1,415 MHz were made with the Westerbork synthesis radio telescope of a 1° × 1° field centred near the position of Cyg X-1. The bandwidth was 4 MHz. Baselines ranging in length from 36 to 1,471 m were used, resulting in a synthesized beam of half-power diameter 23″ in right ascension and 40″ in declination. The first observations on February 28, 1971, from 10 h 29 min to 15 h 02 min UT showed no source stronger than 0.005 flux units near the X-ray position. The field was observed again during April 28–29 from 23 h 04 min to 11 h 06 min UT, and in the map resulting from these observations there is an unresolved source within the X-ray error box.

The flux density of the radio source is 0.021 ± 0.004 f.u. and its position, determined by a least-squares fit to the antenna pattern, is in 1950 coordinates: $\alpha = 19$ h 56 min 28.9 s ± 0.2 s, $\delta = 35°\ 03'\ 56'' \pm 3''$. This can be compared with the X-ray position determined by the Uhuru satellite which is $\alpha = 19$ h 56 min 25 s ± 15 s, $\delta = 35°\ 03'\ 25'' \pm 1'$ (unpublished work of Tananbaum *et al.*). Because of the close agreement in position and because this radio source is so strongly variable, it is almost certainly associated with Cyg X-1. A search at the radio position may therefore enable the X-ray source to be identified optically. A likely candidate is the ninth magnitude star AGK2 +35° 1,910 only 1″ from our position, but photometric and spectroscopic observations are needed to confirm the identification. Further study of the radio emission is also of great importance. Simultaneous measurements over a range of frequencies should reveal whether its radio spectrum is non-thermal as in the case of Sco X-1 (refs. 2 and 3), and observations with high time resolution are essential to determine whether the radio source is a pulsar.

During the preparation of this article we learned from Drs R. M. Hjellming and C. M. Wade that the Cyg X-1 radio source has been detected independently at a frequency of 2,695 MHz with the NRAO interferometer at Green Bank. Their position is in good agreement with that given here.

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Variation of the Strong and Electromagnetic Coupling Constants over Cosmological Times

THERE has been a long history of speculation on the possibility that the fundamental constants of physics may vary slowly over long periods of time[1,2]. This speculation was most recently brought forward as a possible explanation of the cosmological redshift[2]. Numerous authors pointed out that there are many reasons for ruling out any large scale variations of the fine structure constant (electrical charge) with time[3]. In this article, we show that on the basis of the liquid drop model of the nucleus and the observed half lives and abundances of the transuranium elements, approximate limits can be put on the rate of change of the ratio g^2/e^2, where e is the electric charge of the electron and g is the strong coupling constant. If we assume that the strong interactions do not vary as a function of time, then we find limits of the time rate change of e of about the same stringency as those in refs. 3, 4 and 5. If, however, we assume the conclusions[3–5] that e does not change as a function of time, then we can show that the quantity

$$\frac{1}{g^2}\frac{dg^2}{dt}$$

must be less than $\sim 2 \times 10^{-11}$ yr^{-1}.

The liquid drop model of the nucleus[6] treats the stability of the nucleus as the result of the competition between two forces —the Coulomb repulsion between the protons, which tends to expand the nucleus, and the strong interactions, which tend to hold it together. The effect of the strong interactions is introduced through a surface tension T, which we will take to be proportional to g^2, the strong interaction coupling constant. The criterion that a nucleus of atomic number A and charge Ze be stable against spontaneous fission is

$$Z^2/A < \frac{40\,\pi\, r_0^3}{3\,e^2}\,T \qquad (1)$$

where r_0 is the nuclear radius parameter given by $r_0 \sim 1.2 \times 10^{-13}$ cm.

From this criterion, we see that changes in the ratio T/e^2 could result in a nucleus which was stable becoming unstable and vice versa. For the sake of argument, let us assume that the strong interactions do not vary as a function of time. Then if the redshift is to be explained as an effect of the change of e, e will have been smaller in the past than it is at present. This means that some nuclei which are now unstable would have been stable in the past.

Suppose that we find nuclei which (1) are now unstable, (2) have a long half life, and (3) do not occur naturally. If the electric charge were changing over long time scales, there will be some time in the past, call it t_p, when the electrical charge was such that the nucleus was stable. This time must have been appreciably longer than the half life of the nucleus to allow all the stable nuclei which are present at t_p to have decayed by the present time, and thus meet requirement (3).

We denote by e_p the value of the electric charge at time t_p (the time at which the nucleus was just stable), and e_0 the value of the charge at the present time (t_0). Then

$$\frac{1}{\alpha}\frac{d\alpha}{dt} \simeq \frac{e_0^2 - e_p^2}{e_0^2\, t_p} \qquad (2)$$

and the only problem remaining is to assign some value to t_p. From requirement (3) above, we know that $t_p \gg \tau$, the half life of the nucleus. We choose, somewhat arbitrarily, the value