DR. SCIAMA has proposed an interesting explanation of the Faraday rotation which is observed to be associated with the radiation from Centaurus A. The agreement between the observed rotation and that which would be produced by magnetic fields, electron densities and path lengths appropriate to his model of the local cluster of galaxies[1] is indeed very good. Experimental evidence for or against this model may soon be obtained from observations of other polarized sources at various galactic latitudes and longitudes, and we are able to report that Drs. Gardner and Whiteoak of this laboratory have now detected Faraday rotation in some 16 additional sources. Their results, which are soon to be published, indicate that there is a substantial galactic contribution to the rotation; in general, sources at high galactic latitudes show less rotation than those close to the plane.

In considering a possible intergalactic source of the rotation it should be pointed out that Prof. F. Hoyle[2] now sees no objection to a field as high as 10^{-6} gauss in inter-galactic space. With such a field, and an acceptable value of 2×10^{-5} cm^{-3} for the inter-galactic electron density, the rotation may be produced in a path length of 3 megaparsecs.

On reflexion, we are prepared to admit that the magnetic field of $\sim 10^{-5}$ gauss which we postulated for the galactic halo is higher than most current estimates. However, it is still possible that such fields do exist in the first 1–2 kiloparsecs of the path between the Earth and Centaurus A; this passes close to the Sagittarius arm of the Galaxy. Reducing the effective path-length to ~ 1 kpc the electron density then requires to be raised to $\sim 10^{-2}$ cm^{-3}, an acceptable value in this restricted region.

In summary, we hope that the experimental data will soon be numerous enough to arbitrate between the various models which have been proposed.

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[1] Sciama, D. W., *Mon. Not. Roy. Astro. Soc.*, **123**, 317 (1962).

[2] Hoyle, F. (private communication to Dr. E. G. Bowen).

PHYSICS

Neutron–Proton Interaction

OUR attention has been directed to a note by Y. P. Varshni on neutron–proton interaction in the deuteron (ref. 1, hereafter referred to as I). The object of this communication is to point out that the magnetic dipole interaction suggested by Varshni does not lead to a bound state of the deuteron and his method has many self-contradictions and misapprehensions. It will further be shown that the n–p scattering cross-section based on this potential turns out to be much smaller than the experimentally observed value. It fails to account for the charge independence of nuclear forces. The slight observed difference between singlet n–p and p–p scattering lengths cannot also be accounted for by purely magnetic dipolar interaction[2].

The formula given in (I) for the attraction energy is

$$V = -2\mu_p\mu_n/r^3 \qquad (1)$$

This is also taken to be the total energy. It is not clear why the kinetic energy should be neglected. To estimate the binding energy from (1) Varshni calculates r by three methods. In the first, r is taken to be an integral multiple of the fundamental length:

$$r = n\hbar/Mc \qquad (2)$$

where M is the reduced mass of the n–p system. The ground-state corresponds to $n = 1$. This ground-state separation, of the order of 0·4 Fermi, disagrees with the observed value of 4 Fermis[3]. Also, it cannot be said that the charge centre separation in the deuteron is $4f$ while the magnetic moment centres are separated by $0{\cdot}4\,f$. Analyses of electron scattering data exclude such a possibility[4–6]. Moreover, such a separation would lead to a much larger quadrupole moment for the deuteron than is observed. The smaller value seems to have been chosen to get a value for V close to the experimental value of the binding energy (2·2 MeV). The observed neutron–proton separation would give a value a thousand times less.

The fundamental length is not a very well-defined concept, less so in the case of the nucleon. Various authors introduce it by various methods and get different values for it. If it is introduced to remove quantum mechanical divergences associated, for example, with cavity radiation its value is $5f$[7]. Other methods are due to Flint[8], who gets two fundamental lengths $\hbar/Mc$ (for field-quantum free case) and e^2/Mc^2 (with field) from a unified field theory coupled with a quantum theory of measurement, and Podolsky[9], who obtains it from an interpretation of the formulæ of electrodynamics.

The assumption that the orbital velocity $v \to c$ made in the second deduction of r_n contradicts Varshni's earlier statement that there is no orbital motion.

The third deduction depends on the similarity of deuteron with the hydrogen atom. Using Bohr's theory consistently to replace the electrostatic force Ze^2/r^2 by the assumed magnetic force $6\mu_p\mu_n/r^4$, we get for the radius:

$$r = 6M\mu_p\mu_n/n^2\hbar^2 = 6{\cdot}16 \times 10^{-16}/n^2 \text{ cm} \qquad (3)$$

Varshni uses the hydrogenic atom value $r_n = n^2\hbar/Mc$ and puts $\alpha = 1$, which is again self-contradictory because strong coupling has been completely ruled out by postulating magnetic interaction. Nevertheless, using the expression (3) for r_n, the total energy is

$$W = (Mv_n^2/2) - \hbar^6 n^6/(108M^3\mu_p^2\mu_n^2) = \hbar^6 n^6/(M^3\mu_p^2\mu_n^2)\ (1/72 - 1/108)$$

This being positive, binding is not possible.

It can be shown, using the uncertainty principle[10], that a particle subjected to a potential varying as r^{-3} will 'fall' to the centre. For if we confine the wave function to a small region of radius a, then the minimum uncertainty in momentum will be $\approx \hbar/a$. The mean kinetic energy in this state will be of the order $\hbar^2/Ma^2$ and the mean value of the potential energy is $-2\mu_p\mu_n/a^3$ where $2\mu_p\mu_n > 0$. Therefore the total energy $\hbar^2/Ma^2 - (2\mu_p\mu_n/a^3)$ can be made to take arbitrarily large negative values for sufficiently small a. The 'normal' state will therefore be of energy $-\infty$ and corresponds to the particle at the origin. If, however, we cut off the potential at a length a, then there can be binding only if $a < (2\mu_p\mu_n M/\hbar^2) = 10^{-16}$ cm, an improbably small distance.

It can also be shown that purely magnetic forces will give a very small value of the n–p scattering cross-section. The treatment given as follows[11] is general

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