SHORT COMMUNICATIONS

SCATTERING OF HIGH ENERGY ELECTRONS BY CARBON AND THE NUCLEAR DENSITY DISTRIBUTION*

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The elastic scattering of 187 MeV electrons by ^{12}C has been calculated, using the Born approximation and the independent particle model with spherical box wave functions and with harmonic oscillator wave functions (Tassie 1956).

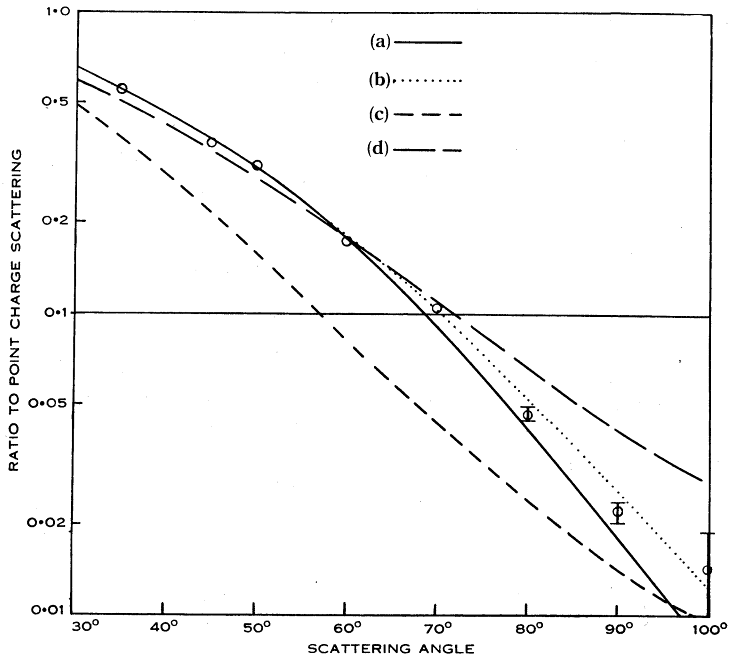

Fig. 1.—Elastic scattering of 187 MeV electrons by ^{12}C. Experimental points are those of Fregeau and Hofstadter (1955).

(*a*) Calculated using the independent particle model with spherical box wave functions.

(*b*) Calculated using the independent particle model with harmonic oscillator wave functions.

(*c*) Calculated using the nuclear density distribution of Gatha, Shah, and Patel (1954).

(*d*) Calculated using the nuclear density distribution of Gatha, Shah, and Patel reduced in linear dimensions by 0·82.

The results are plotted in Figure 1 as the ratio to point charge scattering, and are compared with the experimental results of Fregeau and Hofstadter (1955). The parameters required for best agreement with experiment were

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$a_{SB}=3\cdot9\times10^{-13}$ cm and $a_{HO}=(h^2/4\pi^2m_pw)=1\cdot58\times10^{-13}$ cm, where w is the spacing of the harmonic oscillator energy levels.

As shown in Figure 2, the corresponding nuclear charge distributions are similar, but differ from the nuclear density distribution calculated by Gatha, Shah, and Patel (1954) from the experimental results on the scattering of 340 MeV protons by C and Al (Richardson *et al.* 1952), and their distribution when used as the charge distribution does not give an electron scattering distribu-

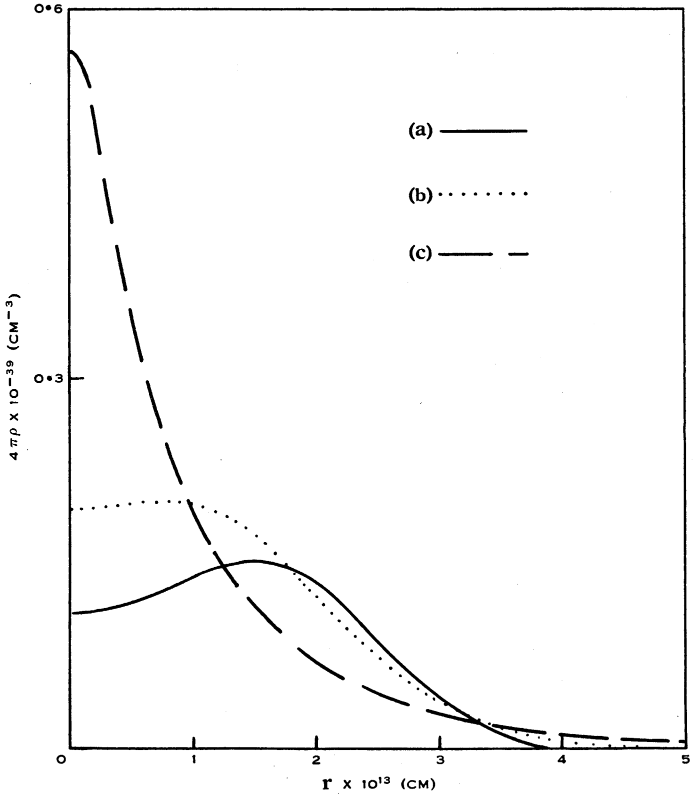

Fig. 2.—Nuclear charge and density distributions for ^{12}C. ρ normalized so that

$$\int \rho \, dV = 1.$$

(*a*) Using spherical box wave functions.
(*b*) Using harmonic oscillator wave functions.
(*c*) Nuclear density distribution of Gatha, Shah, and Patel (1954).

tion agreeing with experiment (Fig. 1) for C (Fregeau and Hofstadter 1955). While it does appear to agree with experiment for Be (Hofstadter, Fechter, and McIntyre 1953 ; Gatha, Patel, and Patel 1954), in this experiment, the elastic scattering was not resolved from the $2\cdot54$ MeV loss scattering, and this fact throws doubt on the agreement.

It is therefore important to examine the assumptions in the calculations of Gatha, Shah, and Patel (1954). They have used a complex potential with the

Born approximation, and this approximation is unsatisfactory for scattering by the imaginary part of the potential (Mohr and Robson 1956), although, when the imaginary potential is small, it provides a reasonable approximation for the dependence of the relative angular distribution of scattering on the shape of the scattering potential. Thus, this method should give the correct shape of the scattering potential.

It has been assumed by Gatha, Shah, and Patel (1954) that the nuclear scattering potential has the same shape as the nuclear density distribution. This assumption is valid only if the effect of the finite range of internucleon forces can be neglected. Williams (1955) has treated the problem of obtaining the nuclear scattering potential from the nucleon distribution with internucleon forces of non-zero range. Using a similar procedure, and taking the internucleon force as a square well of radius α, the nuclear potential will arise from a nucleon distribution $\rho_\alpha(r)$ given by, for small α,

$$\rho_\alpha(r)=\rho_0(r)-(\alpha^2/5r)\rho_0'(r)-(\alpha^2/10)\rho_0''(r), \quad \text{for } r\geqslant\alpha,$$

and

$$\rho_\alpha(0)=\rho_0(0)-(3\alpha^2/10)\rho_0''(0), \quad \ldots\ldots\ldots\ldots \quad (1)$$

assuming $\rho_0'(0)=0$, where $\rho_0(r)$ is the nucleon distribution obtained by assuming internucleon forces of zero range. $\rho_\alpha(r)$ must then be normalized so that

$$\int\rho_\alpha(r)\mathrm{d}V=\int\rho_0(r)\mathrm{d}V.$$

Using the nuclear density distribution of Gatha, Shah, and Patel for $\rho_0(r)$ it was found for small α that ρ_α is more peaked at $r=0$, and of smaller radial extension than ρ_0. For ^{12}C,

$$\rho_0(r=\alpha)=0\cdot34\rho_0(0),$$

assuming a range of internucleon forces of $\alpha=10^{13}$ cm, and we can hardly expect equation (1) to be valid when the nuclear density varies so rapidly in a distance α. Nevertheless we can still expect the above conclusion for small α to apply, and the effect of the range of internucleon forces certainly cannot be neglected.

An attempt was made to fit the experimental electron scattering for ^{12}C by varying the size of Gatha, Shah, and Patel's (1954) distribution, but it is impossible to fit the scattering at all angles because the distribution is too peaked at the origin. Figure 1 shows the scattering for a reduction in size of this distribution of 0·82.

Since by taking the finite range of nuclear forces into account a more peaked nucleon distribution would be derived from the nucleon scattering experiments, there would seem to be some discrepancy in the shape of the nucleon distribution for light nuclei indicated by high energy electron scattering and by high energy nucleon scattering experiments.

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References

Fregeau, J. H., and Hofstadter, R. (1955).—*Phys. Rev.* **99** : 1503.

Gatha, K. M., Patel, N. J., and Patel, P. F. (1954).—*Proc. Phys. Soc. Lond.* A **67** : 1111.

Gatha, K. M., Shah, G. Z., and Patel, N. J. (1954).—*Proc. Phys. Soc. Lond.* A **67** : 773.

Hofstadter, R., Fechter, H. R., and McIntyre, J. A. (1953).—*Phys. Rev.* **92** : 978.

Mohr, C. B. O., and Robson, B. A. (1956).—*Proc. Phys. Soc. Lond.* A **69** : 365.

Richardson, R. E., Ball, W. P., Leith, C. E., and Moyer, B. J. (1952).—*Phys. Rev.* **86** : 29.

Tassie, L. J. (1956).—*Proc. Phys. Soc. Lond.* A **69** : 205.

Williams, R. W. (1955).—*Phys. Rev.* **98** : 1387.