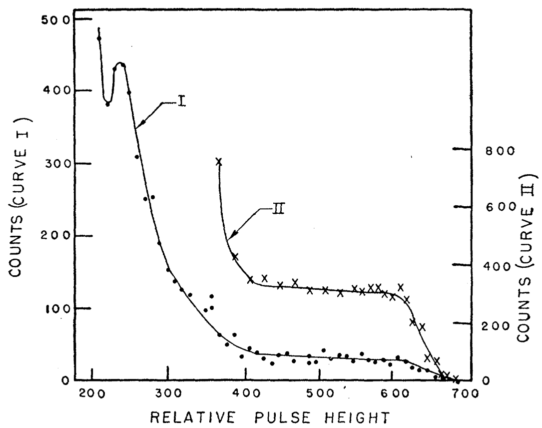

FIG. 1. Scintillation spectrum of the γ radiation from the bombardment of thick B_4C by 10.8-Mev deuterons. For Curve II more deuterons were incident on the target per point, and the discriminator was set to accept a wider range of pulse heights. A relative pulse height of 610 on Curve II was assumed to correspond to $(E_\gamma - 1.02)$ Mev. There is no significance in the apparent pulse-height shift in the two curves. The data were taken at different times and in each case a spectrum of the 4.43-Mev γ ray from C^{12*} was also taken for an energy calibration (see text).

radiation >12.5 Mev. Land Camera pictures of an oscilloscope screen indicated that this was probably the same γ ray as observed with the boron target. Comparison of integral counting rates from the Melmac and B_4C targets, after subtraction of background, gave an intensity ratio of ~ 0.03.

We have also looked for this radiation from a thick beryllium target bombarded by 21.7-Mev α particles. Gamma radiation of the same energy (± 0.5 Mev) and ~ 6 percent of the intensity of that from B_4C was observed. Examination of the original data of McMinn *et al.*[3] indicates that this yield is consistent, within an order of magnitude, with that for $Be^9(\alpha,p)B^{12}$.

Our results do not seem to have any immediate bearing on the isotopic spin assignment for this state in C^{12}. The possible small yield from $N^{14}(d,\alpha)C^{12*}$ can be explained by the approximate nature of the isotopic spin selection rules. On the other hand, it does not seem proper to say that its smallness proves that a $T=1$ state is involved, since there is no reason to expect the uninhibited (d,α) and (d,n) cross sections to be equal. However, we see no reason to doubt the $T=1$ assignment of Cohen *et al.*[1] Assuming this, we can infer that the α width of this level is small. This follows from the requirement of the charge-independence hypothesis that the $Be^9(\alpha,p)$ and $Be^9(\alpha,n)$ cross sections differ only by a factor of two[4] and from the approximate equality of the proton and γ-ray yields from $Be^9+\alpha$. After allowance for error in the yields involved, we conclude that Γ_γ is certainly less than 100 Γ_α and is probably less than 10 Γ_γ. Since 7.8 Mev is available for α emission, a strong selection rule is indicated. For this purpose, we note that as the analog of B^{12} and N^{12}, this C^{12} state might be assumed to have spin $J=1^+$, thus forbidding decay to the 0^+ ground state of Be^8 and requiring d-wave α emission to the 2^+ first excited state. Isotopic spin rules would further inhibit decay to the first excited state.

Another possible origin of the γ ray, in the cascade $C^{12} \rightarrow Be^{8*} + He^4$; $Be^{8*} \rightarrow Be^8 + h\nu$, may be ruled out, since it should have been easily observed in previous work on the $Li^7(d,n)Be^8$ reaction[5] and since a 15-Mev state in Be^8 is not energetically accessible in the bombardment of Be^9 with 21.7-Mev alpha particles.

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Calculations on Charge Independence with Repulsive Core Potentials

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BECAUSE of the current interest in two-body static potentials with repulsive cores,[1] calculations have been carried out to see whether such a potential can explain both the np and pp low energy scattering in the ^1S state, i.e., the experimental values of the scattering lengths $a_s(n-p)$ and $a_s(p-p)$ and the effective ranges $r_{0s}(n-p)$ and $r_{0s}(p-p)$. According to the effective range theory,[2] these four constants may be obtained from the solutions of the wave equation at zero energy for (a) the $n-p$ system and (b) the $p-p$ system. These two problems were coded for FERUT, the digital computer at the University of Toronto, for potentials of the form[3]

$$V = \infty \quad \text{for} \quad r < r_c,$$
$$= -V_0 f(r/r_s) \quad \text{for} \quad r > r_c.$$

The equations were solved by numerical integrations, starting with the asymptotic solutions and integrating inwards until the solutions became zero, thereby determining the core radius r_c. The integrals giving the effective ranges were evaluated using these solutions. In order to improve the accuracy of the solutions, the substitution $y = \ln(r/r_s)$ was made in the differential equations.[4] Because of this substitution, there was a

TABLE I. Charge-independent potentials and corresponding effective ranges. The potential is $V=\infty$, for $r<r_c$, $V=-V_0e^{-r/r_s}/(r/r_s)^2$, for $r>r_c$.

r_s (10^{-13} cm)	r_c (10^{-13} cm)	V_0 (Mev)	$r_{0s}(n-p)$ (10^{-13} cm)	$r_{0s}(p-p)$ (10^{-13} cm)
2.60	0.014	3.50	2.33	2.60
2.70	0.007	3.07	2.35	2.65
2.80	0.000	2.70	2.37	2.70

minimum core radius which the program could handle. The method of integrating inwards has the advantage that only solutions corresponding to the experimental values of the scattering lengths are obtained, since the asymptotic solutions depend only on the scattering lengths. For a given pair V_0, r_s, the criteria for charge independence used were: (a) the same cutoff r_c should be obtained for both $n-p$ and $p-p$ and (b) the effective ranges should satisfy $1.9<r_{0s}(n-p)<2.9$, $2.54<r_{0s}\times(p-p)<2.74$ (units 10^{-13} cm). Runs were done for scattering lengths corresponding to the best experimental value and to the experimental limits in order to determine how closely the two values of r_c had to agree.

The values used for the scattering lengths were $a_s(n-p)=-23.69\pm0.06\times10^{-13}$ cm,[5] $a_s(p-p)=-7.68\pm0.04\times10^{-13}$ cm.[6] Calculations were made for the following attractive wells outside the core: (1) exponential,[7] (2) Yukawa, (3) Gaussian, (4) $f(x)=e^{-x}/x^2$. About 200 pairs of values V_0, r_s were used for each shape. Only e^{-x}/x^2 gave charge independence, and this for very small core radii. Three choices of parameters giving charge independence are given in Table I, together with the corresponding effective ranges.[8] Because of the small core radii involved, extrapolations were necessary, giving possible errors of 2 or 3 in the last digits of the numbers quoted.

We see that charge independence can be obtained with a static potential. Two features of this potential are of significance: (1) it has a strong singularity near the origin ($\sim1/r^2$) and (2) this infinity is cut off by a core of extremely small radius (zero core radius is consistent with charge independence). The potentials derived from pseudoscalar meson theory are even more singular; the Lévy potential,[1] for example, behaves as $1/r^3$ near the origin. Thus, this work seems to indicate that the meson potentials may yield charge independence, and it is planned to try some of these in the near future. We would also be glad to make the code available to check other potentials (with cores) which other workers may obtain.

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[3] The code is actually more general and can handle potentials of the form $Af(r/a)+Bg(r/b)+Ch(r/c)$ with very slight modifications.

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[6] M. C. Yovits *et al.*, Phys. Rev. **85**, 540 (1952). The value of $a_s(p-p)$ was taken from their shape-independent fit; the error was assigned so as to include their results for other shapes.

[7] The $n-p$ equation can be solved explicitly for the exponential potential. This was used as a check on the program. The cutoffs agreed to 6 figures, the effective ranges to 5 figures.

[8] The results of E. M. Hafner *et al.*, Phys. Rev. **89**, 204 (1953), and an estimate of the shape parameters, P, suggest $r_{0s}(n-p)=2.21\pm0.25$ for these potentials.

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Minutes of the 1954 Spring Meeting of the Ohio Section at Ohio University, Athens, Ohio, April 16 and 17, 1954

THE regular spring meeting of the Ohio Section of the American Physical Society was held at Ohio University, Athens, Ohio, on Friday and Saturday, April 16 and 17, 1954. For Friday morning, no formal program was prepared save the showing of recently released educational films and time provided for viewing the exhibits of the High School projects prepared for the Junior Section of the Ohio Academy of Science. Approximately one-third of all the exhibits were related to the field of physics. Eight invited papers were presented having as the main theme the development of physics in the past century in the Northwest Territory. The subject was suggested by the Sesquicentennial of Ohio in 1953 and the present celebration of Ohio University which was the first college organized within the Territory; "Ohio University Celebrates its Sesquicentennial, 1804–1954," by John E. Edwards, Ohio University; "Remarks on the History of Astronomy in Cleveland," J. J. Nassau, Case Institute of Technology; "A New Analysis of the Interferometer Observations of Dayton C. Miller," by R. S. Shankland, S. W. McCuskey, and F. C. Leone, Case Institute of