Letters to the Editor

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Slow Neutron Cross Sections of the Neodymium Isotopes

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THE total cross section, i.e., the sum of the absorption and scattering cross sections for neodymium of normal isotopic distribution is 53×10^{-24} cm^2.[1] If we assume a scattering cross section of 8 barns, the total absorption cross section is 45 barns. The sum of the known activation cross sections is 0.56 barn.[2] Thus one might expect one or more isotopes of large cross section which absorb neutrons to form other stable isotopes of neodymium. In order to locate any such isotope, ten miligrams of neodymium oxide (Hilger Laboratory No. 6783) was submitted to long slow neutron irradiation in a graphite moderated pile. After removal from the pile the sample was allowed to stand for sufficient time to permit most of the induced activities to decay. The isotopic composition of the irradiated sample was then compared with that of normal material. The data obtained is summarized in Table I.

The method of isotopic analysis was as follows. The neodymium oxide was dissolved in 16*N* HNO_3 to produce the nitrate. An aliquot of the solution was then pipetted onto a tungsten ribbon filament and heated in air to form an adherent oxide coat. This filament was then inserted into the source of a 60° direction focussing mass spectrometer. Upon heating, ion currents consisting principally of NdO^+ ions, with very much weaker currents of Nd^+, were detected. Details of the method have been previously published.[3]

For this analysis, normal neodymium and the neutron-irradiated neodymium were introduced alternately into the spectrometer so that an accurate isotopic comparison could be made. The results, tabulated in Table I, are an average of sixty-six individual determinations on two different aliquots of each sample. The comparative values of the cross sections are more reliable than the absolute values. This is due to the fact that with a fixed neutron energy distribution the former depends only on the accuracy of the mass spectrometer measurement, while the latter depends on a knowledge of the integrated flux, or on the absorption cross section for neodymium of normal isotopic composition irradiated under the same neutron flux distribution. The isotopic cross sections given in Table I are computed assuming the flux time obtained from other measurements.[4] Any error in this flux will enter linearly into the cross section and limits given. The cross sections given in brackets are the known activation cross sections.[2]

The data shows that there is one neutron-absorbing isotope in normal neodymium with an isotopic cross section at least six times that of any other isotope. This is the neodymium isotope of mass 143 which by a (n,γ) reaction forms a stable neodymium isotope of mass 144. For the rest of the isotopes it is possible only to assign upper limits to the cross sections. The limits given in the table are tabulated assuming only (n,γ) reactions took place. This is a reasonable assumption since in the graphite of a graphite moderated pile the flux is predominantly slow.

TABLE I. Isotopic composition of neutron-irradiated neodymium.

Mass No.	Percent abundance normal	Percent abundance bombarded	Net change	Isotopic cross section in 10^{-24} cm^2	Contribution to total cross section in 10^{-24} cm^2
142	27.13	27.09	-0.04 ± 0.05	<12	<3.5
143	12.20	11.72	-0.48 ± 0.05	240	29.3
144	23.87	24.35	$+0.48\pm0.05$	<15	<3.5
145	8.30	8.27	-0.03 ± 0.04	<30	<2.5
146	17.18	17.17	-0.01 ± 0.05	<20 (1.5)	<3.5
147	0.005	<0.005	——		
148	5.72	5.77	$+0.05\pm0.04$	<45 (5.5)	<2.5
149	<0.002	<0.002	——		
150	5.60	5.63	$+0.03\pm0.04$	<45	<2.5
151	<0.002	<0.002	——		

[1] C. Muehlhause, Argonne National Lab., private communication.
[2] 1947 Summary of Nuclear Data, Nucleonics **2**, 82 (1948).
[3] Inghram, Hayden, and Hess, Phys. Rev. **72**, 967 (1947).
[4] Hayden, Reynolds, and Inghram, Phys. Rev. **75**, 1500 (1949).

On the Radius of the Elementary Particle

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RECENTLY it was shown[1] that the present theory of quantized fields could be generalized in conformity with the idea of reciprocity proposed by Born[2] to the case, in which field quantities were no longer functions of time and space coordinates alone.[3] The possibility of a theory of such non-localizable fields was illustrated by simple types of scalar neutral zero-mass fields in vacuum. It was further indicated that the theory could be extended to the particle with non-zero rest mass by considering non-localizable fields in five-dimensional space. In this connection, Pais[4] pointed out that the theory of non-localizable fields with non-zero mass could also be formulated in the usual four-dimensional space. In fact, as will be shown in the following paragraphs, the classical rigid sphere model for the electron, which has been believed to be much too classical to be incorporated into quantum theory of fields, can be reproduced as a very simple type of quantized non-localizable fields satisfying postulates of reciprocity.

First we consider a scalar non-localizable field with the mass m satisfying a set of reciprocal commutation relations

$$[x^\mu, p_\nu]=i\hbar\delta_{\mu\nu}, \tag{1}$$
$$[x_\mu[x^\mu, U]]-\lambda^2U=0, \tag{2}$$
$$[p_\mu[p^\mu, U]]+m^2c^2U=0, \tag{3}$$
$$[p_\mu[x^\mu, U]]=0, \tag{4}$$

where x^μ denote contravariant space-time operators with $x'=x$, $x^2=y$, $x^3=z$, $x^4=ct$, and p_μ ($\mu=1, 2, 3, 4$) are covariant space-time displacement operators. For any two operators A and B, we write

$$[A, B]\equiv AB-BA. \tag{5}$$

λ is a constant with the dimension of length, which will be interpreted as the radius of the elementary particle described by the field U.[5]

Now the scalar operator U can be expressed as a matrix $(x_\mu'|U|x_\mu'')$ in the representation in which operators x_μ are diagonal. The matrix element $(x_\mu'|U|x_\mu'')$ can alternatively be regarded as a function $U(X_\mu, r_\mu)$ of $X_\mu=\frac{1}{2}(x_\mu'+x_\mu'')$ and $r_\mu=x_\mu'-x_\mu''$. Then (2), (3), and (4) reduce to

$$(r_\mu r^\mu-\lambda^2)U=0, \tag{2$'$}$$
$$\left(\frac{\partial^2}{\partial X_\mu\partial X^\mu}-\kappa^2\right)U=0, \quad \kappa=mc/\hbar, \tag{3$'$}$$
$$r^\mu(\partial U/\partial X^\mu)=0. \tag{4$'$}$$