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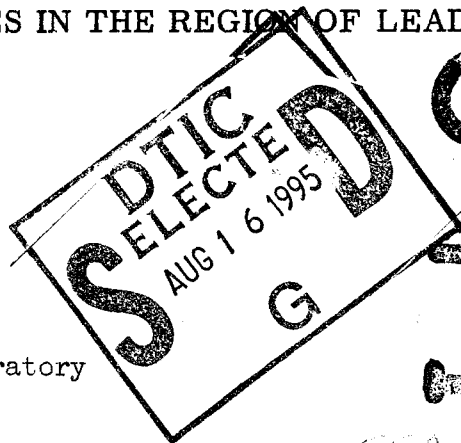
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NEUTRON AND PROTON BINDING ENERGIES IN THE REGION OF LEAD

by

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# NEUTRON AND PROTON BINDING ENERGIES IN THE REGION OF LEAD

By Katharine Way\*

The maxima in  $\alpha$  particle decay energies for mass numbers 210-215 recently emphasized by Perlman, Ghiorso, and Seaborg<sup>1</sup> can be looked at in terms of neutron and proton binding energies and, when thus interpreted, reveal rather sharp discontinuities in these bindings at proton number 82 and neutron number 126. The numbers 82 and 126 are two of the "magic" numbers connected with marked nuclear stability on which attention has been focused by M. G. Mayer.<sup>2</sup> If one considers these "magic" numbers as numbers for which neutron or proton "shells" are closed one would expect unusually high binding energies for the 82nd, 81st, etc., proton and for the 126th, 125th, etc., neutron and unusually small bindings for protons with number slightly greater than 82 and neutrons with number slightly greater than 126. As the new shells fill up, the binding energies should gradually return to "normal."

The binding energy of four neutrons to certain heavy nuclei can be found with a good deal of accuracy from known  $\alpha$  and  $\beta$  decay energies. Thus the binding energy of four neutrons to  $U^{234}$  is equal to  $\{ \text{mass}(U^{234}) + \text{mass}(4 \text{ n's}) - \text{mass}(U^{238}) \}$  or  $\{ \text{mass}(4 \text{ n's}) - \text{mass}(He^4) - E\alpha(U^{238}) - E\beta(UX_1) - E\beta(UX_2) - E_{\text{recoil}} \}$  which equals  $\{ 29.64 - 4.18 - 0.203 - 2.324 - .07 \}$  or 22.9 mev. The binding energy of four neutrons to  $Pb^{208}$  turns out by a similar calculation to be only 17.6 mev using  $E\beta(ThB) = 0.88$  mev,  $E\beta(ThC) = 2.20$  mev, and  $E\alpha(ThC') = 8.78$  mev. The Bohr-Wheeler<sup>5</sup> liquid drop model with the semi-empirical constants given by them gives 22.8 mev for the binding of 4 neutrons to  $U^{234}$  as against 22.9 mev found above. However, for the  $Pb^{208}$  value the Bohr-Wheeler model gives again 22.8 mev in marked disagreement with the 17.6 mev found from decay energies.

Assuming that the individual Bohr-Wheeler values for the binding of a neutron to  $U^{234}$ ,  $U^{235}$ ,  $U^{236}$ , and  $U^{237}$  are correct one can calculate binding energies in the region of Pb from known  $\alpha$  and  $\beta$  decay energies. For instance

$$B_n(A - 4, Z - 2) = B_n(A, Z) + E\alpha_1 - E\alpha_2$$

when  $B_n(A, Z)$  is the binding energy of a neutron to a nucleus with mass A and charge Z and where  $E\alpha_1$  and  $E\alpha_2$  are the disintegration energies associated with the emission of  $\alpha$  particles from the nuclei (A, Z) and

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