DELAYED NEUTRON EMITTERS

If 50 or 82 neutrons form a closed shell, and the 51st and 83rd neutron have less than average binding energy, one would expect especially low binding energies for the last neutron in Kr^{87} and Xe^{137}, which have 51 and 83 neutrons, respectively, and the smallest charge compatible with a stable nucleus with 50 or 82 neutrons, respectively. It so happens that the only two delayed neutron emitters identified are these two nuclei.[5]

The fission products Br^{87} (N = 52) as well as I^{137} (N = 84) have not enough energy to evaporate a neutron, and undergo β decay; in the resultant nuclei, Kr^{87} and Xe^{137}, the binding energy of the last neutron is small enough to allow neutron evaporation.

ABSORPTION CROSS SECTIONS

The neutron absorption cross sections for nuclei containing 50, 82, or 126 neutrons seem all to be unusually low. This is seen very clearly in the measurements of Griffith[6] with Ra γ-Be neutrons, and those by Mescheryakov[7] with neutrons from a (d,d) reaction. These measurements extend from mass number 51 to 209. In general, the cross sections increase with increasing mass number. Griffith investigates, of the nuclei in question, yttrium 89 with 50 neutrons and lanthanum and praseodymium with 82 neutrons. The activation cross section for yttrium is the smallest he observes for any element; it is about 20 to 30 times smaller than the cross sections in that region of mass number. There is a very pronounced dip of cross sections for lanthanum and praseodymium; the cross section of Pr^{141} is about one seventh of the average of this region, and that of La^{139} is still smaller by a factor 3. Mescheryakov investigates, among others, La, Pr, barium^{138}, and bismuth^{209}. He finds a similar dip at La and Pr, and finds that the cross section of Ba^{138} with 82 neutrons is even lower, namely, less than .03 of that of lanthanum. The cross section of bismuth with 126 neutrons is even smaller. The only other unusually small cross section which Griffith finds is that of thallium (122 or 124 neutrons), which is about the same as that for praseodymium.

ASYMMETRIC FISSION

It is somewhat tempting to associate the existence of the closed shells of 50 and 82 neutrons with the dissymmetry of masses encountered in the fission process. U^{235} contains 143 = 82 + 50 + 11 neutrons. It appears that the probable fissions are such that one fragment has at least 82, one other at least 50, neutrons.

THEORETICAL ESTIMATE OF THE DISCONTINUITY IN BINDING ENERGIES

It is possible to make an estimate of the change in neutron binding energy at, for instance, 82 neutrons. There exists the semiempirical formula for the mass of an atom[8] with mass number A and charge Z.

$$M_{A,Z} = A - .00081\,Z - .00611\,A + .014\,A^{2/3} + .083\,(A/2-Z)^2\,A^{-1} - .000627\,Z^2\,A^{-1/3} + \delta$$

$$\text{with } \delta = 0 \text{ for A odd} \qquad (1)$$

$$\delta = -.036\,A^{-3/4} \text{ for A even, Z even}$$

$$\delta = -.036\,A^{-3/4} \text{ for A odd, Z odd}$$