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Previous workers have shown from an analysis of the energetics of alpha and beta decay that the pairing energy of protons is greater than that of neutrons. It is here postulated that this effect is responsible for the absence of odd-proton isomers for $50<Z<82$.

THE strong spin-orbit coupling model[1,2] of the nucleus has been remarkably successful in coordinating a number of features of the behavior of odd-A nuclei, with particular regard to the assignment of the spin and parity of both ground and excited states. It has been pointed out by Scharff-Goldhaber[3] that one of the failures of this "shell-structure" theory in its present form has been the relative scarcity of odd-proton isomers for elements with $50<Z<82$, as compared to the relative abundance of odd-neutron isomers for $50<N<82$. The present form of shell structure theory recognizes little difference between protons and neutrons in the availability or population of levels, except perhaps as proposed by Mayer[1] that Coulomb repulsion, tending to concentrate the charge on the outside of the nucleus, would probably put the last odd proton in a state of higher angular momentum than the last odd neutron.

In order to bring the sequence of energy levels obtained from those of a square well by strong spin-orbit coupling into accord with the observed spins of ground states of odd-A nuclei, Mayer[1] found it necessary to assume that "For a given nucleus the pairing energy of the nucleons in the same orbit is *greater* for orbits with larger j." (Note: the italics are mine. R. K.) This assumption implied, for example, that for an odd A nucleus whose odd-nucleon number lay between 50 and 82, the $h_{11/2}$ state would not be occupied as the ground state of the last odd nucleon.

Depending on the magnitude implied by the word *greater*, the $h_{11/2}$ level might not even be found in the excited states of nuclei of odd-nucleon number between 63 and 82, where the pairing energy might be sufficiently large to cause occupancy of all twelve $h_{11/2}$ levels in the shell. Herein appears to be the difference between odd proton and odd neutron nuclei. The abundance of odd neutron isomers lying between $63<N<82$ described by Goldhaber and Hill[4] owe their isomerism to an excited $h_{11/2}$ state which lies within 0.661 Mev of the ground state in the case of Ba^{137}, and considerably closer for most other isomers. If the pairing energy for protons were greater than the pairing energy for neutrons by $\frac{1}{4}$ to $\frac{1}{2}$ Mev in this region, the $h_{11/2}$ state would be populated by $Z=63$. Odd proton isomerism could then be expected only in a region of odd nucleon number where the $h_{11/2}$ level for odd neutron isomers was energetically quite distant from the ground state, as in the case of ${}_{54}Xe^{135}$ (0.52 Mev) and ${}_{56}Ba^{137}$ (0.66 Mev). Existing data on odd proton nuclei tend to agree with these observations. The only long-lived odd proton isomer presently known has 79 odd protons (${}_{79}Au^{197}$). Recently completed work[5] on ${}_{63}Eu^{153}$ reveals no excited $h_{11/2}$ state.

By analysis of α and β decay energies, Glueckauf[6] has shown that the pairing energy of protons exceeds that of neutrons in heavy nuclei. The mass defects of isobars of odd mass number when plotted against the neutron excess (N-Z) do not lie on a single smooth parabola but on two parabolas, one for odd Z and one for even Z, separated by about 0.2 Mev. This energy is of the right magnitude to explain the rarity of isomerism in odd proton nuclei.[7]

Kohman[8] has called attention to the relationship between this pairing effect and beta lability, and has offered some possible theoretical explanation of the effect. It is from his paper that the title of the present paper is drawn.

The pairing effect described herein, and the low excitation energy in this region of an even-even core discussed by Scharff-Goldhaber[3] both argue against existence of odd proton isomerism. The extent to which responsibility may be assigned to either effect is presently unknown.

[1] M. G. Mayer, Phys. Rev. **78**, 16, 22 (1950).
[2] Haxel, Jensen, and Suess, Phys. Rev. **75**, 1766 (1949).
[3] G. Scharff-Goldhaber, Phys. Rev. **90**, 587 (1953).
[4] M. Goldhaber and R. D. Hill, Revs. Modern Phys. **24**, 179 (1952).
[5] M. R. Lee and R. Katz (to be published).
[6] E. Glueckauf, Proc. Phys. Soc (London) **61**, 25 (1948).
[7] In this connection see also A. E. S. Green and D. F. Edwards, Phys. Rev. **91**, 46 (1953) for proton and neutron pairing energy differences.
[8] T. P. Kohman, Phys. Rev. **85**, 530 (1952).