Deviations from Mayer's Scheme for Filling Nuclear Shells and the Interaction of Levels

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THERE are nuclei which do not fit into Mayer's scheme for the filling of shells [1]. These deviations can be explained by making the following assumptions: between similar nucleons which are in neighboring orbital angular momentum quantum number levels and have the same spin orientation with respect to the orbit-namely that for which the total angular momentum j is the largest possible- there exists a strong interaction, leading to the weakening of the coupling between nucleons in the level with the lower angular momentum. The coupling of a pair of nucleons in this level may become weaker than the coupling of a pair of nucleons in higher levels. This phenomenon may be considered as the extraction of a nucleon from the filled level of lower l and the coupling of it to one of the odd nucleons of the higher level.

Consider the first nucleus which deviates from the scheme, $_{11}Na^{23}$. The particles in this nucleus are in the following states: $1s_{1/2}\ 2p_{3/2}\ 2p_{1/2}\ 3d_{5/2}$. The $2p_{3/2}$ and $3d_{5/2}$ levels satisfy the conditions given above. In the $3d_{5/2}$ level of $_{11}Na^{23}$ there are not less than two particles. They cause a weakening of the coupling between the particles in the $p_{3/2}$ level, resulting in the extraction of a particle from the filled $p_{3/2}$ and the coupling of it to the particles in the $d_{5/2}$ level. The Na nucleus will have the following structure: $1s^{(2)}_{1/2}\ 2p^{(3)}_{3/2}\ 2d^{(2)}_{1/2}\ 3d^{(4)}_{5/2}$. The magnitude of the magnetic moment corroborates the fact that $_{11}Na^{23}$ is in a $p_{3/2}$ state. In shell IV, $_{25}Mn^{55}$ is an exception to the scheme. The following levels enter into the state of the nucleus: $1s_{1/2}\ 2p_{3/2}\ 2p_{1/2}\ 3d_{5/2}\ 3d_{3/2}\ 2s_{1/2}\ 4f_{7/2}$. The $3d_{5/2}$ and $4f_{7/2}$ levels satisfy our conditions. The $4f_{7/2}$ of $_{25}Mn^{55}$ has to be filled by at least two particles; they weaken the coupling between the nucleons in the $3d_{5/2}$ level. As a result, a particle is extracted from the full $3d_{5/2}$ level and is coupled with the particles in the $4f_{7/2}$ level. Thus $_{25}Mn^{55}$ has the following structure:

$$1s^{(2)}_{1/2} 2p^{(4)}_{3/2} 2p^{(2)}_{1/2} 3d^{(5)}_{5/2} 3d^{(4)}_{3/2}\ 2s^{(2)}_{1/2} 4f^{(6)}_{7/2}.$$

The magnitude of the magnetic moment corroborates the $d_{5/2}$ state of Mn^{55}.

The existence of an unfilled $d_{5/2}$ level together with a filled $d_{3/2}$ level is not inconsistent with spin-orbit coupling, which requires that the $d_{3/2}$ level be filled after the $d_{5/2}$ level is completely full. This requirement is fulfilled when there are no particles in the $4f_{7/2}$ level. With the presence of nucleons in the $4f_{7/2}$ level, however, the energy of a particle in the $d_{5/2}$ level becomes greater than in the $d_{3/2}$ level. These considerations carry over to other appropriate levels also. Especially interesting is the manifestation of this level interaction in shell IV. Here our conditions are satisfied by the $4f_{7/2}$ and $5g_{9/2}$ levels. However, the level interaction does not lead to a nucleus with a ground state spin 7/2, but the excited states have isomers with this spin. The existence of spin 7/2 in the excited states of nuclei with number of particles between 39-49 is difficult to explain in the ordinary shell structure theory. In $_{34}Se^{79}$ the state with spin 7/2 is the ground state. In shell V our conditions are satisfied by the $4g_{9/2}$ and $6h_{11/2}$ levels; as spins of 9/2 do not occur here, we conclude that the extraction of particles from the $g_{9/2}$ level does not occur. The appropriate levels of shell VI are the $6g_{11/2}$ and $7i_{13/2}$ levels. There are few nuclei with unknown spins in this region, and investigating them is difficult.

[1] M. I. Korsunskii, Usp. Fiz. Nauk 52, 1 (1954)

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The Fission of Heavy Nuclei by Slow Mesons

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IN this letter, there are briefly described the results of work during 1950-1952 on fission of heavy nuclei as a result of interaction with slow π^- mesons. The results are presented in reports