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VIRTUAL MECHANISMS OF THE NUCLEAR DECAYS AND REACTIONS

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The one-step decay ($A \longrightarrow a_1 + A_1$) of the ground state of the resting parent nucleus A with the formation of real states of nucleus A_1 and particle a_1 is impossible, if the heat Q_1 of this decay, defined as $Q_1 = E_A - E_{A_1} - E_{a_1}$, where E_A, E_{A_1} and E_{a_1} are the internal energies of nuclei A, A_1 and particle a_1 , and connected at the implementation of the energy conservation law with the kinetic energies T_{A_1} and T_{a_1} of nucleus A_1 and particle a_1 as $Q_1 = T_{A_1} + T_{a_1}$ has a negative value. At the same time, the two-step decay of the same nucleus ($A \longrightarrow a_1 + A_1 \longrightarrow a_1 + a_2 + A_2$) described by the Feynman diagram, including at the first step the flight of the real particle A_1 from the nucleus A with the formation of the virtual state of the intermediate nucleus A_1, described by the Green function G_{A_1} of this nucleus whose pole lies in the region of negative values of the kinetic energy T_{A_1} of the nucleus A_1, and at the second step the decay of the nucleus A_1 with the formation of the real particle a_2 and the real daughter nucleus A_2, is possible if the heat Q_2 of the decay of the nucleus A_1 satisfies the condition Q_2 >⊠Q_1⊠, when the total heat Q of the analyzed decay, defined as $Q = Q_1 + Q_2$, is positive. For the first time, the named above virtual mechanism of the two-step decay was successfully used [1] to describe the true double β-decay of an even-even parent nucleus (A, Z) with the formation of a daughter nucleus (A, $Z\pm2$) and flight of two electrons and two electron antineutrinos or of two positrons and two electron neutrinos, when one-step β-decay of nucleus (A, Z) with the formation of an intermediate nucleus (A, $Z\pm1$) is forbidden. This situation was realized because of the influence of Cooper pairing of two protons and two neutrons in the parent nucleus (A, Z), when the heats Q_1 and Q_2 of the single β-decays of the nucleus (A, Z) and the virtual state of the intermediate nucleus-isobar (A, $Z\pm1$) satisfy the conditions $Q_1 < 0$, Q_2 >⊠Q_1⊠and $Q = Q_1 + Q_2 > 0$. In [2], the phenomenon of two-proton radioactivity also caused by the proton pairing effects was predicted for series of neutron-deficient nuclei (A, Z) even in Z. In [3], the presentation about virtual two-step mechanism for the two-proton decay of nuclei was first used unlike to the earlier proposed concept [4] of two-proton decay of the nucleus (A, Z) with the simultaneous flight of the daughter nucleus ($A - 2$, $Z - 2$) and two protons. This allowed to describe the two-proton widths and the energy and angular distributions of two emitted protons in the superfluid model of atomic nucleus in a consistent manner. Finally, it can be shown that the appearance of long-range -particles emitted as third (fourth) particles in the true ternary (quaternary) fission of compound nuclei (A , Z) produced in nuclear reactions with slow neutrons can be described successively with usage the stationary mechanism of named above reactions associated with the appearance of virtual states of intermediate nuclei formed in the two-step (three-step) nuclear decay of compound nuclei (A , Z) in contrast to the nonstationary nonadiabatic mechanism of [5].

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