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Extended Abstract

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T-invariance and mechanisms of the many particle multistep nuclear reactions and fission

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It has been shown that the coefficients of anisotropies caused by the unified mechanism of their appearance in differential cross sections of the initial and time-reversed many particle multistep nuclear reactions are expressed through common scalar (pseudoscalar) functions depending on the momentum and spin vectors of the particles for the initial and final channels of the analyzed reactions.

It has been demonstrated that the T-invariance condition in nuclear systems requires the equality of the investigated coefficients for the initial and time-reversed reactions, when these coefficients transform into each other at the inversion of momentum and spin vectors and the transposition of these vectors in accordance with the reversion of the consecution of reaction stages for the transition from the initial to time-reversed reaction. It has been concluded that the detection of the coefficients of anisotropies for the initial reaction allows to determine the analogous coefficients for the time-reversed reaction without its experimental realization and by usage of the T-invariance condition to select possible mechanisms of these coefficients' appearance. The found T-invariance condition was used to analyze mechanisms of the appearance of the possible asymmetries with various P- and T-parities in cross sections of the binary and ternary fission reaction of oriented target-nuclei by cold polarized neutrons. It has been shown that coefficients of analyzed asymmetries for ternary fission satisfy the T-invariance condition if third particles and fission fragments fly from the compound fissile nuclei non-simultaneously but on the sequential stages of this fission. In contrast to the representations of some articles in which the absence of the T-invariance null-test is declared, for example, it has been found that the T-noninvariant asymmetries, which coefficients vanish for all possible T-invariant mechanisms of their appearance. It has been proposed applying of the similar asymmetries experimental analysis for the detection of characteristics of the T-noninvariant interactions in nuclear systems. T-invariance conditions for the differential cross sections of multiparticle multistep nuclear reactions are found with allowance for spin orientations of particles in the initial channels of such reactions. It is shown that the asymmetry coefficients for different T-parities in the differential cross sections for original and time-reversed reactions are expressed in terms of unified scalar (pseudo scalar) functions that depend of the 3-momenta and spins of particles involved in the initial and final channels of the reactions under analysis. It is also shown that knowledge of the aforementioned functions for the asymmetries under analysis in the original reaction makes it possible to reconstruct the respective functions for the analogous asymmetries in the time-reversed reaction without studying it experimentally. By considering the example of T-even and T-odd asymmetries in reactions where oriented nuclei undergo binary and ternary fission induced by cold polarized neutrons, it is demonstrated that the T-invariance conditions in question can be used to select mechanisms behind the appearance of the above asymmetries—in particular, mechanisms associated with the presence of T-noninvariant interactions.

It is shown that a quantum system whose Hamiltonian is independent of time is T -invariant if this Hamiltonian contains only those terms that do not change sign upon time reversal. It is also shown that the coincidence of the amplitudes for multistep direct and statistical nuclear reactions with the time reversed amplitudes for the reactions being studied is a condition that ensures the T -invariance of the amplitudes in question, the transition from the original amplitudes to their time-reversed counterparts being accomplished, first, upon introducing the inverse-reaction matrices T instead of the original-reaction matrix T and, second, upon replacing the wave functions for the initial, final, and intermediate states of the system by the respective time-reversed functions. It is found that the T -even (T -odd) asymmetries in cross sections for nuclear reactions stem from the interference between the amplitudes characterizing these reactions and having identical (opposite) T -parities. It is shown that the T -invariance condition for the above T -even (T -odd) asymmetries is related to the conservation of (change in) the sign of these asymmetries upon going over from original to inverse nuclear reactions. Mechanisms underlying the appearance of possible T -even and T-odd asymmetries in the cross sections for the cold-polarized neutron- induced binary and ternary fission of oriented target nuclei are analyzed for the case of employing T -invariant Hamiltonians for the systems under study. It is also shown that the asymmetries in question satisfy the T -invariance condition if the reactions being considered have a sequential multistep statistical character. It is concluded that T -invariance is violated in the limiting case where, in ternary nuclear fission, the emission of a light third particle froma fissile compound nucleus formed upon incident-neutron capture by a target nucleus and its separation to two fission fragments are simultaneous events.

Bottom Note: *This work is partly presented at 2nd International Conference on Physics August 28-30, 2017, Brussels, Belgium*