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TUNED ELECTRON-NUCLEUS RESONANCE AS A TOOL OF PRODUCING THE 229Th ISOMER

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Much attention is paid to the problem of creating nuclear optical clocks and, accordingly, the next generation frequency standard. Record samples of atomic clocks demonstrate an error within several units of 10−18, while in order to solve challenging fundamental and applied problems it is necessary to further reduce the errors by another order of magnitude. The development of heavy-ion clocks has good prospects. A further reduction in the error would allow to resolve the long-standing question about the possible drift of the fundamental constants. The most pressing task of modern physics is the search for dark matter and energy. Here the fundamental idea is to detect wave oscillations of particles of ultralight matter in its interaction with ordinary matter. And their use to search for the drift of fundamental constants has irreplaceable features, since the contribution from the nuclear component, compared to the Coulomb component, to the transition frequency is much stronger than in optical ones. Some projects are based on the joint use of atomic and nuclear clocks, using the specified features of the latters.

The number one candidate for the creation of nuclear clocks is the unique nuclide of 229Th, whose excited state 3/2+[631] lies at a height of only 8.355740(3) eV above the ground state 5/2+[633] [7]. The possibility of further refining its energy by means of resonance optical pumping is discussed. Attention is focused on considering the broadening of the resonance in order to reduce scanning time. The two-photon method proposed exploits the radical broadening of the isomer line due to mixing with the electron transition. This is not burdened with the cross-section reduction, in contrast with internal-conversion-based resonance broadening or intended extra-broadening of the spectral line of a pumping laser. In the case under consideration, according to the calculations, it turns out to be two orders of magnitude more efficient. It is applicable to both ionized and neutral thorium atoms. Realization of the method supposes excitation of the both nucleus and electron shell in the final state.

Section

Neutrino physics and nuclear astrophysics

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