Electron-Nuclear Resonance as the Alternative Path to Nuclear Clocks

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The new era of laser-nuclear technologies enters our life. Much attention in current scientific research is paid to the problem of creation of the nuclear clocks and, accordingly, the next-generation frequency standard. The number one candidate for creating a nuclear clock is the unique nuclide ^{229}Th, whose excited state $3/2^{+}[631]$ lies only 8.355740(3) eV above the ground state $5/2^{+}[633]$. And the year of 2024 will go down in the history of physics and metrology as the year of nuclear clocks. It was marked by a fountain of publications on the successful excitation of the ^{229}Th nucleus by a laser through the joint efforts of physicists from LMU Munich, PTB, JILA, UCLA, and others. Record-breaking samples of atomic clocks demonstrate a relative error within several units of 10^{-18}, while to solve complex fundamental and applied problems, an additional reduction in errors by another order of magnitude is necessary. A further reduction in error would resolve the long-standing issue of the possible drift of fundamental constants. The most pressing problem of modern physics is the search for dark matter and energy.

We discuss the possibility of radical enhancement of the laser-nucleus interaction using resonance with the electron shell. This allows one to realize manipulations with nuclei similar to how they are usually implemented with atoms. Resonance width plays a key role in this matter. Metrology is based on two pillars: accuracy and stability (Allan deviation). Resonance with the electron shell increases its width, which would seem to reduce accuracy. On the other hand, the isomer lifetime and, consequently, the interrogation time are reduced, which positively impacts both the accuracy and stability of the nuclear clocks.