Towards a Nuclear Clock with ^{229}Th

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Incredibly precise nuclear clocks may soon outperform and replace the present atomic clocks that define the global time standard. The only known nuclear transition in the range of vacuum-ultraviolet (VUV) lasers occurs in ^{229}Th and promises such a novel and unprecedently precise nuclear clock. The nuclear excited level is a metastable state with an energy of 8.19(12) eV, allowing driving with VUV lasers. As a high-precision oscillator whose frequency is predominantly determined by the strong interaction, the ^{229}Th transition also offers an increased precision for the determination of fundamental constant variations.

The talk will follow the newest theoretical developments on employing electronic bridge processes for the driving or quenching of the nuclear clock transition. The electronic bridge is one of the mechanism coupling the nuclear isomeric transition to the electronic shell. First, we will discuss the prospects of the electronic bridge in highly charged ^{229}Th ions. This process can be used to populate the Th isomer in highly charged ions produced in an electron beam ion trap using a tunable UV laser. With the absorbed laser photon energy directly related to the isomer energy, this mechanism promises the determination of the latter with improved accuracy of 10^{-4} eV and is feasible under presently available experimental parameters [1]. Second, an alternative electronic bridge process in crystals will be introduced. In VUV-transparent crystals, this process is facilitated by defects, *i.e.*, states appearing in the bandgap close to the isomeric energy and caused by the Th doping itself. Excitation rates far above direct photoexcitation can be achieved with current technology [2]. The impact of using the electronic bridge to quench the isomeric state for the accuracy of a future nuclear clock is discussed.

References

[1] P V. Bilous, H Bekker, J C Berengut, *et al.*, Phys. Rev. Lett. **124**, 192502 (2020)

[2] B S Nickerson, M Pimon, P V Bilous, *et al.*, Phys. Rev. Lett. **125**, 032501 (2020)