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X-ray FEL lays the groundwork for Scandium-45 nuclear clock

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Precise timekeeping is indispensable in everyday life, science, and technology. It relies on reference oscillators with stable frequencies. Atomic clocks – the most precise time-measurement devices at present – use spectrally very narrow resonant transitions between electronic states in atoms as their reference oscillators. With the advent of hard x-ray FELs, the use of extremely narrow resonant transitions in atomic nuclei as reference oscillators for ultra-high-precision clocks is now within reach. Nuclear oscillators are naturally more stable and more resilient to external perturbations than their atomic counterparts. Resonant excitation of a ultra-narrow transition in Scandium-45 nuclear isomer with hard x-rays became recently possible [1] due to the high spectral photon flux delivered by the European XFEL in self-seeded high-repetition-rate mode. In this talk, the results of this experiment will be presented along with discussion of further developments of hard X-ray FELs required for ultra-high precision nuclear clocks.

[1] Shvyd'ko, Yu. et al. *Resonant x-ray excitation of the nuclear clock isomer* ⁴⁵Sc. Nature **622** (2023) 471.

Footnotes

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