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Resonant X-ray excitation of the nuclear clock isomer Scandium-45

Using the high spectral flux and timing properties of the European X-ray Free-Electron Laser, we succeeded to excite the sharpest atomic transition in the hard X-ray range, the 12.4 keV nuclear resonance of the stable isotope Scandium-45 [1].

With its extremely narrow natural linewidth of 1.4 femto-eV, it opens not only new possibilities for the development of a nuclear clock, but also for research linked to the foundations of physics, such as time variations of the fundamental constants, the search for dark matter as well as probing the foundations of relativity theory.

Furthermore, our experiment demonstrates the great potential of self-seeding X-ray lasers with high pulse rates as a promising platform for the spectroscopy of extremely narrow-band nuclear resonances.

The next steps towards a nuclear clock based on Scandium-45 require a further increase of the spectral photon flux using improved X-ray laser sources at 12.4 keV and the development of frequency combs reaching up to this energy.

[1] Yuri Shvyd'ko, R. Röhlsberger, O. Kocharovskaya, J. Evers et al., Nature 622, 471 (2023)

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