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Laser spectroscopy of thorium-229 nuclei in solids

固体中のトリウム229原子核のレーザー分光

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^{229}Th possesses an exceptionally low-lying nuclear excited state with an energy of 8.36 eV, corresponding to a wavelength of 148 nm in the vacuum ultraviolet region. In this wavelength range, narrow-linewidth lasers can be employed, making the system a promising candidate for a frequency standard based on nuclear transitions, often referred to as a nuclear clock. While atomic clocks operate with atoms trapped in a vacuum chamber, nuclear transitions are much less sensitive to the surrounding environment and a solid-state nuclear clock is also feasible, since the linewidth broadening of the nuclear transition remains small even in a solid. Furthermore, similar to Mössbauer spectroscopy, measuring the level splitting induced by interactions between the nucleus and surrounding atoms can provide insight into the local atomic configuration around ^{229}Th.

Research on ^{229}Th has progressed rapidly in recent years. In 2024, the first laser excitation of ^{229}Th nuclei in a solid-state target was achieved, marking a major milestone that has accelerated global competition toward the realization of nuclear clocks. In this presentation, I will review recent advances in nuclear clock research and introduce experiments performed in our group using ^{229}Th-doped CaF_2 crystals.

Pre-registration