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Solid-State 229Th Laser Based on the Optonuclear Quadrupolar Effect (25+5)

The radiative excitation of the 8.3 eV isomeric state of 229Th is an outstanding challenge due to the lack of tunable far-ultraviolet sources. In this talk, I will first introduce an optonuclear quadrupolar (ONQ) effect, which facilitates efficient interactions between optical photons and nuclear degrees of freedom. Using the ONQ control over nuclear spins, we suggest several promising applications ranging from materials spectroscopy to quantum memory and quantum transduction. Leveraging the ONQ coupling to nuclear orbital excitations, we propose an efficient two-photon pumping scheme for the 229Th isomeric state, which only requires a 300 nm UV-B pumping laser. We further demonstrate that population inversion between the nuclear isomeric and ground states can be achieved at room temperature using a two-step pumping process. The nuclear laser, which has been pursued for decades, may be realized using a Watt-level UV-B pumping laser and ultrawide bandgap thorium compounds (e.g., ThF4, Na2ThF6, or K2ThF6) as the gain medium.

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