Isomeric Excitation of Thorium-229 in a Strong Femtosecond Laser Pulse

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^{229}Th has a peculiar nucleus with an isomeric state of energy around 8 eV, which is the lowest known nuclear excited state. It has received much attention in recent years due to its potential application as a "nuclear optical clock". It also provides an interesting platform on which nuclear physics interplays with atomic physics.

One of the current research focuses is to find efficient methods to actively excite the ^{229}Th nucleus from the ground state to the isomeric state. In this presentation I will explain how a strong femtosecond laser pulse (with intensity around 10^{14} W/cm^2) can be used for the isomeric excitation. I will first explain the isomeric-excitation process using a semiclassical model based on the recollision picture [1,2], then I will present a quantum mechanical theory for a more complete description [3]. Numerical results show that the isomeric excitation probability is on the order of 10^{-11} per nucleus per femtosecond laser pulse.

Our method is a natural combination of strong-field atomic physics and ^{229}Th nuclear physics. Besides the efficiency, our method has the following advantages:

(1) Precise knowledge of the isomeric energy is not needed, because the laser-driven electronic transitions have relatively broad energy distributions covering the isomeric energy.

(2) Only table-top femtosecond laser systems are needed which are widely accessible.

(3) The excitation is well timed and only happens within the short laser pulse, which may be important for future coherent operations of the excitation process.

References

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