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## Nuclear Hyperfine Mixing and Laser-Nuclear Physics

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An inner electron can generate a strong electromagnetic field at the nucleus, leading to the mixing of nuclear levels—a phenomenon known as nuclear hyperfine mixing (NHM). This effect can significantly alter nuclear properties, particularly the lifetimes of nuclear excited states. For instance, the lifetime of the  $^{229}\text{Th}$  isomer is reduced by five orders of magnitude, from  $10^3$  seconds to  $10^{-2}$  seconds, due to NHM [1]. Our recent findings reveal a novel NHM mechanism in the  $^{205}\text{Pb}$  isomer, where its lifetime is shortened by four orders of magnitude, from 15 minutes to 32 milliseconds [2].

The NHM effect greatly enhances the coupling between the nucleus and the electromagnetic field, resulting in the observed reductions in lifetime. This enhancement also extends to interactions with external laser fields. Under currently achievable intense laser fields, NHM can induce highly nonlinear responses in the  $^{229}\text{Th}$  nucleus, enabling very efficient nuclear isomeric excitation and nuclear high harmonic generation [3].

[1] V. M. Shabaev et al., Phys. Rev. Lett. 128, 043001 (2022).

[2] W. Wang and X. Wang, Phys. Rev. Lett. 133, 032501 (2024).

[3] H. Zhang, T. Li, and X. Wang, under review.

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