Transient Nuclear Inversion by X-Ray Free Electron Laser in a Tapered X-Ray Waveguide

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The enhancement of X-ray-matter interaction by guiding and focusing radiation from X-ray free electron lasers is investigated theoretically [1,2]. We show that elliptical waveguides using a cladding material with high atomic number such as platinum can maintain an X-ray intensity up to three orders of magnitude larger than in free space. This feature can be used to place a nuclear sample in the waveguide focal area and drive nuclear Mössbauer transitions up to transient nuclear population inversion. The latter is a long-standing goal related to gamma-ray lasers or nuclear state population control for energy storage.

We show that inverted nuclei numbers of up to approximately 2×10^5 are achievable in the realistic region of longitudinal X-ray-free-electron-laser coherence time ≤ 10 fs.

Our results anticipate the important role of tapered X-ray waveguides and strategically embedded samples in the field of X-ray quantum optics.

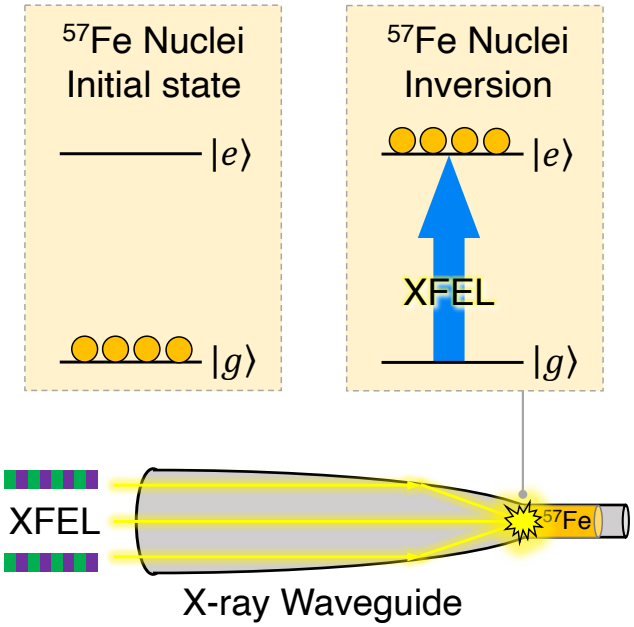

Figure 1: A nuclear sample is placed at the tapered waveguide focal point. A X-ray-free-electron laser pulse is focused and produces transient nuclear population inversion when propagating in the waveguide

References

[1] Y-H Chen, P-H Lin, G-Y Wang, A Pálffy and W-T Liao, Phys. Rev. Research (2022), in print

[2] Y-H Chen, P-H Lin, G-Y Wang, A Pálffy and W-T Liao. arXiv:2104.09624 (2021)