

# De-excitation dynamics of a nuclear ensemble after strong impulsive excitation

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Mössbauer nuclei are an extreme platform for quantum optics because of their narrow transitions in the x-ray regime. These narrow transitions feature long lifetimes, but on the other hand also allowed to only study single excitations for decades. This has recently changed with first experiments at X-ray free electron lasers, where now multiple photon excitations and the subsequent dynamics [1] [2] as well as nuclear clock transitions [3] [4] can be studied.

This technological progress immediately raises the question whether there are new effects expected depending on the number of resonant photons. Yet, a theoretical modeling of the decay dynamics of the interacting nuclear ensemble is still an open challenge. Therefore, we derived a toolbox which is capable of efficiently modeling large nuclear ensembles for arbitrary degrees of excitation, with which we can study new effects in the de-excitation dynamics as well as finite size effects [5].

Here, I will comment briefly on our experimental advances and and discuss the findings of our theoretical simulations.

## References

- [1] M. Gerharz et al., arXiv:2509.15833 (2025)
- [2] A. Chumakov et al., *Nature Physics* **14** 261-264 (2018)
- [3] Y. Shvyd'ko et al., *Nature* **622** 471-475 (2023)
- [4] P. Liu, M. Gerharz et al., arXiv:2508.17538 (2025)
- [5] M. Gerharz, J. Evers, arXiv:2510.00970 (2025)

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