From Multiexcitation to Superradiant Burst in Resonant Nuclear X-Ray Emission

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The advent of X-ray free-electron lasers (XFELs) has opened the door to exploring X-ray–nuclei interactions in the multiexcitation regime [1-3]. In this talk, I will discuss how the emission properties of X-ray photons from an ensemble of identical resonant nuclei depend on the number of excitations, based on theoretical methods we have developed [4]. We find that, under multiexcitation conditions, the detection of emitted X-ray quanta becomes emission-order selective, with a clear dependence on the excitation number.

Building on this framework, I will present our theoretical results on nonlinear collective emission in the strongly excited regime, where superradiant bursts of X-ray photons emerge from resonant nuclear ensembles [5]. We establish the excitation conditions required for observing such bursts with current XFEL capabilities and analyze their dynamical behavior. In particular, we identify nonlinear relationships between the peak emission intensity, the time required to reach the peak, and the excitation number. We further introduce a dimensionless parameter that quantitatively characterizes the onset and strength of the burst behavior for different excitation configurations.

References

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