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Effects of non-linear excitation on the propagation of light

With the increasing number of nuclear-resonant photons per pulse at x-ray free electron lasers (XFELs), achieving higher excitation levels experimentally becomes feasible. This development makes it particularly compelling to investigate light propagation and dynamics beyond the low-excitation regime (LER) and around population inversion. Thus, in my thesis, we examined the time response of resonant nuclear scattering of x-rays beyond the LER. In the LER, it is possible to obtain an analytical solution for light propagation, which becomes not possible beyond this regime. To study dynamics beyond the LER, we employ numerical methods to analyze propagation effects and nuclear dynamics. We implement the method of lines (MOL) to solve the Maxwell-Bloch equations.

In this talk, I would like to present the results of my thesis. Here we discovered interesting phenomena, such as time shifts in the minima of the observed coherently scattered light intensity and transitions around population inversions. We proposed an experimental signature to detect nonlinear excitations by calculating the relative time shifts as a function of target thickness. Finally, we analyze our model in the non-decaying limit ($\gamma = 0$) and find good agreement with the results from Burnham and Chiao [BC69], concluding that spontaneous decay plays a major role in the creation of transitions around population inversions.

[BC69] BURNHAM, DAVID C. and CHIAO, RAYMOND Y., “Coherent Resonance Fluorescence Excited by Short Light Pulses”. In: physical review 188.2 (1969)

Field of study

Quantum Physics

Supervisor

Jörg Evers

Primary author: ADIGÜZEL, Deniz

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