X-ray quantum optics

Dr. Jörg Evers

Max-Planck-Institut für Kernphysik, Heidelberg

Ideas from quantum optics based on coherence and interference have proven extremely successful for the study and manipulation of atoms and molecules. Recent improvements in existing synchrotron light sources and upcoming novel coherent x-ray light sources prompt the question, whether such techniques could also be applied in the hard x-ray regime, for new applications, and to fully exploit the potential of these new machines. In this talk, I will review our recent theoretical and experimental progress in the development of quantum optics with hard x-rays, focusing on large ensembles of nuclei embedded in a thin film cavity probed with x-rays in grazing incidence. After a brief introduction to our theoretical model [1], I will discuss the engineering of advanced nuclear multi-level schemes in experimentally relevant settings. As first exaxmple, I will show how the interaction with vacuum can be exploited to generate coherences between different nuclear states, which opens new perspectives for quantum control and quantum state engineering in an essentially decoherence-free setting [2]. As second example, I will discuss control of nuclear line shapes and optical response exploiting a recently established time-domain analysis [3]. I will present an implementation of this framework in the hard x-ray regime, and discuss applications in precision metrology on neV energy and sub-nm distance scales.

[1] K. P. Heeg and J. Evers, arXiv:1305.4239 [quant-ph]

[2] K. P. Heeg et al., Phys. Rev. Lett. 111, 073601 (2013)

[3] C. Ott et al., Science 340, 716 (2013)