Inverse Design Approach to X-Ray Cavity Quantum Optics with Mössbauer Nuclei

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Nanometer-sized thin-film cavities containing ensembles of Mössbauer nuclei have been demonstrated to be a rich platform for X-ray quantum optics [1]. At low excitation, these systems can be described by effective few-level schemes, thereby providing tunable artificial quantum systems at hard X-ray energies. With the recent advent of an ab-initio theory [2,3], a numerically efficient description of these systems is now possible. On this basis, we introduce the inverse design and develop a comprehensive optimization which allows one to determine optimum cavity systems realizing few-level schemes with desired properties [4,5]. Using this approach, we characterize the accessible parameter spaces of artificial two- and three-level systems and determine optimum cavity designs for several applications. Further, we discover a number of qualitative insights into X-ray photonic environments for nuclei that will likely impact the design of future X-ray cavities and thereby improve their performance.

References

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