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Light in Periodic Structures: Crystallization of Optoelectronic Perovskites & Eigenmodes of Optical Metamaterials

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Periodic on the atomic scale, perovskites are a group of crystalline materials which are particularly promising as a photo-active material in solar cells. Commonly processed from a solution, there exist several fabrication methods to produce perovskite thin films and the techniques used for lab-scale prototypes vary significantly from candidate methods for industry-scale perovskite solar cell production. A central characteristic that has to be optimized in the fabrication is the crystalline morphology of the perovskite active layer. Original experimental results and analysis on the nucleation and crystallization mechanisms in organic-inorganic metal halide perovskites are presented in this thesis. The parameter space for seeding the nucleation is investigated and perovskite films with a predetermined patterned morphology are obtained. An *in-situ* experiment gives insight into the film formation in annealing conditions resembling those in many candidate fabrication methods for industry-scale production.

Periodic on the sub-wavelength scale of visible light, optical metamaterials are structured composite materials, commonly composed of a (noble) metal, such as gold or silver, and a dielectric, such as air or a common polymer. The periodically repeating elements are called meta-atoms and their periodic assembly, in analogy to the role of atoms in a periodic crystal, results in effects that are not merely due to the sum of its constituents. These metamaterials can exhibit properties upon the interaction with visible light that are not found in natural occurring media. In the second part of this thesis, a new theoretical method to characterize the optical properties of such metamaterials is presented. A structure consisting of aligned silver cylinders, a nanowire array inspired by experimental samples, serves as a proof of concept and a computational implementation of the theoretical method is used to show and discuss the electromagnetic states in a semi-infinite slab of the nanowire medium.

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