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Nanostructured Optical Materials: From Biological Photonic Structures to Block Copolymer-based Plasmonic Materials

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The production mechanisms of colors, the main characteristic of the visual appearance, are a great example of nature's biodiversity. Colors can arise from pigments or nanostructures that interact with the incoming light and reflect a specific color. The latter are called structural colors, their nanostructure dimensions and its morphology will determine the reflected color. A large variety of structures are found in the scales of insects. The first part of the thesis will investigate the physics of structural colors in the moth *Micropterix aureatella* and the beetle *Hoplia argentea*. Their visual appearance is spectrally characterized and associated to their nanostructure. *M. aureatella* carries one of the simplest conceivable structures to reflect colors. A simple thin film is responsible for the gold-, bronze- and purple-colored scales that constitute the wing pattern. On the other hand, *H. argentea* exhibits a more complex nanostructure consisting of a multilayered photonic crystal supporting hair-like filaments. This results in a dull green coloration with the potential function to hide within plant leaves.

Materials can also be engineered to achieve optical properties that are not found in nature. So-called optical metamaterials generally consist of a metallic subwavelength structure, where their color depends on their nanostructured morphology. The second part of this thesis investigates the plasmonic properties of block copolymer-based metamaterials. Block copolymers have the advantage of self-assembling into nanostructures with a periodicity below 100 nm, size scales that are difficult to achieve cost-effectively with standard lithographic methods. These block copolymers are used as templates for the fabrication of metallic replica creating optical metamaterials having different morphologies: i) Aligned metallic nano-cylinders result in a strongly anisotropic optical response. ii) The gyroid morphology is chiral and displays a previously not observed circular dichroism depending on the handedness of the nanostructure. For both morphologies, tuning of the optical response via liquid infiltration is demonstrated. In addition, the transmission properties of a gyroid metamaterial were characterized by a complex Jones matrix, an established algebraic formalism, based on the symmetry properties of the gyroid. Finally, some hints toward the influence of the gyroid orientation on the optical response are given in an extended outlook part.

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