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Titre et résumé de la thèse – Title and abstract of the thesis

Light-matter interactions of biophotonic nanostructures and 3D optical metamaterials

Colour dominates human life, be it as a visual cue or a means to enable art. The colour production mechanisms vary on a fundamental level and usually arise from the interaction of light with (i) molecules through selective absorption or (ii) with nanostructured materials. Depending on the wavelength of structural order and the local morphology, the latter will result in so-called structural colours.

Structural colours are discussed in the first part of this habilitation thesis. Light manipulation is not limited to human technologies and is probably most eminent in the biological world, where colour-related signals are employed as a source of information and are often vital to the survival of an animal. Natural selection has favoured a vast array of mechanisms that are optimised for the control of light and can be found in the integuments and eyes of beetles, plants, butteries, and birds. The work presented in this habilitation unravels the light-matter interaction across a range of biophotonic structures, from moths to butterflies and beetles, and highlight novel optics of thin films doped with pigments to the optics of more complex 3D photonic crystals with order and disorder.

The second part of this habilitation thesis focusses on engineered optical metamaterials with optical properties that are not found in nature. These materials generally consist of a metallic sub-wavelength structure and the resulting colour depends on their nanostructured morphology alone. These materials were fabricated from thin film block copolymer templates with a periodicity below 100 nm – a length scale that is difficult to achieve cost-effectively with other lithographic structuring methods. By using block copolymers with an alternating gyroid morphology, these 3D chiral materials show novel optical properties such as linear and circular dichroism. It is further demonstrated that the optical response of these metal networks can be further tuned by liquid infiltration.

Titre et résumé de la leçon d'essai – Title and abstract of the inaugural lecture

Röntgenstreumethoden zur Nanostrukturcharakterisierung

Nanostrukturen findet man in anorganischer und organischer Materie in weiten Bereichen der Naturwissenschaften von amorphen und kristallinen Festkörpern zu Insektenoberflächen und Polymerblends. Es existieren viele Methoden um diese Strukturen direkt oder indirekt zu charakterisieren.

Von besonderer historischer und technologischer Bedeutung zur Nanostrukturaufklärung sind Röntgenstreumethoden, welche in dieser Vorlesung eingeführt werden sollen. Hierzu wird die Streuung von elektromagnetischen Wellen an Atomen vorgestellt um hierüber den Streuvektor zu definieren, einer fundamental wichtigen Grösse für alle Röntgenstreumethoden.

Anschliessend werden typische experimentelle Aufbauten für Klein- und Weitwinkelexperimente erklärt, welche die Messung verschiedener charakteristischer Strukturlängen erlauben. An einem Fallbeispiel eines teilkristallinen Polymersystems werden die Röntgenstreumethoden konkret vorgestellt und ihr Nutzen zur Analyse von Nanostrukturen demonstriert.