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Metasurfaces to Control Multiple Aspects of Visual Appearance

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Abstract: Metasurfaces have flourished over the last few years thanks to their extraordinary capabilities to manipulate light. In fact, the rich color tuning possibilities offered by metasurfaces have been largely confirmed. In this work, we go beyond purely chromatic properties of metasurfaces and focus on their complete visual appearance. We theoretically model and experimentally demonstrate unusual and novel visual effects by exploiting the large number of degrees of freedom available.

Materials with highly customizable optical properties and targeted functionalities is a well established ambition in the optics community [1,2]. Notably, light manipulation by means of micro- and nanostructured metasurfaces [3] has found fertile ground in the control and generation of visual features [4]. Main control knobs include plasmonic [5], Mie [6] and Fabry-Pérot resonances [7]. Curiously, most of the attention has gone to overall chromatic properties and many important aspects that determine the integral visual appearance of a surface have been mostly ignored.

Our work here goes a step further, taking the metasurfaces design toolbox to the next level. In the first part, we will explore some atypical visual appearances exhibited by disordered metasurfaces and show how the size, spatial arrangement, and density of the scatterers and substrate configuration define the scattering response of a metasurface. Specifically, we fabricated dielectric and plasmonic metasurfaces composed of silicon or silver nanoparticles with different degrees of disorder on single- and multi-layered substrates [8,9].

We experimentally demonstrate the resulting unusual visual effects and provide important hints to the capabilities of metasurfaces to shape reflected light spectrally and angularly. Most importantly, we will highlight the main physical mechanisms involved and discuss the origin of the different resonances and their impact on the scattering properties of individual particles and metasurfaces. The study is completed by a powerful modelling platform [8] combining resonant and multiple light scattering and transport at the nano-, meso- and macroscale, capable of revealing the visual appearances of macroscopic objects covered by disordered metasurfaces in realistic conditions.

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