Rigorous modeling of the scattering properties of complex nanostructured surfaces

One-year (possibly two-years) post-doc position in the "[Light in Complex Nanostructures]" group at LP2N

Disordered ensembles of electromagnetic nanoresonators arranged on layered substrates – or "disordered metasurfaces" (Fig. 1) – are attracting growing attention since the past few years owing to their potential to exhibit a wide range of exotic optical properties, such as efficient scattering with controlled directivity and polarization and/or spectrally sharp resonant features, which could result in new optical technologies. This richness of optical features is due to the properties of the individual nanoresonators, their interaction with metallo-dielectric interfaces, and their mutual interaction via free-space and guided modes.

A key quantity to describe scattering by surfaces is the so-called **Bidirectional Scattering Distribution Function** (BSDF), which describes the spectral and angular response in reflection and transmission (including specular and diffuse components) of a macroscopic surface. Few theoretical models, often limited to small (non-resonant) particles, exist to date but generally lack validation by experiments or quantitative numerical predictions. Numerical predictions of the optical properties of such complex, multi-scale nanostructures are generally obtained by simulating either periodic arrays of nanoresonators (typically with FEM or FDTD) or small disordered ensembles of nanoresonators (typically with the T-matrix method). Both strategies are however not realistic.

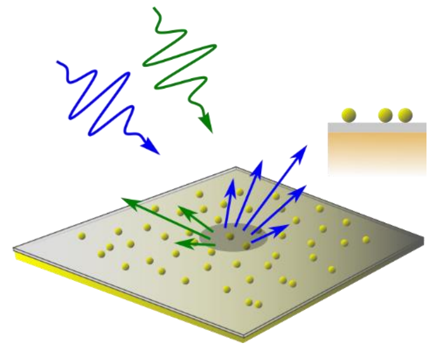

Figure 1. *Complex nanostructured surface, consisting of a disordered ensemble of nanoparticles deposited on a thin-film optical stack.*

The post-doctoral project proposed here aims to develop a **general method** based on an advanced numerical tool presently under development in our group [1,2] that will allow the **first quantitative predictions of the BSDF of *macroscopic* complex nanostructured surfaces** composed of arbitrary (e.g., non-spherical) strongly resonating nano-objects arranged in a disordered manner on a layered substrate.

The proposed work is a key element of a long-term project initiated several years ago at LP2N which aims to use complex nanostructured surfaces to **generate visual effects** in reflection and transmission **that are unattainable with other approaches** relying on pigments, layered nanostructures (e.g., thin-film stacks) or periodic photonic crystals and metasurfaces. Thanks to a collaboration with experimental teams, we hope to demonstrate the first "metasurfaces" producing exotic visual effects in the coming year. The post-doctoral fellow will hence work in the frame of a potentially fruitful collaboration and have the opportunity to exchange with experts in nanofabrication and optical characterization.

The postdoc will need to have a **solid background in optics and electromagnetism**, with a **strong interest in computational methods**. As a return, he/she will receive advanced knowledge in a field that is of strong interest to many academics and companies.

To apply, please send your CV, motivation letter and recommendation letters to Philippe Lalanne (philippe.lalanne@institutoptique.fr) and Kevin Vynck (kevin.vynck@institutoptique.fr).

Expected starting date: October 2019 – January 2020

[1] A. Jouanin *et al.*, Advanced Functional Materials **26**, 6215 (2016).
https://onlinelibrary.wiley.com/doi/abs/10.1002/adfm.201600730
[2] M. Bertrand *et al.*, to be soon posted on ArXiv.

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Philippe Lalanne is a CNRS Research Director and is an *international expert in nanoscale electrodynamics*. With his colleagues, he has launched new and powerful tools and models in computational electrodynamics, which helped providing deep insight into the physical mechanisms involved in key nanoscale optical phenomena and devices, and designing and demonstrated novel nanostructures with record or completely novel performance in their time. To date, he has co-authored about 190 publications in peer-reviewed journals and filed 10 patents. He was the supervisor of 17 PhD candidates and has co-supervised 6 PhD candidates. He is currently working on computational electrodynamics, optical nanoresonators, and complex optical nanostructures and various topics in nanophotonics.

Kevin Vynck is a CNRS Research Scientist and is *specialized in the theoretical and numerical modelling of wave transport and scattering in complex media*, including periodic structures (photonic crystals, metamaterials) and disordered media (disordered photonic structures, media with fractal heterogeneity, ...). He has co-authored 36 papers in peer-reviewed journals, 1 book chapter and 3 patents. In 2019, he was awarded the CNRS Bronze Medal. He is currently working on coherent wave phenomena in complex ensembles of resonant nanoparticles.