

PhD Position: Modeling and Design of Holey Metasurfaces

Context. *Holey metasurfaces* are realized with holes drilled or slots etched in metallic plates, and can support the propagation of spoof plasmons, waves resembling to plasmons [1] but propagating without a lossy substrate. Their interest is due to their simple realization, possible conformability, easy modulation of the periodic textures, and for the absence of dielectric losses. It was recently shown that the use of higher symmetries in each unit cell is an effective tool to increase the periodic load of each lattice element, and maximize the range of variation of the obtained effective electromagnetic parameters. To this aim, *higher-symmetries metasurfaces* (HSM) [2][3] are defined by unit-cell elements exhibiting *additional internal symmetries* beyond the periodic symmetry of the device. Fig. 1a shows an example of glide-symmetric structure, a particular case of higher symmetry. This structure is not only periodic, but each cell is also invariant after a translation of half a period and a mirror reflection. Fig. 1b shows a screw-symmetric surface, whose unit cell is invariant after a translation and a rotation, and another glide-symmetric structure, providing anisotropy due to the presence of skewed cylinders. These additional symmetries also provide marvelous properties of the waves propagating across HSM. A stable equivalent refractive index over an ultra wide band (UWB) was achieved in a parallel-plate waveguide whose plates were glide-symmetric holey metasurfaces, and where radiation occurs at the end of the waveguide (Fig. 1c). These structures open a unique opportunity for **UWB dielectric-less** metasurfaces which can be used to produce flat lens antennas (e.g., Luneburg lenses) with **1D scanning capabilities**.

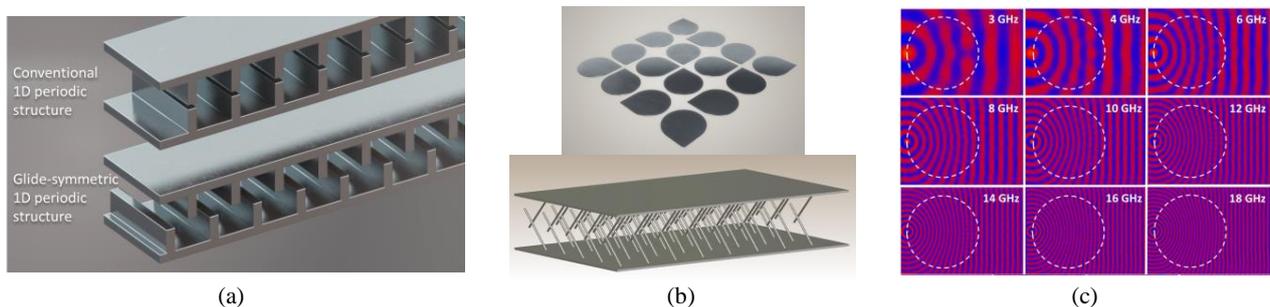


Fig. 1 – (a) Conventional periodic structure and glide-symmetric structure. (b) Examples of screw-symmetric and anisotropic glide-symmetric metasurface. (c) UWB glide-symmetric Luneburg lens transforming a cylindrical wave into a plane wave for directive radiation at its end (the phase of the fields is shown in the picture).

Research Activities. Due to the difficulty to study HSM holey metasurfaces for the presence of different geometric scales (large device, small details in each cell), reliable models need to be developed. Furthermore, HSM may also present strong interaction between surfaces (Fig. 1a) preventing from using approximate boundary conditions separately on each of them.

The PhD student will work on the modeling and the design of HSM. She/he will derive a circuit model for the unit cell of different kinds of HSM (e.g., those shown in Fig. 1b and others), starting from the solution of the periodic problem through a Method of moments or a mode matching. She/he will study the excitation of the HSM through a single localized source, by means of both full-wave models and the circuit methods developed. She/he will use the developed codes to design graded-index lenses based on HSM providing assigned radiation patterns, through transformation optics approaches. She/he will be in charge of the fabrication of the prototypes and their measurements.

She/he will collaborate with another PhD student and a post-doc, recruited on similar subjects on different projects (an EMERGENCE grant funded by Sorbonne Universités recently obtained by the PhD director). Exchanges will be possible with researchers at KTH Royal Institute of Technology, Stockholm, Sweden, in the framework of an existing collaboration with UPMC. She/he will have access to the computational facilities of the UPMC (laboratory simulation server, simulating software) as well as UPMC



fabrication and measurement facilities (milling machine, 3D printer, anechoic chamber and measurement equipment).

Skills required:

- The candidate must have completed a master degree in electrical engineering, physics or applied mathematics.
- The candidate should have a strong background in electromagnetic theory (electromagnetics theorems, guides waves and modal expansions, plane, cylindrical and spherical waves, Green's function) and antennas (elementary antennas, aperture antennas, microstrip antennas). Graded-index lenses and leaky-wave antennas would be a plus.
- The candidate must have a good knowledge of one or more programming languages for scientific computation (Matlab, C, Fortran)
- Previous experience on periodic media and on computational methods in electromagnetics (method of moments, finite elements, mode matching) will be a plus.
- The candidate must be fluent in English. The knowledge of French language is not required.
- The candidate needs to be autonomous, hard-working, and motivated.

Place and dates of the postdoc:

Laboratoire d'Electronique et Electromagnétisme (L2E), Campus Jussieu

Duration: 3 years. Starting date: spring 2017.

Contact:

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References:

- [1] J. B. Pendry, L. Martín-Moreno and F. J. Garcia-Vidal, "Mimicking surface plasmons with structured surfaces," *Science*, 305, pp. 847-848, 2004.
- [2] G. Valerio, Z. Sipus, A. Grbic, and O. Quevedo-Teruel, "Accurate equivalent-circuit descriptions of thin glide-symmetric corrugated metasurfaces," submitted to *IEEE Trans Antennas and Propag.*
- [3] O. Quevedo-Teruel, M. Ebrahimpouri, and M. Ng Mou Kehn, "Ultra wide band metasurface lenses based on off-shifted opposite layers," *IEEE Antennas Wireless Prop. Lett.*, vol. 15, 2016, pp. 484-487.