# SCIENTIFIC REPORT

**Short Visit Grant 7204, Starting date 19/04/2015, Duration 15 days**

## TRANSFORMATION OPTICS FOR NEAR FIELD FOCUSING

### 1. Purpose of the visit:

The purpose of this visit was to start a new collaboration between Université Pierre et Marie Curie (sending institution) and KTH Royal Institute of Technology (hosting institution). The research topics were focused on the application of Transformation Optics to artificial surfaces for near-field shaping, and relevant numerical models on the analyzed structures.

Furthermore, Guido VALERIO (guest researcher) took part to the Antenna course in KTH, organized by Oscar QUEVEDO-TERUEL (host researcher) and proposed a course on numerical methods for antennas and electromagnetic.

### 2. Description of the work carried out during the visit:

During the short visit, the development of specific transformation optics has been studied, capable to shape the near field starting form a given field distribution on a given surface.

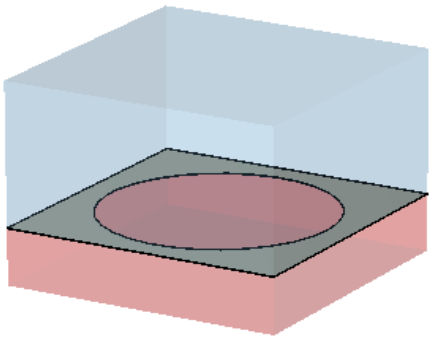
At first, the possibility to shape the phase of the field on the output surface by means of a conformal transformation (i.e., by using inhomogeneous *isotropic* materials) has been investigated. A first solution has been attempted, yielding good results in terms of realized phase; the size and the complexity of the device has also been considered, in order to obtain a continuous lens as a competitive alternative to transmission-line connections used in discrete beam-forming networks.

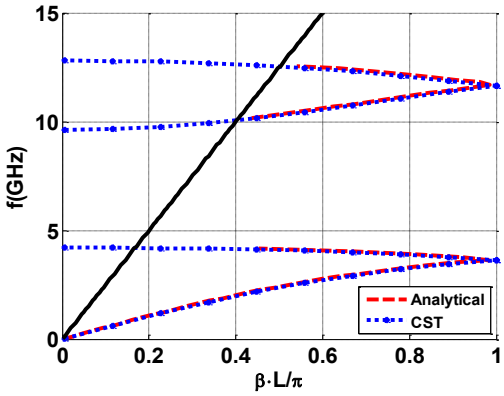
At the moment, different solutions are under investigation in order to shape both the phase and the amplitude of the output field.

At the same time, the practical implementation of the inhomogeneous medium has also been the object of a preliminary study. A holey plate implementation included in a parallel-plate waveguide has been chosen for his reduced losses. This structure has been modelled with a method of moments using entire-domain basis functions and a fast-converging expression for the parallel-plate Green's function. The use of entire-domain basis functions, possible thanks to a simple shape considered for each hole, allows a drastic reduction of the number of unknowns with respect to usual subdomain triangular basis functions, leading to a quasi-analytic solution.

### 3. Description of the main results obtained:

As an example of a result, in Fig. 1 a dispersion diagram of a periodic arrangement of holes is shown, with a comparison between the code developed during this short visit, and the commercial software CST Microwave Studio. For the moment, a 1-D periodic arrangement of holes has been considered, with excellent results in terms of accuracy (as shown in the figure) and a substantial reduction of the computation time. During the short visit, a 2-D periodic arrangement of holes has also been considered, and the numerical formulation of the method of moments has been stated. The 2-D code is currently in phase of implementation and will be further developed during next months.






(a) (b)

**Figure 1:** (a) Geometry of the unit cell.
(b) Typical dispersion curve: Comparison between analytical and numerical solutions.

**4. Future collaboration with host institution (if applicable):**

The collaboration between the two institutions will proceed in the next months. A visit of G. VALERIO and O. QUEVEDO-TERUEL will take place at the University of Michigan in the months of June and July, and this will be an opportunity to have further discussions and results on the topics developed during this first exchange visit. Another short visit of G. VALERIO is going to be organized in December 2015 or January 2016.

**5. Projected publications / articles resulting or to result from the grant (ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant):**

The numerical modelling of the holey surface will be published on an international journal (*IEEE Transactions Antennas and Propagation* or *IEEE Antennas and Wireless Propagation Letters*) as soon as the code will be validated with commercial software in a great variety of geometrical and physical parameters.

The conformal transformation capable to shape near field will be published as soon as its complete implementation will be finalised, which is supposed to happen within the next months.