SCIENTIFIC REPORT

1. Purpose of the visit:

The main objective of this project was to initiate a research collaboration between two antenna groups: IETR (host institution), and KTH Royal Institute of Technology (sending institution). This collaboration expected to produce a thorough study of the performance of consolidated and novel lenses for high frequency applications, which complements or substitute the inconveniences of array configurations.

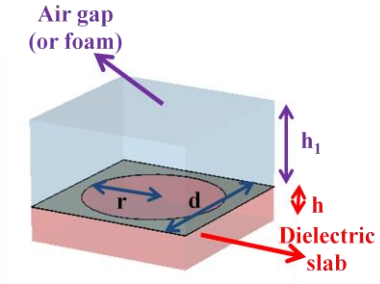
2. Description of the work carried out during the visit:

The work was focused on the study of the performance of parallel plate metasurfaces, and their possibilities to design flat lenses at high frequency. Two Luneburg lenses designs were explored at 16GHz and 25GHz, respectively. These designs exploited the advantages of the first two modes which are excited in parallel plate technology, and taking into account commercially available dielectric materials.

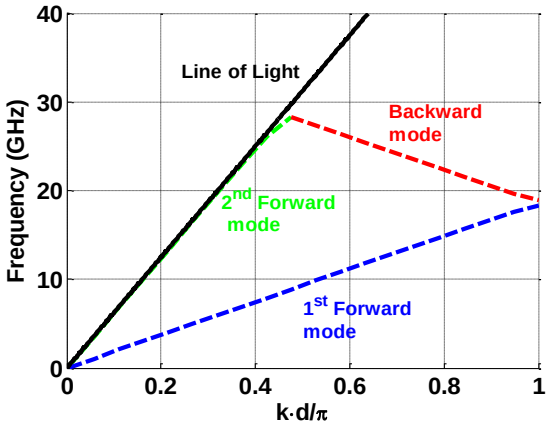
The maximum range of equivalent refractive index was simulated with commercial software *CST Microwave Studio*. This range was obtained for dielectric materials which can be provided by *ROGERS Corporation*, and taking into account the resolution of conventional micro milling machines. After obtaining the available range of refractive indexes, two Luneburg lenses were designed and simulated in HFSS demonstrating the validity of the theory.

3. Description of the main results obtained:

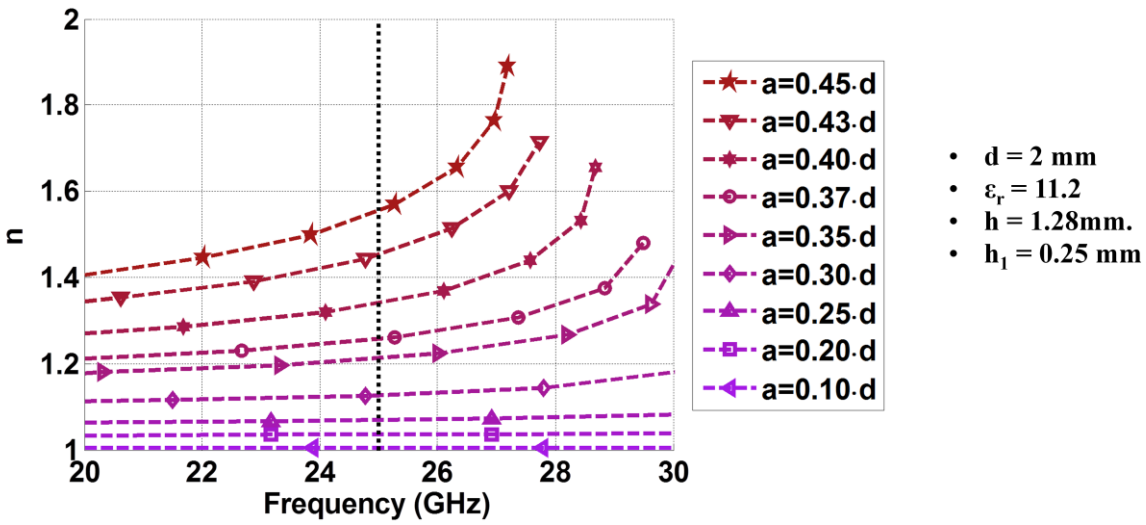
The main aim of this mission was to generate planar lenses in parallel plate technology for high frequency applications. In order to produce changes in the refractive index inside the parallel plate, a metasurface was employed. This metasurface is composed of two layers, one of dielectric material and one of air. Between both layers, there is a thin metallic layer with a periodic repetition of holes which can produce equivalent refractive indexes at a certain frequencies. The unit cell of the periodic structure is represented in the following sketch:



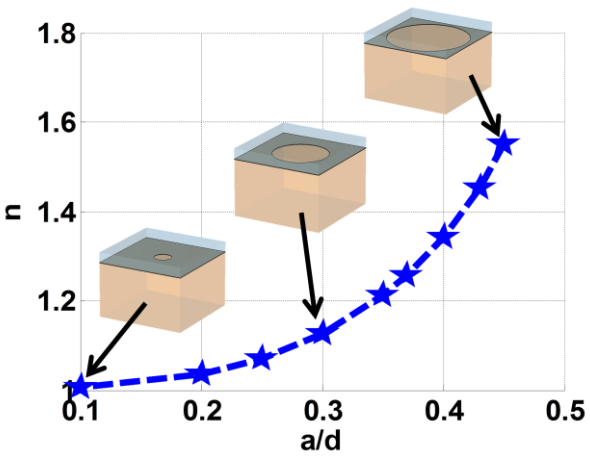
The modes which can be excited in this unit cell were calculated with the *eigenmode solver* of CST. The main modes are the following (when ε_r = 11.2, h = 1.28mm, h_1 = 1 mm, d = 2.4 mm, a = 0.2·d):



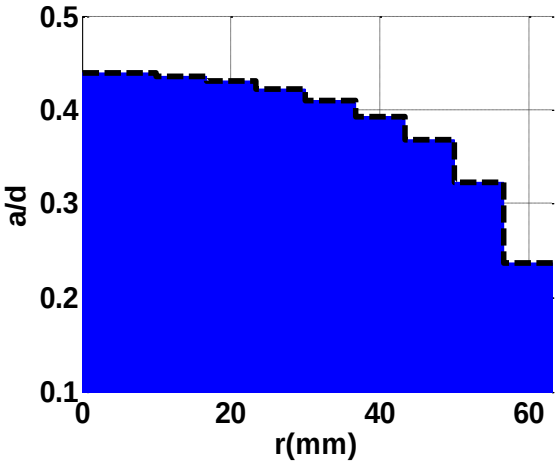
This configuration produces three modes, two forward and one backward. The backward mode was not studied during this mission. Modifying the radius of the holes, it is possible to tune the equivalent refractive index of the modes. In the next graph, it is demonstrated how to obtain equivalent refractive indexes for the second mode (at 25GHz) from 1 to 1.6 modifying this radius:



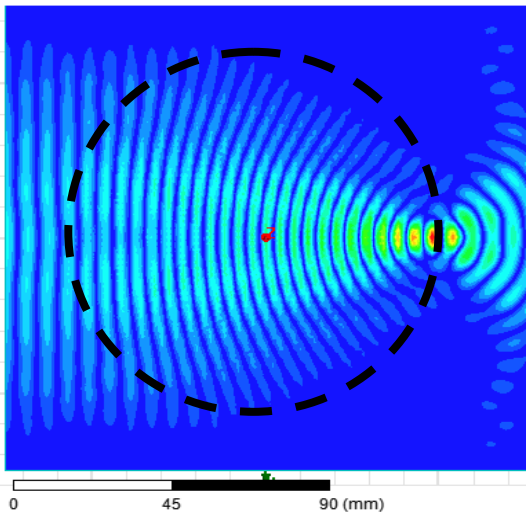
With these refractive indexes, it is possible to create a table which relates radius of the cell and refractive index:



And this table can be used to produce an equivalent lens in the parallel plate technology. Particularly, in order to produce a Luneburg lens, it is required holes with the following radii:



Once the lens is designed, it can be validated with a full wave simulator. In this case, HFSS was selected, and the result is the following:



It can be identified how a plane wave which is incident from the left side can be focalized in a point in the right side, i.e. a Luneburg lens behavior.

This lens will be manufactured and measured during the next months.

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

A part of the original goals were not achieved due to the lack of time. Additionally, the mission has opened new possible topics of collaboration. In this sense, a PhD student of University of Rennes I: Cheikh-Dieylar Diallotart, has applied to a short mission with ESF funding ('New Frontiers in Millimetre / Sub-Millimetre Waves Integrated Dielectric Focusing Systems') to visit KTH between the dates 29/09/2014 and 28/11/2014. This mission is intended to complete the initial goals, and to produce new results in the new topics of collaboration.

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):

An conference presentation in EuCAP2015 is expected. This conference will be held in Lisbon 12-17April 2015, and it is the most important conference in Europe on Antennas and Propagation.