

SCIENTIFIC REPORT

1. Purpose of the visit:

The purpose of this visit was to enhance the research collaboration between University of Zagreb (host institution) and KTH Royal Institute of Technology (sending institution). The research work was focused on the analytical analysis of flat and conformal lenses at mm and sub-mm ranges, as well as on the use of Transformation Optics.

Additionally, O. Quevedo-Teruel (KTH) established new contacts with local manufactures in Zagreb which is beneficial for his present and future work; and it was designed a leaky wave antenna in X-band based on gap waveguide technology in collaboration with a third party: Universidad Carlos III de Madrid (UC3M), Spain. This collaboration was carried out at a distance.

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

The research work started with a fundamental understanding of parallel plate configurations which have off-shifted unit cells. These configurations were demonstrated to produce an ultra wide band response in preliminary results by O. Quevedo-Teruel at KTH.

After initial discussions, the work continued with the derivation of an analytical solution for those configurations. To this aim, an initial case on 1D was derived assuming metallic corrugations. A code in *MATLAB* was developed, and validated with commercial software *CST Microwave Studio*. The code was extended to the 2D case for metallic slabs with holes.

The possibilities of this technique for conformal surfaces was discussed, as well as his combination with Transformation Optics for producing high efficient lens antennas.

New links of O. Quevedo-Teruel with local industry at Zagreb were established. These local links can be of his interest for the manufacturing of his present and future research prototypes.

Additionally, O. Quevedo-Teruel gave a talk to the Department of Wireless Communications, related to his last research on Transformation Optics: Euclidean and non-Euclidean Transformations.

Finally, a new link of collaboration with a third party (Universidad Carlos III de Madrid, UC3M) was established. This collaboration produced results on a leaky wave antenna based on gap waveguide technology. A prototype is now being manufactured, and it will be measured soon by the group in Madrid, Spain.

3. Description of the main results obtained:

An analytical solution for corrugations based on TEM modes on the cavities were derived. This derivation was implementation in *MATLAB* and compared with *CST Microwave Studio* simulations. As an example, in Figure1, we present few results. The unit cell is represented in the left side, and in the right side, we represent a comparison between analytical and numerical calculations of the propagation constant of the first two modes assuming periodic conditions. The presented results are for a case of $L = 6$ mm, $l = 1$ mm, $W = 3$ mm, and $x_0 = 1$ mm. A perfect agreement between analytical calculations and *CST* was achieved.

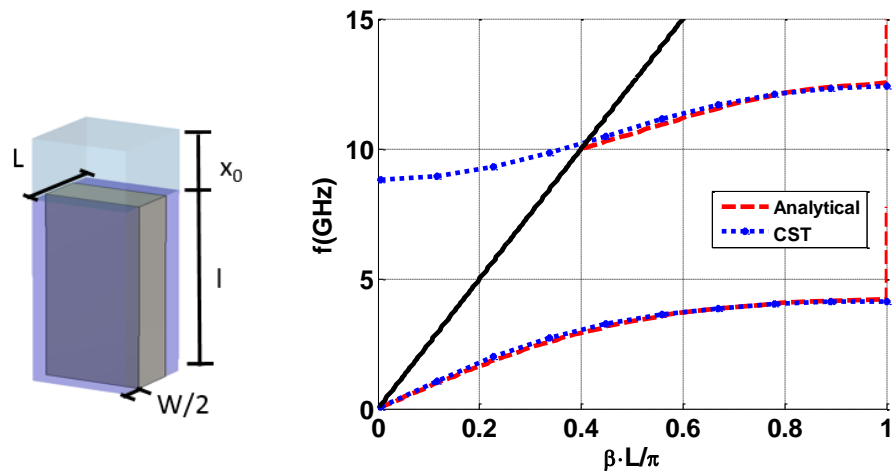


Figure 1: Left) Configuration of a unit cell.

Right) Comparison between analytical and numerical solutions.

This type of configuration can be used to obtain Ultra Wide Band (UWB) 2D lenses under off-shifted conditions. As an example, a Luneburg lens was derived, and simulated with *CST Microwave Studio*. The results for this lens can be found in Fig. 2 which operates from 5GHz to 15GHz.

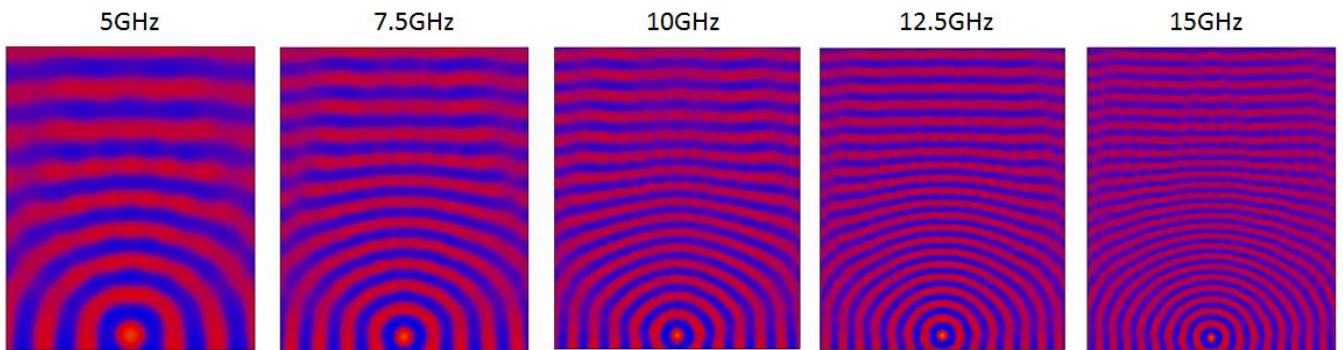


Figure 2: Operation of a flat UWB Luneburg lens.

Finally, in collaboration with UC3M, a leaky wave antenna on gap waveguide technology was designed. In this task, Mladen Vukomanovic, PhD student at University of Zagreb, participated. The results for a single frequency (9.5GHz) are presented at Fig. 3. The antenna was designed to work in X-band, and the manufacturing is in progress right now.

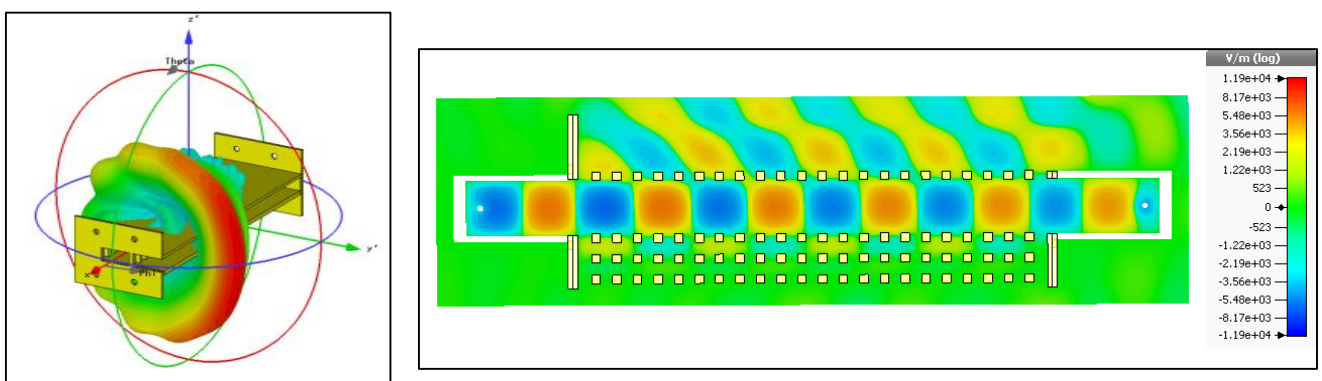


Figure 3: Leaky wave antenna on gap waveguide technology.

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

This short mission has opened new collaborations on the topic of conformal antennas and transformation optics. O. Quevedo-Teruel have applied to a KTH funding for continuing this collaboration with a new visit during this autumn to Zagreb. Additionally, Prof. Sipus and O. Quevedo-Teruel will visit together University of Michigan, USA, during this summer, where they will continue with this work.

Additionally, in the near future, the measurements of the leaky wave antenna will require the contact between both institutions and UC3M. A meeting at European Conference on Antennas and Propagation (Eucap 2015), during this April will be arranged between the 3 institutions (UNIZG, UC3M and KTH) to lead new lines 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):

The work on the leaky wave antenna is expected to be submitted this year to *IEEE Antennas and Wireless Propagation Letters*, but before the publication, the experimental results have to agree with the already obtained simulations. This publication will acknowledge this project.

The work on flat lenses is still more immature, because it requires a final design and measurements. The publication of the results, if any, is expected to be on 2016.