Transformation Optics and its Application to the Design of Broadband Antennas: Experimental Demonstration.

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Transformation optics (TO) has been proven to be a very promising tool for antenna engineers to design novel devices (D.-H. Kwon and D. Werner, IEEE Antennas and Propag. Magazine, 52, 24-46, 2010), since it provides the guidelines to modify the shape of antennas. According to this theory, an antenna can be modified into any new one, while maintaining the same electromagnetic properties, provided that the magnetic and electric constants are adequately modified (U. Leonhardt, Science, 312, 1777-1780, 2006).

However, most of the TO devices derived from this fundamental theory require the use of metamaterials, which leads to high losses and narrow bands of operation (O. Quevedo-Teruel, W. Tang, and Y. Hao, Opt. Lett., 37, 4850-4852, 2012). In addition, when the space of coordinates is transformed into a new arbitrary one, the dielectric and magnetic constants become anisotropic diagonal tensors in which at least one of the components can be lower than unity, thus, the use of dispersive materials or metasurfaces is required (D. A. Roberts, N. Kundtz, and D. R. Smith, Opt. Express, 17, 16535-16542, 2009).

To overcome this drawback, some authors have studied the effect of simplifications in the definition of permittivities and permeabilities maps; such as to omit those regions with refractive indexes lower than unity (N. Kundtz and D. R. Smith, Nature Materials, 9, 129-132, 2010), or to approximate to a constant value (higher than 1) the dispersive components of the refractive index matrix (A. Demetriadou and Y. Hao, Opt. Express, 19, 19925-19934, 2011).

In this presentation, we will demonstrate that the use of discrete transformation optics can provide all dielectric antennas such as those published in (R. Yang, W. Tang, and Y. Hao, Opt. Express, 19, 12348-12355, 2011). Therefore, in this implementation of transformation optics, the use of metamaterials is not necessary, and thus, the redesigned antenna exhibits the same operational bandwidth as the original one. We also studied the robustness of this technique with respect to the employed discretisation (for the convenience of practical implementations). To this aim, as a particular example, a flat antenna which is derived from a hyperbolic lens has been chosen. Two practical discretisations have been studied and compared. Simulations and measurements have been undertaken, and both results will be presented in the conference with good agreement between them.