Modelling of a Geodesic Lens Antennas Using a Raytracing Model

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In order to meet the demands of low latency and high data rates, mobile networks are migrating to higher frequency bands. With increased frequency, both path and material losses increase as well creating a need for low loss and highly directive antennas. Fully metallic lens antennas offer an interesting solution to this problem. Lens antennas can provide a highly directive beam that can be steered using electronic switching, avoiding complex beam steering methods such as mechanical steering or phased arrays. Additionally, the fully metallic implementation of lenses mitigates material losses since no dielectric materials are needed. One possible way of realizing fully metallic lenses is by taking advantage of geodesic surfaces. These surfaces can mimic the refractive index of gradient-index dielectric lenses such as the Luneburg lens or the Maxwell-Fish Eye lens [M. Šabort & T. Tyc, "Spherical media and geodesic lenses in geometrical optics," *J. Opt.*, 2013].

Modeling these lenses in commercial full-wave simulation software is however time-consuming since lenses are typically large in terms of wavelength. It is, therefore, impractical to design such a lens using these simulation tools, especially if the lens is to be optimized for a certain performance, e.g. side-lobe levels or a desired beamwidth. A procedure that is efficient in terms of computational time while being sufficiently accurate is provided by the ray tracing technique. This technique has been widely used to study gradient-index dielectric lenses and is here applied to also deal with geodesic metallic lenses [R. F. Rinehart, "A family of designs for rapid scanning radar antennas," *Proc. IRE*, vol. 40, no. 6, pp. 686–688, 1952].

A possible disadvantage of the design of lens antennas using geodesic surfaces, compared to e.g. metasurfaces, is the increased profile of the lens since the direction orthogonal to the beamforming plane is employed to generate the geodesic surface. A solution to this problem was long ago addressed in [K. S. Kunz, "Propagation of microwaves between a parallel pair of doubly curved conducting surfaces," *J. Appl. Phys.*, vol. 25, no. 5, pp. 642–653, 1954]. This author proposed to fold the geodesic surface so that the height profile was reduced without affecting the performance of the lens. Moreover, this folding can be applied any number of times to achieve the required compression. An important practical drawback caused by these foldings is the appearance of slope discontinuities at the folding locations. The profile in these regions should then be "smoothed" and, in doing so, the geodesic surface is being changed with the undesired risk of a degraded performance of the lens. To maintain the required performance of the lens, the profile used at the folding locations has to be optimized, but this task is rather impractical if carried out by means of full-wave commercial simulators. The raytracing technique is here a perfect candidate for a more efficient modeling. In summary, in this presentation a raytracing code will be presented capable of an efficient modeling a folded geodesic lens antennas. The results obtained by the code are then compared to results achieved by full-wave simulation software.