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Accurate Ray Description of the Field Scattered by Reflecting Intelligent Surfaces for Smart Radio Environments

Matteo Albani, Ernest Ofosu Addo, Enrica Martini*, Stefano Maci
University of Siena, Siena, Italy, e-mail: matteo.albani@unisi.it; erny.addo@gmail.com; martini@dii.unisi.it; macis@dii.unisi.it

The last years have experienced a continuous growing request for massive and ubiquitous multimedia information access. Therefore, the Fifth Generation (5G) network is currently faced with the challenge of limited data speed, exacerbated by the proliferation of billions of data-intensive applications. Radically new communication paradigms, especially at the physical layer, are required to handle this problem. In this context, the revolutionary concept of Smart Radio Environment (SRE) has recently emerged as a new paradigm for wireless communications, in which the environment is controlled and programmed jointly with the transmitters and receivers, rather than something to compensate for [1].

The key technology underpinning SREs is represented by reconfigurable reflective metasurfaces (MTSs), artificial surfaces consisting of electrically small elements whose electromagnetic behavior is electronically controlled [2]. MTSs do not require signal processing nor signal amplification processes, so they have an extremely low power consumption, and they can process EM signals directly at the speed of light, dramatically reducing latency and complexity with respect to corresponding fully digital solutions.

This ambitious scenario has recently become a thriving research area; most of the published studies, however, are focused on system-level performances and architectures, and they generally considered the MTS as an ideal component, able to re-route all the power of the impinging electromagnetic wave in a desired direction with ideal performances. However, the performances of practically realizable metasurfaces will be inevitably limited by a number of factors including losses, frequency dispersion, discretization and quantization of the equivalent boundary conditions, and existence of spurious radiation in undesired directions, due to spurious diffraction orders. An accurate estimate of the actual field scattered by the MTS is a key element for the definition of the achievable system performances.

This paper presents an effective approach for the accurate representation of the field scattered by finite polygonal MTS-based Reflective Intelligent Surfaces. The approach is based on the modelization of the MTS through homogenized impedance boundary conditions and it consists of two steps: first, an infinite periodic problem is rigorously solved to determine the physical optics current on the MTS in terms of a Floquet Wave expansion. Then, the obtained current is windowed over the finite scattering surface, and the scattered field is calculated through a close-form representation based on a ray formalism. This latter step is performed by applying a procedure similar to the one applied in [3] for the representation of the field radiated by a finite periodic array. The proposed representation can also be applied in the near field region, thus, it is also applicable for near-field communications.

References

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