Speeding up Parameter Extraction of Circular and Elliptical Ring Patch Metasurfaces by means of Closed Form Fourier Spectra of Basis/Testing Functions

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Metasurfaces (MTSs) can be considered nowadays a planar, low-cost and low-weight alternative with to more traditional electromagnetic (EM) devices to control surface wave (SW) propagation (M. Mencagli, E. Martini, and S. Maci, IEEE Trans. Anten. Propag., 63, 7, 2992–3003, 2015; S. C. Pavone, E. Martini, F. Caminita, M. Albani, and S. Maci, IEEE Trans. Anten. Propag., 65, 7, 3540–3548, 2017), and to convert them into leaky waves (S. Maci, G. Minatti, M. Casaletti, and M. Bosiljevac, IEEE Anten. Wirel. Propag. Lett., 10, 1499–1502, 2011; G. Minatti, M. Faenzi, E. Martini, F. Caminita, P. De Vita, D. Gonzalez-Ovejero, M. Sabbadini, and S. Maci, IEEE Trans. Anten. Propag., 63, 4, 1288–1300, 2015). Since MTSs are made by periodically (or quasi-periodically) arranging elements small in terms of wavelength, the proper choice of the basic constituting element is of primary importance, indeed it affects the overall MTS performance.

Here, we consider circular and elliptical ring patches as possible unit cells for MTSs, that have the advantage of an increased loading with respect their "full" counterparts. The efficient characterization of the wavenumber dispersion versus frequency of MTSs made by circular or elliptical rings requires the development of a periodic spectral Method of Moments (MoM). According to such a technique, the Fourier spectra of basis/testing functions are required (N. Engheta and R. Ziolkowski, chap. XIII, J. Wiley & Sons, 2006), hence the knowledge of the spectra of basis/testing functions in closed form allows an important speedup in the numerical procedure, that becomes faster and more efficient. Indeed, the usage of general purpose Rao-Wilton-Glisson (RWG) basis/testing functions, normally adopted for unit cell current discretization, requires an increased computational complexity with respect to few closed form entire domain basis/testing functions.

It is shown that the spectra of the proposed basis functions for both circular and elliptical ring patches can be written in closed form, thus the above-mentioned procedure to speedup spectral MoM can be profitably applied. The possibility of efficiently calculating the wavenumber dispersion of circular and elliptical ring MTSs permits to reduce the filling time required to realize a database for parameter extraction of MTSs, and can be in general extended to all patch/slot shapes for which a small set of entire domain basis functions can be defined, for which the spectrum can be found in closed form, by using proper analytical techniques and the well-known properties of Fourier transforms.