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Modeling of electromagnetically functional surfaces and extraction of physical bounds, using Herglotz functions and convex optimization

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Abstract

Electromagnetically functional surfaces can be realized as composite structures, being periodic in a plane and finite in the normal direction. Typical functionality that can be targeted is absorption, frequency selective filtering, pulse shaping, polarization selectivity and conversion, or magnetic conductivity. These properties can be controlled by the periodic microstructure and temporal dispersion of the constituting materials. The functionality can be quantified through the reflection and transmission coefficients of the structure, which can be modeled using Herglotz functions. The analytical properties of these functions, together with hypotheses on the low and high frequency asymptotes, can provide surprisingly sharp physical bounds on the electromagnetic functionality, for instance bounding the bandwidth of a high impedance ground plane in terms of its thickness. The critical dependence of sum rules on the low and high frequency asymptotes can be relaxed by using an integral representation theorem for Herglotz functions, enabling a convex optimization approach to extracting physical bounds. We will present an overview of the mathematical background to this modeling, and some of the physical bounds it leads to.