Surface Waves, Complex Modes, and Leaky Waves on a Metasurface

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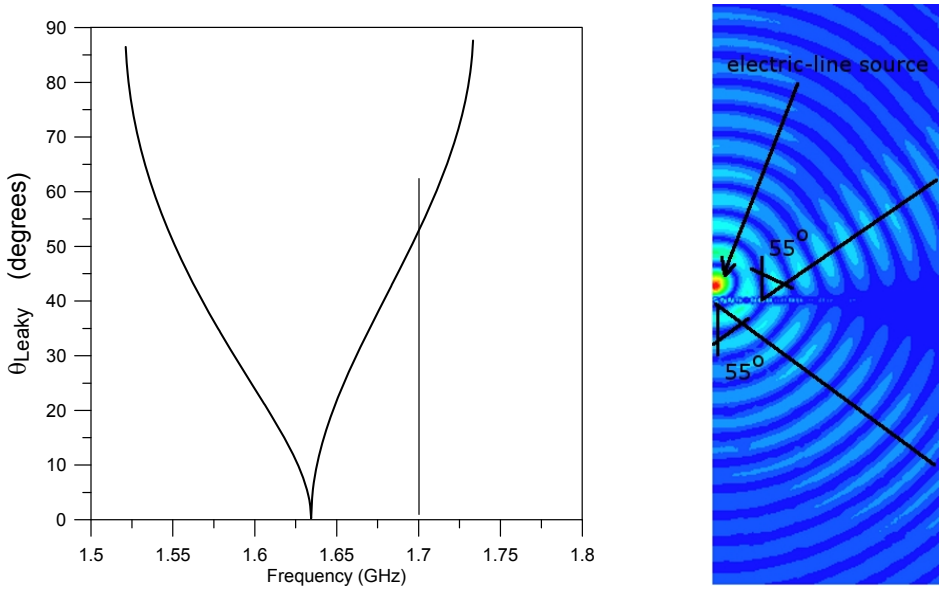
With the use of a generalized sheet transition condition (GSTC) we have investigated the existence and excitation of guided waves (both surface waves and complex modes) on a metasurface [Holloway *et al.*, *IEEE Trans. AP*, **60**(11), 5173 (2012)]. In the case of a metafilm, the GSTC permits the characteristics of the guided waves to be expressed in terms of the surface susceptibilities of the metafilm, which are directly related to the electric and magnetic polarizabilities of the scatterers of which it is made up. The GSTC formulation also allows us to write down analytical expressions for the propagation constants in both the longitudinal and transverse directions. Based on this information, we are able to give conditions on the surface susceptibilities that specify when surface waves and/or complex modes will exist. In this paper, we will show that under certain conditions, leaky waves can exist, propagating at a well-defined angle away from the metasurface. The angle of propagation of a leaky wave (θ_{Leaky}) is a sensitive function of the resonances that can appear in the surface susceptibilities, and indeed leaky waves on a metafilm will generally exist only in a narrow range of frequencies. For example, Figure 1(a) shows the theoretical values for θ_{Leaky} (obtained from our formulation) for a metafilm consisting of spherical particles with radius 10 mm, lattice constant 25.67 mm, ε_r=100, μ_r=1 and tanδ=1x10^{-4}. Figure 1(b) shows a numerical simulation of the magnitude of the E-field for an electric line source at 1.7 GHz placed above the metafilm. From Figure 1(b) we see that energy is propagating away from the surface at approximately 55^O. This is in agreement with the angle predicted by theory as shown in Figure 1(a).



(a) (b)

Figure 1. Leaky waves on metasurfaces: (a) θ_{Leaky} , and (b) Magnitude of the E-field at 1.7 GHz.