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Dispersion Effects in Waves Reflected by Lossy Conductors: The Optics vs. Electromagnetics Approach

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Abstract : The study of dispersion phenomena in electromagnetic waves reflected by conductors at infrared and lower frequencies is a topic which finds a number of applications. We aim to explain in this work what are the most relevant ones and how this phenomenon is modeled from both optics and electromagnetics points of view. We also explain here how the amplitude of an electromagnetic wave reflected by a lossy conductor could depend on both the frequency of the incident wave, as well as on the electrical properties of the conductor, and we illustrate this phenomenon with a practical example. The mathematical analysis made by a specialist in electromagnetics or a microwave engineer is apparently very different from the one made by a specialist in optics. We show here how both approaches lead to the same physical result and what are the key concepts which enable one to understand that despite the differences in the equations the solution to the problem happens to be the same. Our study starts with an analysis made by using the complex refractive index and the reflectance parameter. We show how this reflectance has a dependence with the square root of the frequency when the reflecting material is a good conductor, and the frequency of the wave is low enough. Then we analyze the same problem with a less known approach, which is based on the reflection coefficient of the electric field, a parameter that is most commonly used in electromagnetics and microwave engineering. In summary, this paper presents a mathematical study illustrated with a worked example which unifies the modeling of dispersion effects made by specialists in optics and the one made by specialists in electromagnetics. The main finding of this work is that it is possible to reproduce the dependence of the Fresnel reflectance with frequency from the intrinsic impedance of the reflecting media.

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