Electromagnetic media with no Fresnel (dispersion) equation and novel jump (boundary) conditions

Alberto Favaro*,
Institute for Theoretical Physics,
University of Cologne, Germany

Ismo V. Lindell**,
Department of Radio Science and Engineering, Aalto University,
School of Electrical Engineering, Espoo, Finland

5 June 2013

At a boundary that separates two insulators, the components of the electric field strength E and of the magnetic field excitation $\mathcal{H}$ parallel to the interface are continuous; moreover, the same is true for the components of the magnetic field strength B and of the electric field excitation $\mathcal{D}$ that are perpendicular to the interface. Because these *jump conditions* are an immediate consequence of Maxwell's equations, they are valid for all electromagnetic materials [1]; in the statement above, electric conductors were ruled out as a matter of simplicity. Numerous recent works discuss further jump conditions, whose role in the foundations of electrodynamics is secondary, but which have unique technological properties. For example, the boundary separating a perfect electromagnetic conductor (PEMC) and vacuum can act as a *twist polariser*. More in detail, for a specific choice of the key material parameter, the electric field of a wave being reflected off the interface is totally cross-polarised [2]. Another possibility is to require that the components of the magnetic field strength B and of the electric field excitation $\mathcal{D}$ orthogonal to the interface vanish. Such "$\mathcal{D}B$" jump conditions can be used to achieve *invisibility to the monostatic radar*, whose transmitter and receiver are located at the same point. More in detail, by engineering an appropriate material coating, it is possible to reduce the back-scattering cross-section of any object that is endowed with certain symmetries [3]. The PEMC and various materials that give rise to the $\mathcal{D}B$ jump conditions share an interesting property: the *Fresnel equation*, which describes how light propagates in these and in all dispersionless media, subject to the validity of geometrical optics, is found to be satisfied for any choice of wave-covector. We attempt a systematic investigation of those material classes that exhibit the property just mentioned. Strong evidence is put forward that only three types of local and linear material exist whose Fresnel equation is satisfied *trivially*. In particular, we show that taking the inverse of the electromagnetic response tensor does not lead to new solutions, as appropriate. Further information is provided in the article [4].

References

[1] Y. Itin. *Ann. Phys. (NY)*, 327:359–375, 2012.

[2] I.V. Lindell and A. Sihvola. *J. Electromagn. Waves Appl.*, 19(7):861–869, 2005.

[3] I.V. Lindell, A. Sihvola, P. Ylä-Oijala, and H. Wallén. *IEEE Trans. Antennas Propag.*, 57(9):2725–2731, 2009.

[4] I.V. Lindell and A. Favaro. *Prog. Electromagn. Res. B*, 51:269–289, 2013.

*E-mail: favaro@thp.uni-koeln.de
**E-mail: ismo.lindell@aalto.fi