Light propagation in pre-metric electrodynamics with a local and linear constitutive law

Friedrich W. Hehl[1]

[1]University of Cologne, Köln, Germany, and University of Missouri, Columbia, MO, USA,
hehl@thp.uni-koeln.de

Abstract

Based on electric charge and magnetic flux conservation, we derive the Maxwell equations in terms of the excitations $G = (D, H)$ and the field strengths $F = (E, B)$. The corresponding spacetime is a 4-dimensional differentiable manifold that can be decomposed into time and space, but it carries no metric and no linear connection ('premetric' spacetime). We postulate a local and linear constitutive law between G and F. It carries 36 independent components. The propagation of electromagnetic shock waves is studied. The wave surfaces turn out to be quartic Fresnel-Kummer surfaces (see Fig. 1 for a simple example). If in vacuum birefringence is forbidden, we can derive the light cone of Maxwell-Lorentzian vacuum electrodynamics, that is, the metric up to an undetermined factor. We discuss possible generalizations of electrodynamics involving a dilaton and/or an axion field.

References

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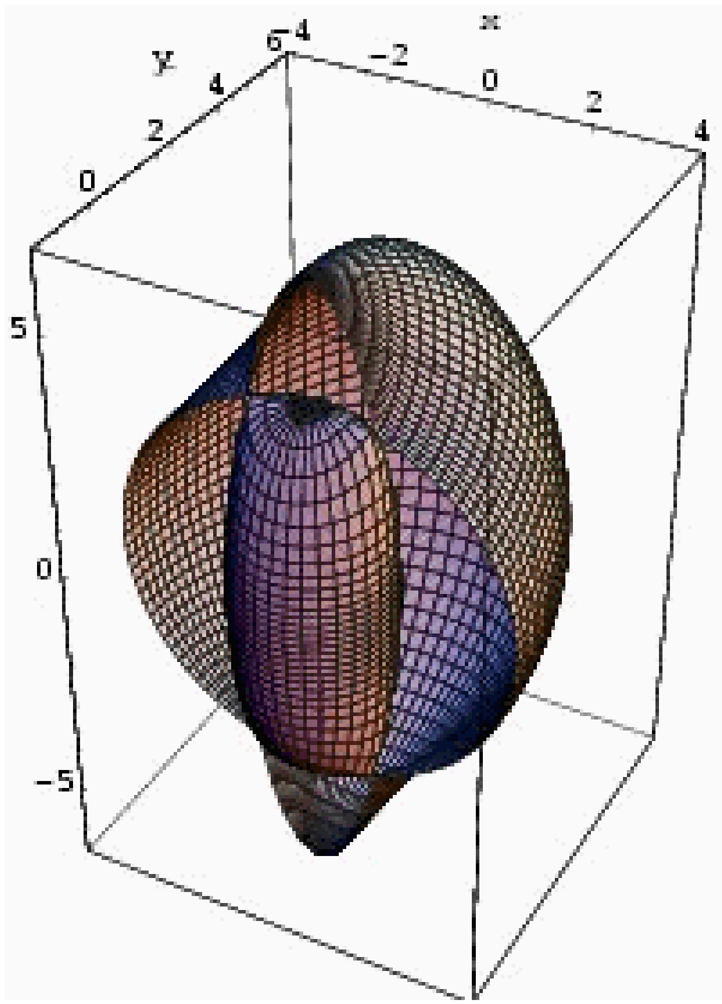

Figure 1: Fresnel wave covector surface for an anisotropic dielectric medium with $\varepsilon_{11} = 39.7, \varepsilon_{22} = 15.4, \varepsilon_{33} = 2.3$. There are two branches: the outer part of the surface is cut in half in order to show the inner branch; we use the dimensionless variables $x := c\,q_1/q_0, y := c\,q_2/q_0, z := c\,q_3/q_0$; 4d wave covector q_i, with $i = 0, 1, 2, 3$ (figure Sergei Tertychniy).