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FOURIER-INTEGRAL DESCRIPTION OF SUPERLUMINAL PHOTON TUNNELING

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We give a general Fourier-integral description of photon tunneling which can be applied either to electromagnetic waveguides and to optical devices. Moreover, we extend to the case of frustrated total internal reflection our previous treatment of superluminal tunneling of evanescent waves in terms of a spacetime deformation.

In recent years, the problem of superluminal tunneling of photons received a great deal of attention, both from the experimental[1–5] and the theoretical side (see Refs. 6–9 for reviews). From the experimental point of view, the last development is provided by the measurement of optical tunneling times in frustrated total internal reflection of a light beam,[5] which confirms the superluminality of the phase time of tunneling of the optical photons (see also Ref. 10).

In a recent paper,[11] we discussed the superluminal propagation of an electromagnetic wave packet in a rectangular waveguide by essentially exploiting the analogy between particles and waves[9,12,13] and the formalism of deformation of the Minkowski space.[14] The former point allowed us to expand the packet in a Fourier series containing both evanescent and anti-evanescent waves, whereas the latter tool permitted us to describe the nonlocal behavior of the barrier in terms of a "spacetime-deformation" tensor (analogous to the Cauchy stress tensor in a continuous medium).

In this paper, we want to provide further developments of our approach, by giving a Fourier-integral description of photon tunneling for both electromagnetic waveguides and optical devices like that considered in the experiment.[5]