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The Effect of Coherence in the Propagation through Periodic Structures

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ABSTRACT
The effects of the coherence properties of light beams propagating through periodic structures are discussed. In particular, spatial coherence may influence the transmitted field. Some 2D structures which give transmittances strongly influenced by the coherence of the incoming field are discussed.

SUMMARY

To investigate the coherence properties of a light beam there are several methods such as the Michelson or the Young interferometers that are very simple methods to determine the time of coherence and coherence area of a beam. All these systems are very useful to determine the coherence properties of a field but unfortunately they are big setup (very big if compared with the wavelength) and so they are very sensible to the perturbations of the external world and difficult to make rugged. It could be interesting to find a system that is very small, comparable with the wavelength of the light we want to investigate, and very compact so to be insensitive to the perturbations of the external world. A filter that put directly on the light beam could give the possibility to find the coherence properties of the field would be very useful.

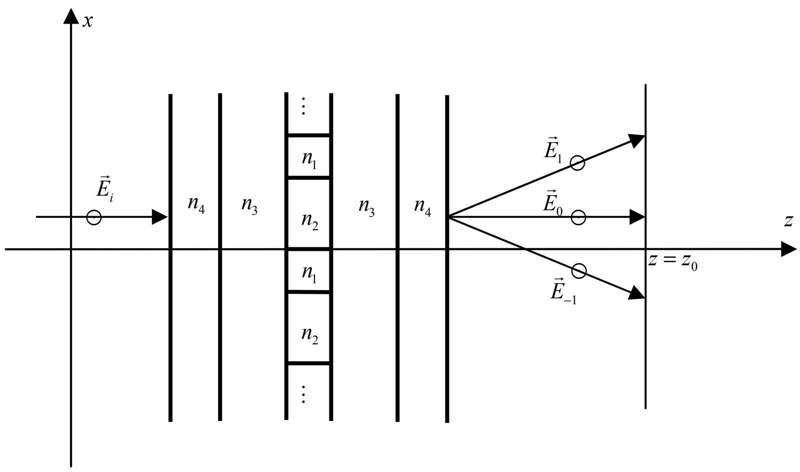

Fig. 1. Schematic representation of the 2D filter.

We discuss here very simple systems that have these properties. A 2D system is shown in Fig. 1. The wave enters from the left side in the system which contains a grating whose period d has been chosen between the wavelength and two times the wavelength. The output electric field can be written as

$$E_y(x,z) = \sum_{n=-\infty}^{\infty} T_n e^{-i(k_{nx}x + t_n z)} \quad , \tag{1}$$

where

$$t_n = \sqrt{n_0^2 k_0^2 - k_{nx}^2} \ , \qquad k_{nx} = n\frac{2\pi}{d} + n_i k_0 \sin\varphi_i = nk_d + k_{x0} \ . \tag{2}$$

In the output only three plane waves propagate that generate an interference field on the output plane ($z = z_0$). The input wave is assumed to have some coherence area that we would like to determine by observing the interference in the output. Fig. 2 show some characteristic results obtained for a partial coherent plane wave with a coherence area described by a Gaussian function with variance σ contrasted with the fringes obtained for a fully spatial coherent beam.

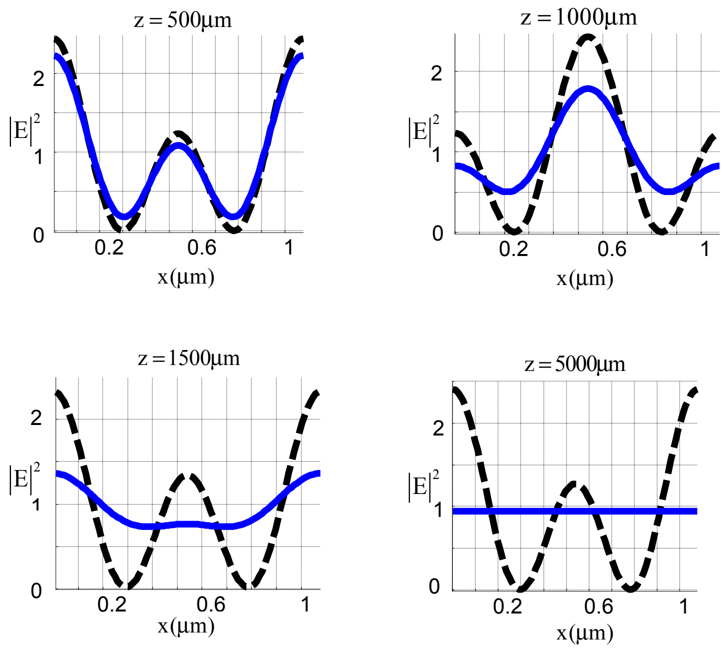

Figure. 2. Square modulus of transmitted electric field at several z output planes, the dashed curves refer to a completely coherent input plane wave, the solid lines refer to a partially coherent input plane wave, with σ = 1000 μm.

Fig. 2 show that by increasing the distance of the observation plane ($z = z_0$) the visibility of the fringes in the partial coherence case decreases.

Other systems of this kind are described and their properties are discussed.