Laser Interaction with a Dielectric Block

Pietro Rotelli [1] [2] and Stefano De Leo [3]

[1]Dipartimento di Fisica, Università del Salento, Italy

[2]Istituto Nazionale di Fisica Nucleare sez. di Lecce,Italy

[3]Department of Applied Mathematics, State University of Campinas, Brazil

This collaboration is now formalized as part of the interuniversity agreement between the State University of Campinas (Brazil) and the University of Salento (Lecce, Italy).

Some optical experiments provide the easiest way to test quantum mechanical predictions. Such a situation applies to a laser beam traversing a dielectric structure. The dielectric structure mirroring quantum mechanical potentials. The simplest of these, studied in this paper, involves a single dielectric block. We exhibit both by analytic and numerical calculations explicit examples of total coherence and total incoherence phenomena. Which case appears depends upon the angle of incidence of the laser beam, and/or the dimensions of beam vs block width. Unlike our previous studies our calculations here are three-dimensional, although, with suitable approximations, somewhat simpler planar expressions can be derived.

We have developed the formalism, conventions and approximations for the interaction of a gaussian laser beam with dielectric structures [1]. We have emphasized in particular the dominant role played by the momentum perpendicular to the dielectric block and in general to any stratified dielectric system. This result draws a strong analogy with one-dimensional non-relativistic Quatum Mechanics (QM). Indeed we have noted that our system corresponds to a QM well potential. The numerical and other calculations displayed in our work invite experimental confirmation. It is particularly interesting to note the conditions for coherence and incoherence in this study, and compare them with those of one-dimensional QM. In QM we deal with time dependent wave packets and coherence requires the size of these wave packets to be large with respect to the well size. In this work the analogy is the separation in the y-variable of laser beams. For this optical study, coherence can be achieved not only by increasing the laser beam size w.r.t. the block depth so that overlap occurs between outgoing beams, but also by reducing the incident angle. This also leads to overlap of individual terms since the separation of the y exit points is reduced, for any fixed laser size, by decreasing the incident angle. We have calculated the various y values for incoherence, both by the Stationary Phase Method and numerically and found complete agreement. They remain, of course, to be confirmed experimentally. We have also calculated, for various incident angles , the outgoing incoherent beam intensities and profiles. A more complex and interesting situation occurs if we consider a dielectric slab cut diagonally.

• The collaboration is now formalized as part of the interuniversity agreement between the State University of Campinas (Brazil) and the University of Salento (Lecce, Italy).

Stefano De Leo [deleo@ime.unicamp.br]
Pietro Rotelli [rotelli@le.infn.it]

REFERENCES

1. S. De Leo and P. Rotelli, to appear in Eur. Phys. J. D (2011).