STUDIES ON THE VISIBILITY OF A MULTIPLE-BEAM INTERFERENCE FRINGES

THESIS

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TO MY FAMILY

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ABSTRACT

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Chapter (I) represents a review on the previous works dealing with studeis on the spectral line profile of a very sharp spectral half width (laser case).

In chapter (II), a theoretical treatment for the visibility (V) of multiple beam interference fringes is given in order to enable the determination of the spectral half width of the considered light beam at much smaller optical path difference than that needed for two beam interference.

Mathematical expressions for the fringes visibility were derived taking into account the spectral profile of the interfering beams and its spectral half width. The considered spectral profiles are: Lorentz-profile, Gauss-profile and Voigte-profile.

The effect of the factors influencing the intensity distribution and the visibility of the interference frings, namley, the spectral line profile, spectral half width, the number of interfering beams, the optical path difference and the reflectivity of the interferometer mirrors have been investigated through a set of computer programs.

The computed curves of the intensity distribution showed fluctuations with a marked damping as the number of interfering beams increased, also as the spectral half width increased and by decreasing the reflectivity of the interferometer mirrors or by increasing the optical path difference.

The comparative study between the computed curves of intensity of two and multiple beam interference showed that the rate of decreasing the visibility with the optical path difference in case of multiple beam is much greater than that for two beams. From other side the visibility for two beams interference starts at higher values and remains constant over more wider range of spectral path difference than that for multiple beam. It showed also that any certain value of the visibility, at which there is a remarkable rate change, can be reached at optical paths smaller by a factor of about (10), for multiple beam than that for two beam interference fringes. This implied that the spectral half width of the spectral line can be determined through the visibility of multiple beam interference fringes at much smaller optical path difference than that needed for two beam interference.

The coherence length (l_c) of the light beam, which is the optical path difference at which the visibility of the fringes reachs a value of about (0.02), was found in both cases of multiple and two beams interference to be given by the well known relation ($l_c \simeq c/\Delta f$) where (Δf) is the spectral half width of the light beam and (C) is the velocity of light.

Also in this chapter, the mutual coherence function between the multiple interfering beams considering the spectral line profile of the light beams theoretically given. Through the obtained mutual coherence function a formula for the degree of coherence is derived, representing its dependence on the spectral line profile, the number of interfering beams and the optical path difference between two successive interfering beams. It was found that, the degree of coherence in case of Lorentz-profile depends exponentially on the number of interfering beams, the optical path difference and the spectral half width of the line profile, while in case of Gauss-profile it depends on the quadratic values of those parameters. Such results can enable us to discriminate between the two profiles.

Also the visibility of the interference fringes could be expressed mathematicaly in terms of the degree of coherence between the multiple interfering beams. By a comparative studies between this last mathematical expression for the visibility and that obtained previously, in the present chapter, gave the same derived mathematical formula for the degree of coherence.

When the optical path difference between two successive interfering beams is equal to the coherence length (l_c), given by the well known relation $l_c = c/\Delta f$ the degree of coherence was found to take a value in the order of the experimental value of the visibility (0.02) at which the coherence length is defined. This confirms our theoretical treatment.

Chapter (III) deals with the spectral line profile with fine structure like that occuring in the spectral line profile of a laser beam (axial modes). The computed curves of visibility, in such case, showed that the dominant factor in determining the coherence length of the light beam is the spectral half width of a single fine structure and not the spectral half width of its spectral line. If the fine structure is a set of different spectral half widths, then the dominant factor in this case is the spectral half width with the sharpest one. These results could explain the physical reason: why a laser beam, of a stable axial modes, is of extremely large coherence length?

CHAPTER (I)

(I-1) INTRODUCTION AND PREVIOUS WORK