

FOCUSING OF LASER BEAM IN AN
INHOMOGENEOUS MEDIUM

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PREFACE

Selfoc fibers and gas lenses have recently been proposed as two exciting possibilities for propagation of optical signals over short, medium and long distances. The guidance of light beams in these media arise from the radial variation of refractive index. The present thesis is devoted to the study of the focusing of laser beams in an inhomogeneous medium. This can be characterized by an index of refraction which assumes a maximum value on axis and decreases quadratically with the distance from the centre axis.

The first chapter of the thesis is devoted to a description of the experimental aspects of the Selfoc fiber and the gas lens so that a proper background, for the appreciation of the theoretical results envisaged in Chapter II, becomes available. A brief discussion is also given to stress upon the importance of the theoretical approach employed in the second chapter.

The second chapter deals with the application of the parabolic equation to the propagation of laser beams in a radially inhomogeneous medium. In the first two sections of this chapter, the parabolic equation is derived from Maxwell's equations and meaningful solutions have been obtained for slowly converging/diverging beam in a radially and axially inhomogeneous medium. It has been shown that the dimensionless beam width parameter

satisfies a second order differential equation. The solution of this differential equation, in geometrical optics approximation, is discussed in Section 3. The path of rays in a typical conical Selfoc fiber have also been obtained and compared with the corresponding experimental data. The agreement between the theoretical results and the experimental data is found to be fairly satisfactory.

In the fourth section of this chapter, the diffraction effects on intensity distribution have been taken into account. For Gaussian beams, the intensity at any point inside the conical Selfoc fiber has been evaluated numerically. Theoretical calculations have also been made for the resolving power of a Selfoc lens and have been compared with the corresponding experimental data. The theoretical results agree well with the experimental data.

In the fifth section, the electromagnetic wave propagation in a gas lens (using the theory developed in the first two sections of this chapter) has been studied. The theoretical results are compared with the experimental data for the focal length in a tubular gas lens and a good agreement between them justifies the theory. The thin lens formula is also found to be valid, to a good approximation, in a gas lens. The last section of this chapter, briefly presents the justification of the present approach.

The last chapter of the thesis is devoted to the

study of the propagation of a Gaussian beam through a circularly curved Selfoc fiber. Effect of radius of curvature on the positions of foci and the intensity distributions at the position of foci has been obtained and it is concluded that Selfoc fibers have a good tolerance towards bending as compared to gas lenses.

The work presented in the thesis resulted in the following publications:

1. Sodha, M.S., A.K. Ghatak and D.P.S. Malik, 'Electromagnetic Wave Propagation in a Radially and Axially Non-uniform Media: Geometrical Optics Approximation', J.Opt.Soc.Am., 61, (1971), 1492.
2. Sodha, M.S., A.K.Ghatak and D.P.S. Malik, 'Electromagnetic Wave Propagation in a Radially and Axially Non-uniform Media: Optics of Selfoc Fibers and Rods; Wave Optics Considerations', J.Phys. D; Appl. Phys., 4, (1971), 1887.
3. Ghatak, A.K., D.P.S. Malik and M.S. Sodha, 'Path of Rays in Conical Selfoc Fibers', J.Opt.Soc. Am., 62, (1972), 594.
4. Ghatak, A.K., K.Singh, D.P.S. Malik and M.S. Sodha, 'Resolution by Selfoc Lens', Optica Acta, 19, (1972), 681.
5. Ghatak, A.K., D.P.S. Malik and I.C. Goyal, 'Electromagnetic Wave Propagation through a Gas Lens', Optica Acta, (In Press, 1973).
6. Malik, D.P.S., Anjana Gupta and A.K.Ghatak, 'Propagation of a Gaussian Beam through Curved Selfoc Fiber', (communicated).

CONTENTS

CHAPTER	PAGE
I- INTRODUCTION	.. 1-10
II- APPLICATION OF THE PARABOLIC EQUATION TO THE PROPAGATION OF LASER BEAMS IN RADIALLY INHOMOGENEOUS MEDIA	.. 11-65
1. The Parabolic Equation	.. 11-18
2. Approximate Solutions for Slowly Converging/Diverging Beams	.. 18-21
3. Solutions in Geometrical Optics Approximation	.. 21-34
4. Wave Optics Considerations	.. 34-50
5. The Gas Lens and Comparison with Experimental Data	.. 50-65
III - PROPAGATION OF A GAUSSIAN BEAM THROUGH A CIRCULARLY CURVED SELFOC FIBER	.. 66-78
1. Modal Analysis	.. 66-71
2. Fundamental Mode of the System	.. 71-73
3. Propagation of a Gaussian Beam	.. 73-74
4. Numerical Results and Discussion	.. 75-78
REFERENCES	.. 79-85