# PHOTONIC BAND-GAPS A TWO CONCENTRIC CORE OPTICAL FIBER

A. Luis-Ramos[1], E. Martí-Panameño[2]

*1 Facultad de Ciencias de la Electrónica*
*2 Facultad de Ciencias Físico-Matemáticas*

*aluis@fcfm.buap.mx*

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## Introduction

Many applications in the field of fiber lasers, light-wave telecommunications, medicine, etc., demand devices based on novel design of optical fiber; the multi-clad fibers play a relevant role in this kind of applications. One of the most important applications is the use of this fiber as dispersion compensating fiber[3]. In this work, the analytical and numerical solution for the HE and EH modes of a two concentric core fiber[6] is presented. This fiber in contrast to the multi-clad one presents a layer where it is supposed that guided modes exist.

The classification of the modes in cylindrical dielectric waveguides consisting of two or three layers have been topic of study for a couple decades. A. Safaai-Jazi and G. L. Yip[9] presented a new scheme based on the separation of the characteristic equation and the classification of hybrid modes. Due to the fact this scheme covers a wide range of structures , we have chosen it as basis to study the modal structure of our fiber. With the aid of computational analytic support, the separation of the dispersion equation for the hybrid modes is achieved. Our results

suggest the existence of discontinuities in the dispersion curves of the modes.

### Formulation of the Problem

The characteristic equation is derived by matching, using continuity conditions, the tangential components $E_\varphi$, $E_z$, and $H_\varphi$, $H_z$ in each boundary, $r = \Gamma$, $r = (\delta + 1)\Gamma$ and $r = (\delta + \gamma + 1)\Gamma$. This provides a system of twelve linear equations for the twelve unknown factors. When using the continuity conditions of $E_z$ and $H_z$, we can eliminate $A_E$, $A_H$, $A_E$, $H_E$ and $H_H$. This permits us to reduce our system of equations to one of $8 \times 8$. So as to avoid trivial solutions the determinant of the given system should vanish. This requirement yields the mode condition that determines the propagation constant.

We tried resolving by traditional methods, but resulted to be a laborious enough task. This was expected since for fibres with two clads it was enough complicated already. We choose to look for a computational package that could solve first the determinant of the matrix and subsequently it could solve the resultant equation in analytic form. We decide to utilize Maple (a package that is a Symbolic Computation System), that has the ability to manipulate information in a symbolic or algebraic manner.

It is important remark the importance of having this result in analytic form, given that in the most cases when fibres with multiple clads are analyzed oversimplified assumption are used at the initial stages of the analysis of the problem.

Once obtained the determinant of the matrix and equalized to zero, the result of this is an equation, mode condition, called dispersion equation, which has a quadratic form for each one of three relations mentioned before.

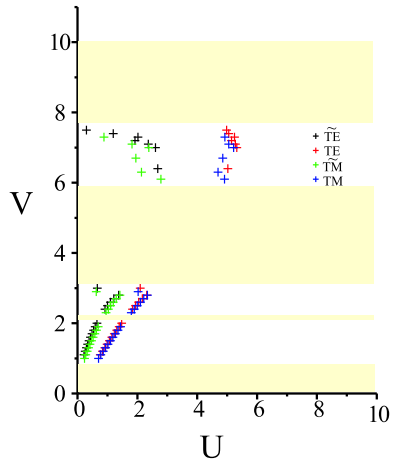


Figura 1: Band-Gaps in a Two Concentric-core Optical Fibre

Given that it is of our interest the relation $\frac{J_2'}{J_2}$, given that in the arguments of the functions are contents the parameters for which we desire to solve we choose this quadratic form and we solve the equation for it. We would be able to have solved for any of these quadratics relations and the classification of the modes will not vary of any form [9]. In general for values of m different to zero , the dispersion equation can split in two parts, that correspond to the hybrid modes HE and EH, when m =0 hybrid modes correspond to the circularly symmetric TE and TM modes, presented subsequently.

**Results**

Figure 1 and 2 shows the behavior of the dispersion curves of the TE and TM modes of the two concentric core optical fiber. These curves have some band-gaps.

**Conclusions**

We have analyzed a new kind of multiclad optical fibre which has as

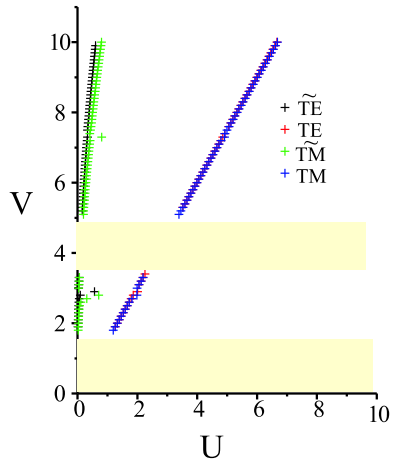


Figura 2: Band-Gaps in a Two Concentric-core Optical Fibre

principal characteristic that it can propagate guided modes in one of its layers. We presented the analytic solution for the dispersion equation for such a fibre. By means of techniques already known we can obtained the analytic separation of TE and TM modes. This result represents a great step in the process for determination of the modal structure of such a fibre, due to the complexity of the equation.

Furthermore, obtaining the analytic solution for this fibre structures type is of prominent importance, since most works accomplish it through approximations or numerical methods.

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