SAPAC SUMMER SCHOLARSHIP

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Open Source Finite Element Modelling Programs

Initially my project involved the search for open source finite element modelling programs. These programs could be used in conjunction with SAPAC's computers to solve problems pertaining to optical fibres. Finite Element modelling is a method in which the area to be solved over is divided into a mesh of sub-domains and each of these sub-domains are solved individually. The ultimate goal of this part of the project was to use an open source program to model microstructured fibres, however to look at the basic functionality of each program I initially tested their performance in the modelling of step index fibres.

Over the course of this project I looked at a number of the most prominent open source FEM programs. These included ELMER, pdnMesh and OpenFoam. Through extensive reading of the documentation of each of these programs and through the installation of these programs on the Hydra computing cluster, I was able to observe how suitable they were for the modelling of optical fibres.

Elmer is a program that was developed by the Finnish IT centre for science and is composed of 3 different parts; ElmerGrid, ElmerSolver and ElmerPost. ElmerGrid defines the mesh to be solved through the use of a rectangular grid of various materials. It then uses edge definitions to set boundary conditions and to geometrically map these edges to define curves. ElmerSolver included one potentially useful solver (Acoustic Helmholtz), however in the end I was unable to modify it to solve the step index fibre problem due to its strict input guidelines. ElmerPost is the final component of Elmer. ElmerPost is a GUI that is used to view the results of ElmerGrid and ElmerSolver visually.

OpenFoam is a program that was developed by OpenFoam Ltd. After reading the documentation for this program it was easy to see that this program was primarily designed to target problems in the fields of chemical and structural engineering. As there were no suitable solvers listed, it was apparent that adapting this program to solve for problems involving the transmission of light would require an additional module to be written. Therefore once this fact was established no further time was invested in this particular program

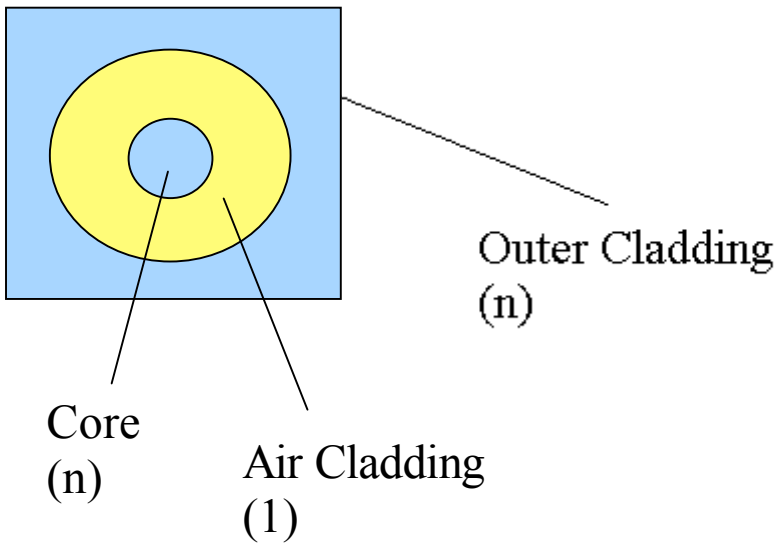
PdnMesh is a program developed by Sarod Yatawatta. The mesh definition in this program is produced via an ASCII text input format and consequently can not produce curved surfaces. I avoided this program by defining the circles required through the use of multi-sided polygons. Unlike the other programs in question, this program included the solver that is required to look at the guidance of light (Inhomogeneous Helmholtz equation). This allowed the program to determine accurate solutions for slab waveguides and many other examples involving the guidance of light. Unfortunately, when applied to the problem of a step index optical fibre it was unable to produce a solution that confined light to the core. This may have been due to a problem with the ARPack that was used, or a programming error on the part of the designer.

It was my conclusion that in the case of all of these programs, although the tools were available to define useful problem geometries, the solvers included in these packages were ineffective in reaching a sensible answer for problems involving the propagation of light.

Modelling of a W-Shaped Optical Profile

The second part of my project was to use the current Finite Element Modelling program used by the optics group (Comsol) present on Corvus to model a W-shaped optical profile. A W-shaped profile in this case is an approximation for a type of optical fibre where due to thin struts between the core and the outer-cladding, the inner-cladding is predominantly air.

The goal in using this approximation was to determine how small the core of the fibre could be made while still maintaining an acceptable confinement loss. This needed to be done as for sensing applications as much light as possible is needed in the air cladding of the W-Shaped optical profile, and as the core size is reduced more and more light will be forced out into this air cladding as the effective mode area is increased.



I looked at this problem in the context of a terahertz regime (600um) and I varied the core diameter between 140um and 220um. I also varied the core to air-cladding ratio from 1:8 to 1:16. I found that for the smaller core sizes (140um – 180um) the confinement loss was unacceptably high (50-500 dB/m) for even the largest ratios. In order to maintain an acceptable confinement loss the core must be at least 200um and even larger as the ratio is decreased.

As a secondary part to this problem struts were introduced between the core and the outer cladding in order to look at the difference this made to the results. Three struts were added into the air cladding, 120 degrees apart from one another and of varying thickness (1/10 – ¼ of the core diameter). Unfortunately I was unable analyse the data gained before the conclusion of the SAPAC summer scholarship program.

By looking at this problem I was able to test the functionality of Comsol on Corvus. I determined that there are certain limitations that reduce the accuracy and efficiency of this program. Some of these limitations are due to it not being the most recent version of the program and therefore lacking some of the latest features. Some other limitations are due to this program for some reason not being compatible with matlab. This means that only the GUI part of the program is useable to solve any given problem and matlab scripts are unable to be used.

In conclusion, the front end of this program is still quite usable. The GUI is quite intuitive and by using it I was able to define the geometry for the W-shaped profile. Through the use Comsol's solvers it was easy to observe the varying degrees confinement loss, as the size of the core was changed.