RF CAVITY COMPUTER DESIGN CODES.

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Abstract

Computer simulation tools for RF cavity design have become a necessity in many laboratories around the world. There is a need for accurate predictions of fundamental frequency, Q factor, accelerating voltage requirements and longitudinal and transverse higher order mode impedances, all of which are of paramount importance when the price of manufacture of these cavities is so great but their influence on beam behavior is critical. There are numerous 2D and 3D simulation codes available at the moment which aid accurate modelling of accelerating structures but this paper focuses on three: MAFIA, URMEL-T and SuperLANS.

I. INTRODUCTION

The design of RF cavity geometry has become highly dependent on the use of computer design packages, whether it is 2D or 3D. There are many commercially available packages [1] on the market at the moment which give accurate geometry solutions to particular design criteria. The three packages which are the subject of this paper, are a small selection of those currently available and have been employed at Daresbury for several years. It is the intention of this paper to outline the internal functioning of these packages and to illustrate the computational resources required to operate them.

II. COMPUTER SIMULATION CODES

A. MAFIA v2.04, release 22/1/90. [2]

MAFIA is a 3D simulation code used for the design of RF cavities and other electromagnetic structures, including electrostatic and magnetostatic devices. It is an acronym for the solution of **MA**xwell’s equations using the **F**inite **I**ntegration **A**lgorithm. MAFIA comprises of a suite of programs which use the Finite Integration Technique to produce a set of finite-difference equations for the electric and magnetic field vectors for a particular geometry under investigation. The solutions to these equations provide time and frequency solutions to Maxwell's equations. The programs have dedicated functions which interact on the proceeding program (Table. 1) i.e. the output from a particular program is partly used as input to the following program.

Program	Description
M3	Mesh Generator
R3	Equation Generator
E31,E32	Eigenvalue Solvers
T3	Time Domain Solver
P3	Post Processor

Table 1. MAFIA subroutines and their function.

MAFIA uses a rectangular mesh generation routine which is flexible enough to model even the most complex geometries. The routine allows the user to specify the "coarseness" of the mesh in a particular area of interest.

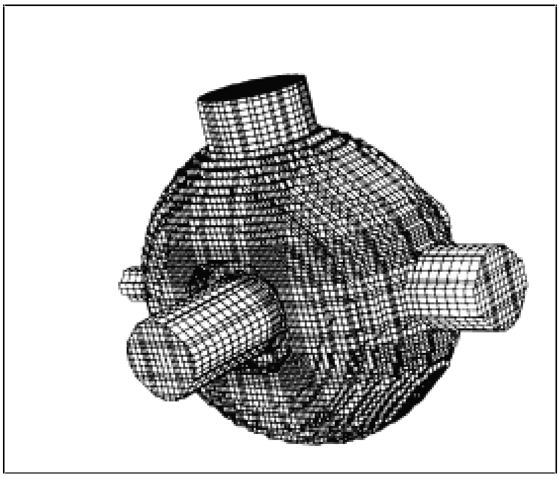

Figure 1. MAFIA 3D Mesh Generation.

MAFIA has been used quite extensively at Daresbury since its release under the auspices of the MAFIA collaboration, which comprised DESY,LANL and KFA in 1987. It is run on a Silicon Graphics *Indigo*^{2} compute server, comprising; MIPS R4400 CPU at 140MHz, 128Mb RAM and is the only 3D simulation code presently available for RF cavity design at Daresbury.

Program	**Real (secs)**	**User (secs)**	**Sys (secs)**
M3b	82.52	71.77	0.51
R3	222.21	149.51	15.37
E31	3631.01	2906.27	33.64
P3b (list)	81.63	31.69	7.58

Table 2. Typical execution times for an optimised nose-coned cavity with 180,000 mesh points.

B. URMEL-T v2.04, release 6/7/90. [3]

URMEL-T is a 2D simulation package which evaluates electromagnetic properties of cylindrical symmetric accelerating structures in the frequency and time domain. It uses a triangular mesh geometry (see Fig. 2) to give good approximation of the accelerating structures. By transforming Maxwell's equations into a linear algebraic eigenvalue problem, the frequency solutions are found in ascending order and "no modes are missed". URMEL-T not only allows for the solutions of longitudinal modes but it also has the ability to solve for Dipole (or transverse) modes.

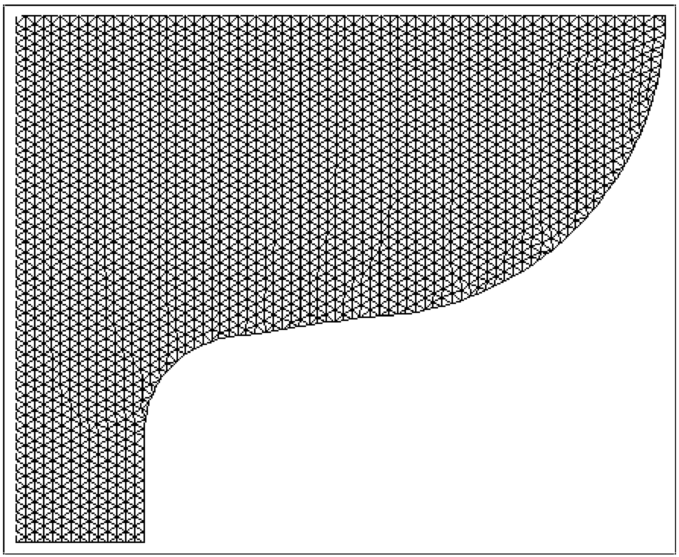

Figure 2. Finite Difference Mesh Generation in URMEL-T.

URMEL-T uses triangular mesh generation techniques, as opposed to its predecessor URMEL which used rectangular methods, which gives URMEL-T a greater flexibility at being able to closely map quite complex cavity geometries. Similarly, URMEL-T is run on a Silicon Graphics *Indigo*[2] workstation and typical execution times for an optimised spherical cavity with 3922 mesh points are:

Program	**Real (secs)**	**User (secs)**	**Sys (secs)**
URMEL-T	111.68	46.58	0.58

Table 3. Typical URMEL-T execution times.

C. SuperLANS. [4]

SuperLANS is a comparatively new finite element code which is used for the calculation of azimuthal homogeneous modes in axisymmetrical periodic structures and also for the calculation of critical frequencies in long homogenous waveguides. The code is used on an IBM compatible PC (with co-processor) and consists of a number of dedicated sub-routines, rather like MAFIA, which interact on the proceeding routine. The code can either be run interactively or in batch mode, Fig 3. shows the sub-routine hierarchy.

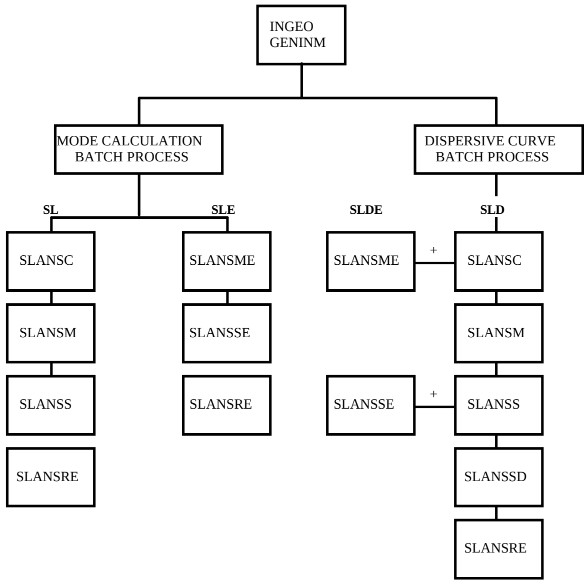

Figure 3. Sub-routine Hierarchy of SuperLANS Program

Whereby each routine performs the following function;

Routine	Description
INGEO	Input geometry
GENINM	Mesh generation
SLANSC	Definition of calculation parameters.
SLANSM	Matrix calculation
SLANSS	Definition of the cavity spectrum.
SLANSRE	Output of results.
SLANSD	Calculation of dispersive curves.
SLANSME	Matrix calculation for coordinated resultants.
SLANSSE	Calculation of coordinated resultants.

Table 4. SuperLANS Program list.

SuperLANS has the facility, whereby the geometry can be modified and interactively, the program will display the new resonant frequency (plus a specified number of HOM's), giving the user the ability to move the HOM spectrum away from potentially dangerous modes whilst maintaining the required resonant frequency.

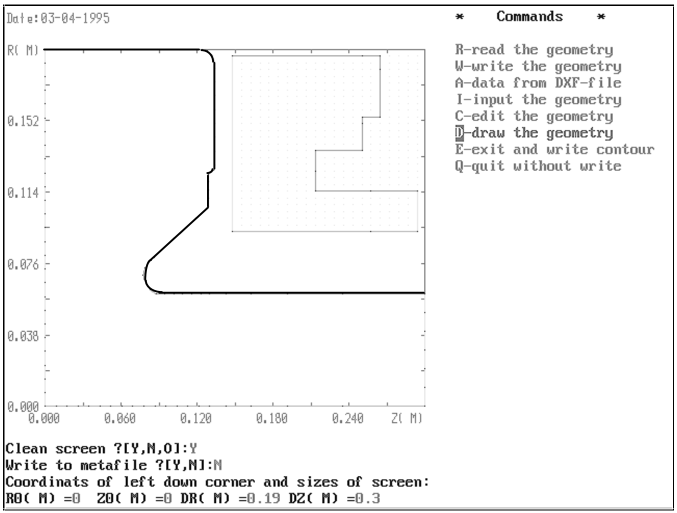

Figure 4. Geometry Manipulation Interface for SUPERLANS.

III. OTHER CODES

It is Daresbury's intention to broaden its use of RF cavity design codes and evaluation is planned for SuperFISH [5] which has been installed on an IBM compatible PC. A thorough evaluation of this code will be carried out by computing geometries already analysed by the aforementioned codes. It is also planned to evaluate the 3D version when it becomes available.

IV. CONCLUSIONS

For the accurate prediction of HOM frequencies of a real structure, a full 3D code is essential. Nevertheless a lot of useful work can be done with 2D codes, particularly in the early stages of the design of a structure. The increase in computational power of workstations and desktop PC's, means that it is no longer essential to have access to mainframe computers for this work.

V. ACKNOWLEDGMENTS

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VI. REFERENCES

[1] Computer Codes for Particle Accelerator Design and Analysis: A Compendium, H.S. Deaven and K.C.D. Chan, LA-UR-90-1766 (1990).

[2] MAFIA User Guide, The MAFIA Collaboration: DESY, LANL and KFA, May 1988.

[3] URMEL and URMEL-T User Guide, U. Laustroer, U van Rienen and T. Weiland, DESY, Feb 1987.

[4] The Code SUPERLANS, D.G. Myakishev, Novosibirsk-90, 630090, Russia, Jan 1993.

[5] PC Version of Poisson/SuperFISH Code Series, Version 4.12, Judith Coleman, Brookhaven National Laboratory, Upton, NY 11973, USA.