

AN INTERACTIVE CODE SUPERLANS FOR EVALUATION OF RF-CAVITIES AND ACCELERATION STRUCTURES

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Abstract

The new code SUPERLANS is described. The main SUPERLANS features are: an evaluation of both the standing waves in axisymmetrical cavities and travelling waves in periodic structures; the number of modes (or dispersion curves) are calculated simultaneously in the arbitrary spectra domain. To increase the code efficiency the following modern methods are used: the isoparametric second order finite elements for the field approximation; the subspace iteration method for the determination of spectra. To increase the accuracy of calculation of the field near the axis the coordinates (Z, R^2) are used. There is code version for IBM PC/AT with the interactive dialogue data input and postprocessor with developed graphics. The code is currently used for the INP RF-system design.

INTRODUCTION

In 1979 the LANS [1] code was developed in the INP. The code used the inverse iteration method with a spectra shift for the calculation of the eigen frequencies in the arbitrary spectra domain in axisymmetrical RF-cavities. The triangular simplex elements were used in the code. Then other codes MULTIMODE [2] and PRUD [3] were developed. The subspace iteration method is used for the simultaneous calculation of the number of modes in the codes. The codes also permits to calculate the dispersion curves in periodic structures. The isoparametric second order elements are used in the codes. We develop new code SUPERLANS based on the methods which are used in these codes. The main features of new code are:

- the code is made for personal computer and has interactive input-output and uses the graphical possibilities of the computer;
- the problem formulation is used, which eliminates the singularity in matrix elements on axis [2, 3];
- the coordinates (Z, R^2) are used for the increase in accuracy of field calculations near axis.

GENERAL

The code SUPERLANS was made for the calculation of azimuthally-homogeneous modes in the axisymmetrical RF cavities and periodic structures. For the evaluation of eigen modes the wave equation with respect to following function is solved: function:

$$\Pi = \begin{cases} r \cdot H_n - E \text{ wave} \\ r \cdot E_n - H \text{ wave} \end{cases}$$

The boundary conditions are set on axis, plane of symmetry and metallic surfaces. The metallic surfaces are supposed to have an ideal conductivity. The grid with eight node isoparametric elements is used in the code. The Galerkin method is used to obtain an algebraic system $(\mathbf{A} - k^2 \cdot \mathbf{B}) \cdot \Pi = 0$. Unlike [2, 3] the integration in the Galerkin method is made over the volume problem, but not over the square of the cavity cross-section. In this case, the matrix coefficients haven't the singularity in integral

expression:

$$a_{ij} = \int (1/x \cdot \partial \psi_i / \partial z \cdot \partial \psi_j / \partial z + \partial \psi_i / \partial x \cdot \partial \psi_j / \partial x) dx dz, \\ b_{ij} = \int \psi_i \cdot \psi_j / x dx dz, \quad \text{where } x = r^2/4.$$

The Dirichlet boundary condition is set on axis, so the matrix coefficients aren't calculated for the axis nodes. The basic functions and their derivatives with respect to z for the nodes near axis are proportional to x , so the matrix coefficients haven't singularity in the integral expression on axis.

The reason of using the coordinate system $(Z, R^2/4)$ is the following. The function Π is proportional to r^2 near axis, since the field is proportional to r near axis. Isoparametric elements are closed to rectangle near axis, so, if the ordinary coordinate system is used, the r and z coordinates are proportional to the corresponding local coordinates. As a result, the function Π and r behave similarly near axis, so Π is proportional to r . Therefore, the coordinate system $(Z, R^2/4)$ is put into operation to remove this uncorrectness in the field description. In this case, we must to move the middle nodes on elements near axis for the right description of coordinates on element. The node on element side perpendicular to the axis is moved. The radius of node is found from the equation $r^2 = r_0^2/2$, where r_0 — the radius of corner node.

As we have said above, SUPERLANS permits to calculate the travelling waves in periodic structures. The calculation of the dispersion curves is made automatically. The Floquet theorem [4] is used for the calculation of travelling waves. The theorem permits to build the travelling wave with the phase shift θ over the structure period by two real functions. One of them is symmetrical on the period, the other is antisymmetrical. The equations for this functions are analogous to the equation for the standing wave. The functions are related on bound of period by coefficients dependent of the phase shift θ .

The code also permits the evaluation of the RF cavity with an inhomogeneous ferromagnetic and dielectric filling. For example, the one version of cavity with the retuning of frequency for the LEB [5] is shown below.

The code is realized on IBM PC/AT and the graphic possibilities of computer are widely used. The interactive input-output are used with simultaneous displaying graphical information. This possibility simplifies the procedure of cavity geometry input. The logical mesh with maximum number of nodes 3000 is used for generating the finite element mesh. Ten modes can be iterating simultaneously in the arbitrary spectra domain.

The code applications are shown on some examples.

The field distributions of two modes in DAW structure [6] are shown in Figs. 1a and 1b, and dispersion curve is shown in Fig. 1c.

The calculation of RF cavity of VEPP-5 [7] is given in the Figs. 2a, 2b. The wide spectra domain was explored (200 modes) for this cavity. The working and one of the highest quasi-optic modes are shown in figures.

The results of cavity calculation for accelerator «Si-

beria» [8] are given in Figs. 3a, 3b. In this case the modes, interacting with a beam, are shown.

The two first modes of cavity of accelerator «ILU-10» [9] are shown in Figs. 4a, 4b. The specific feature of this cavity is that it consists of two parts.

The constant voltage is applied to the internal part to suppress the multipactor.

The calculation result of the one version of cavity for the LEB with an inhomogeneous ferromagnetic and dielectric filling is shown in Fig. 5. This cavity is tuned in RF frequency within 30%.

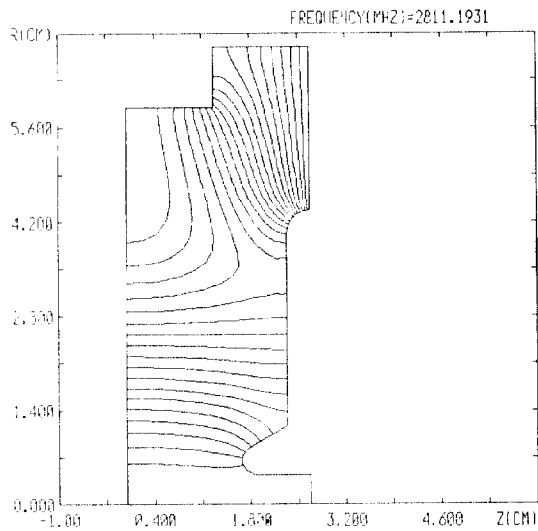


Fig. 1a

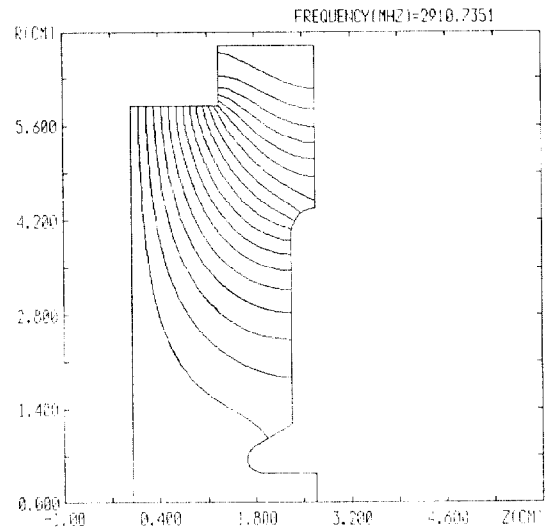


Fig. 1b

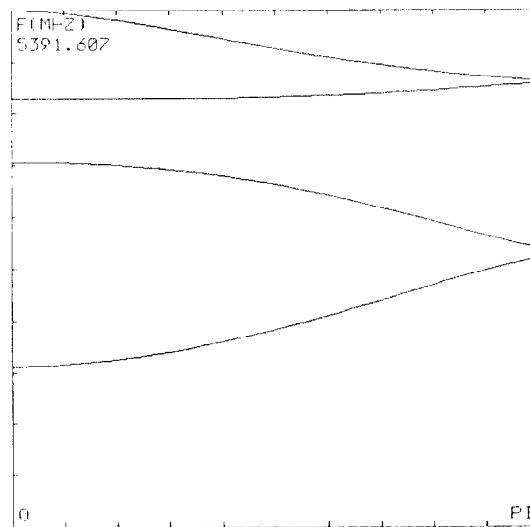


Fig. 1c

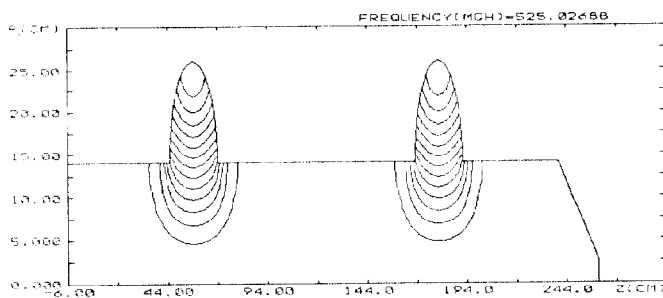


Fig. 2a

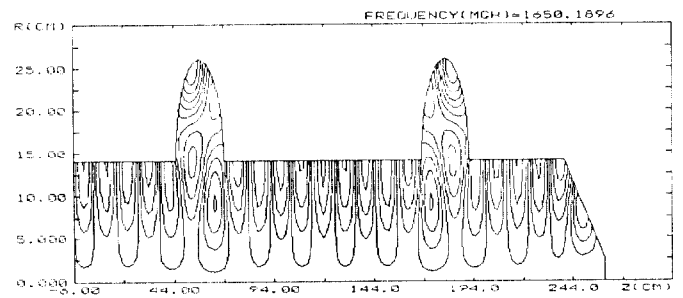


Fig. 2b

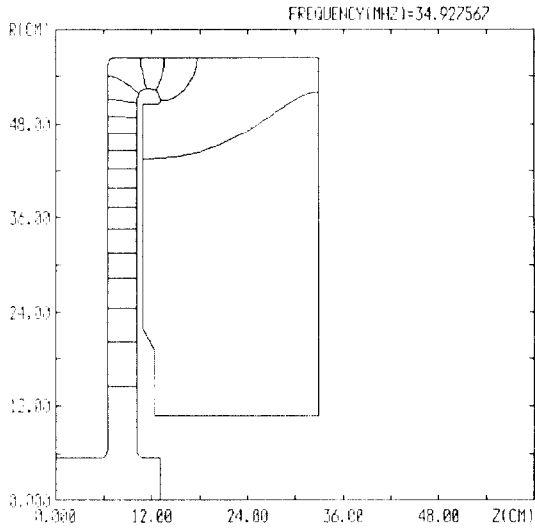


Fig. 3.a

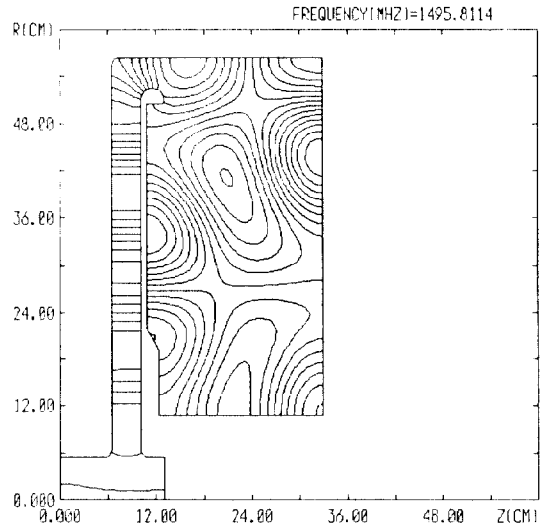


Fig. 3.b

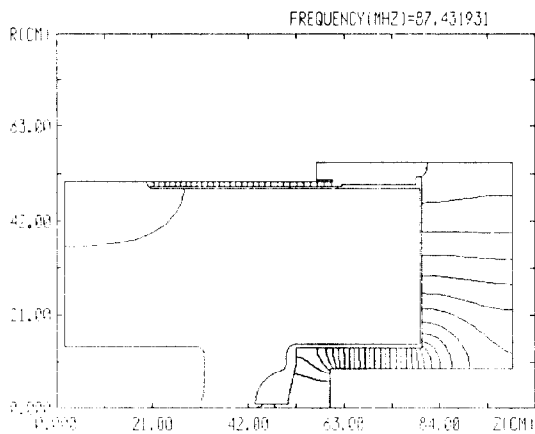


Fig. 4.a

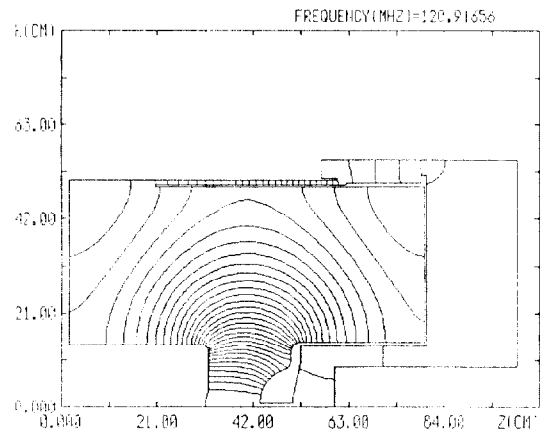


Fig. 4.b

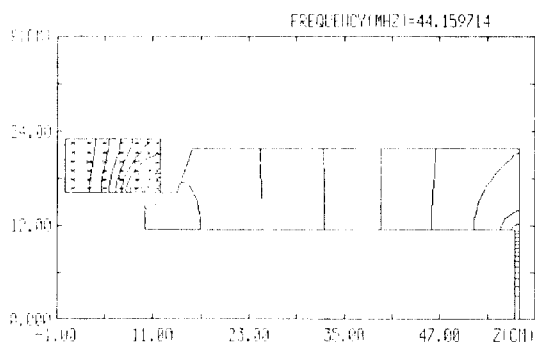


Fig. 5.

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