Acta Societatis Mathematicae Latviensis
Abstracts of the 5th Latvian Mathematical Conference, April 6–7, 2004, Daugavpils, Latvia

RF ELECTRIC FIELD MODELLING IN CAVITY OF GYROTRON

JĀNIS BAJĀRS

Institute of Mathematics of Latvian Academy of Sciences and University of Latvia

Akadēmijas laukums 1, LV-1524, Rīga, Latvia

E-mail: jbajars@one.lv

Three principal radiofrequency (RF) heating schemes are in use in present fusion devices: ion cyclotron (IC), lower hybrid (LH), and electron cyclotron (EC) heating. While IC and LH waves can be used in fusion experiments, the development of powerful EC wave sources is still in progress. The only microwave source capable of generating power levels relevant for fusion in frequency range (100-300 GHz) is called the gyrotron. The operation of gyrotron is, in principle, described by Maxwell's equations for the electromagnetic fields, along with the relativistic equation of motion of the electrons. The step in the derivation of the reduced equations for gyrotron analysis is the description of the electric RF field as a superposition of (relatively few) eigenmodes of the waveguide in the interaction cavity of gyrotron where the interaction takes place. We obtain the following system of partial differential equations which describe self-consistently multimode gyrotron oscillations

$$\begin{cases} \dfrac{\partial p}{\partial \zeta} + i(|p|^2 - 1)p = i\displaystyle\sum_s f_s \exp\left[i(\Delta_s \zeta + a_s \tau + b_s \phi)\right] \\ \dfrac{\partial^2 f_s}{\partial \zeta^2} - i\dfrac{\partial f_s}{\partial \tau} + \delta_s f_s = I_s \dfrac{1}{4\pi^2} \displaystyle\int_0^{2\pi}\int_0^{2\pi} p\, d\theta_0 \exp\left[-i(\Delta_s \zeta + a_s \tau + b_s \phi)\right]\, d\phi \end{cases} \tag{1}$$

with initial conditions

$$p(0) = \exp(i\theta_0) \quad 0 \le \theta_0 < 2\pi, \quad f_s(\zeta, 0) = f_{s,0}(\zeta), \tag{2}$$

and boundary conditions

$$f_s(0, \tau) = 0, \quad \frac{\partial f_s(L, \tau)}{\partial \zeta} = -i\gamma_s f_s(L, \tau). \tag{3}$$

Computation results in Fortran with 7 modes show that one of the mode's total value at the exit from the interaction space goes asymptotically to constant but others to zero. That gave idea to modify program with automatically time step in difference schemes for understanding if large constant time step gives us good accuracy. Results showed that the solution scene is the same and result accuracy differs for one unit in the third number behind comma. Automatically step program let us overtake optimal constant time step for optimal calculation time.

REFERENCES

[1] N.S. Ginzburg, N.A. Zavolsky, G.S. Nusinovich and A.S. Sergeev. Onset of autooscillations in electron microwave generators with diffraction radiation output. *Izv. Vyssh. Uchebn. Zaved. Radiofiz.*, **29** (1), 1986, 106 – 114.(in Russian)

[2] M.I. Airila, O. Dumbrajs, A. Reinfelds and U. Strautiņš. Nonstationary oscillations in gyrotrons. *Phys. Plasmas*, **8** (10), 2001, 4808 – 4812.