HAMILTONIAN THEORY OF COMPLEX ELECTRON DYNAMICS IN GYROTRON RESONATORS*

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The knowledge of the complex electron dynamics in gyrotron resonators is significant for the design of efficient high-power gyrotrons. In this work, electron dynamics are studied in the context of the Hamiltonian formalism. The application of the Canonical Perturbation Theory provides analytical approximate invariants of the electron motion. The latter are used for describing the resonant structure of the electron phase space and the electron rest energies at the output of the cavity. Hysteresis effects are also described through analytic expressions and approximate electron distribution functions are provided. The general case of resonant interaction at an arbitrary harmonic of the electron cyclotron frequency is considered and the effect of a varying frequency mismatch is studied. Also, the case of electron interaction with multiple rf modes is investigated.

Electron dynamics in gyrotron resonators are also described in terms of a Hamiltonian map, constructed with the utilization of the approximate invariants of the motion. This map incorporates the dependency of electron dynamics on the parameters of the interacting rf field and it can be used for trajectory calculations through successive iteration, resulting in a symplectic integration scheme. The direct relation of the map to the physics of the model, along with its canonical form (phase space volume preserving) and the significant reduction of the numberof iteration steps required for acceptable accuracy, are the main advantages of this method in comparison with standard methods such as Runge-Kutta. The general form of the Hamiltonian map allows for wide applications as a part of several numerical algorithms which incorporate CPU-consuming calculations of electron trajectories.

References

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