RADIATION INSTABILITY IN RELATIVISTIC SPLIT-CAVITY OSCILLATOR

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In recent decades, the interest in high-power microwave (HPM) sources has been increasing. The sources are widely used in science and industry, e.g., plasma heating, high-power radars, particle acceleration, etc. Such a wide area of applications led to a large variety of HPM sources (e.g., klystron amplifiers, gyrotrons, backward wave oscillators, travelling wave tubes, transit-time oscillator, virtual cathode oscillator, etc.) that are suitable for specific purposes. Despite the great success in their development, the usage of them is often limited by a large size or low efficiency. To overcome these limitations, Barry M. Marder and his group have developed a new device called a split-cavity oscillator (SCO) [1, 2], which was further improved by others [3, 4]. The SCO consists of a cylindrical resonator with a conducting screen walls splitted by a conducting screen (Fig. 1) through which an electron beam can pass. This configuration has additional electromagnetic modes (Fig. 1) in comparison with a hollow resonator. The first theoretical consideration of the SCO in the relativistic case was carried out by V. Baryshevsky in [5].

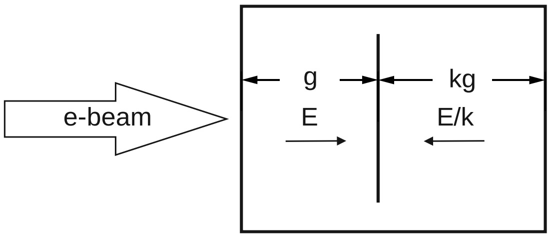

Fig. 1. Schematic representation of the asymmetric SCO, where *g* is the longitudinal size of a cavity, *E* is the electric field, *k* is the parameter of asymmetry.

This work is devoted to the theoretical research of the radiation instability of the electron beam in the SCO. The interaction between the electron beam and the fundamental mode was considered. Expressions of an electron energy change ΔK and a beam current modulation were obtained for the relativistic case in the asymmetric SCO. The influence of the space charge of the beam on ΔK and the beam current modulation was numerically analyzed. The rise time of the modulating electric field in the resonator was estimated. The small-signal analysis showed that the optimal configuration is symmetric (*k*=1, see Fig.1). Moreover, the growth of the space charge increases the energy transfer from an electron to the field (Fig.2) and almost does not affect the resonator size. The rise of the electron velocity decreases the energy transfer to the electromagnetic field (Fig.2).

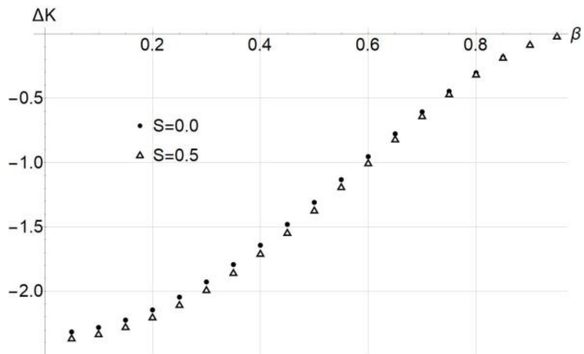

Fig. 2. Dependence of the electron energy change ΔK on electron velocity divided by the speed of light for *S*=0 and *S*=0.5, where the dimensionless parameter *S* describes the beam current.

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