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Self-amplification of Radiation from an Electron Bunch Inside a Waveguide Filled with Periodic Medium

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We investigate the radiation from a bunch of relativistic electrons moving along the cylindrical waveguide axis, assuming that a part of the waveguide is filled with a layered material, the dielectric permittivity and magnetic permeability of which are arbitrary periodic functions. Analytical expression is provided for the spectral distribution of the radiation energy flux through the cross section of the waveguide at large distances from the layered medium. It is based on the corresponding exact solution of Maxwell equations for the case of a single electron moving along the waveguide axis. The results of numerical calculations are presented in the special case of layered medium consisting a finite number of dielectric plates separated by vacuum gaps. We show that under certain conditions on the problem parameters, the quasi-coherent Cherenkov radiation generated by the electron bunch inside the plates is self-amplified at certain waveguide modes. A visual explanation of this phenomenon is provided. We also present a simplified model that reproduces with satisfactory accuracy the main features of the self-amplification phenomenon. The possibility of using this phenomenon to develop powerful radiation sources in the terahertz frequency range is discussed.

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