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Radiation from a Wakefield Dielectric Structure with Open End

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In recent years, emission of terahertz (THz) electromagnetic waves attracts essential attention of researchers. Radiation in this frequency region can be used for variety of applications, for example, investigation of biology objects, beam diagnostics in accelerators, etc. One recent idea for producing efficient THz radiation consists in passing of specially prepared electron bunch through a wakefield dielectric structure [1]. We utilized several approaches to investigate radiation exiting the open end of such a structure [2,3]. In the present report, we consider the situation where semi-infinite cylindrical waveguide with uniform dielectric filling is placed into collinear infinite vacuum waveguide with larger radius, with dielectric part being excited by a single waveguide mode. We utilize rigorous approach based on mode-matching technique and modified residue-calculus technique [4]. In the issue, we obtain certain nonlinear infinite system which should be solved using iteration process. However, convenient zero-order approximation and asymptotic of the solution are dictated by Meixner's edge condition, therefore simplifying considerably the numerical procedure. We develop numerical algorithm and obtain structure of reflected and transmitted modes for various frequencies and structure dimensions.

We also perform 3D simulation of the described problem using CST code. Obtained results are in agreement within less than one percent accuracy. It is noticeable that our rigorous approach takes around 50 times smaller simulation time compared with CST, and this ratio can be further improved. We also consider more complicated cases of a vacuum channel in dielectric structure and excitation by a point moving charge. Moreover, we calculate radiation from considered structure into free space by supposing that the larger radius waveguide has an open end at some essential distance from the dielectric structure. We show that typically reflection from this end is weak, therefore radiation process can be considered separately on the basis of known mode structure and known rigorous formulas [6].

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