PHYSICAL REVIEW A VOLUME 43, NUMBER 7 1 APRIL 1991

Čerenkov traveling-wave tube with a spatially varying dielectric coefficient

Levi Schächter
Laboratory of Plasma Studies and School of Electrical Engineering, Cornell University, Ithaca, New York 14853
(Received 5 October 1990)

The beam-wave interaction in a Čerenkov traveling-wave tube (TWT) is considered theoretically. The system is assumed to operate at 8.75 GHz and the injected electrons have an average kinetic energy of 0.85 MeV. We initially consider the case corresponding to a *prebunched* beam. In order to avoid saturation, two kinds of tapering are considered: one that is adaptable, in the sense that the phase velocity follows exactly the particle's velocity, whereas the other is characterized by a dielectric coefficient that varies linearly in space. When the electrons are in antiphase with the wave (for $E_0=5$ MV/m, $I=1$ A, and $d=0.8$ m), the adaptable tapering causes the accelerated bunch of electrons to achieve an energy that is twice that obtained with a linear tapering. For the same parameters there was practically no acceleration in the case with a uniform dielectric coefficient. The other case considered corresponds to a beam whose electrons have a *uniform* distribution of phases relative to the wave. The development of the bunching is illustrated as well as the strong Compton regime, where the exponential gain occurs. The latter is in reasonable agreement with the predictions of conventional TWT wave theory; however, the bunching takes more of the interaction region to develop than predicted by Pierce's theory. We show that by tapering both gain and efficiency increase. When operated as an amplifier ($E_0=1.0$ MV/m, $I=450$ A, and $d=0.3$ m) with an optimal linear variation of the dielectric coefficient, the device's efficiency is improved to about 30% from 5% in the uniform device.