Coherent Cherenkov-Cyclotron Radiation Excited by an Electron Beam in a Metamaterial Waveguide

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An electron beam passing through a metamaterial structure is predicted to generate reversed Cherenkov radiation, an unusual and potentially very useful property. We present an experimental test of this phenomenon using an intense electron beam passing through a metamaterial loaded waveguide. Power levels of up to 5 MW are observed in backward wave modes at a frequency of 2.40 GHz using a one microsecond pulsed electron beam of 490 keV, 84 A in a 400 G magnetic field. Contrary to expectations, the output power is not generated in the Cherenkov mode. Instead, the presence of the magnetic field, which is required to transport the electron beam, induces a Cherenkov-cyclotron (or anomalous Doppler) instability at a frequency equal to the Cherenkov frequency minus the cyclotron frequency. Nonlinear simulations indicate that the Cherenkov-cyclotron mode should dominate over the Cherenkov instability at a lower magnetic field where the highest output power is obtained.

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