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ELECTRON CYCLOTRON RESONANCE ACCELERATOR eCRA

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Solutions of the single-particle equations of motion for electrons in the fields of an idealized TE111 microwave cavity in an external magnetic field near cyclotron resonance show acceleration rates that substantially exceed the limits for the CARA interaction. We have dubbed this new accelerator "eCRA." Here, results are presented for realistic TE111 eCRA cavity geometry and finite space-charge beams that confirm the idealized solutions. The new features include cavity openings for RF inputs, beam injection, and pumping; RF input couplings that maximize efficiency; a thin window for exit of the accelerated beam; realistic magnetic field profiles; finite diameter multi-Ampere beams; and transient beam dynamics to model pulsed operation. One simulated eCRA example is for a copper cavity with Q0 of about 19,000, and a filling time of 85 ns due to strong external coupling. With RF input power at each of the two ports of 12.5 MW, an 8.0-A, 100 keV beam was shown to be accelerated to 2.2 MeV, giving a pulsed beam power of 17.6 MW and efficiency of 67%. Many applications are recognized for MW-class eCRA beams with energies in the range 1-10 MeV. Our first proof-of-principle demonstration of eCRA is to produce beams to generate intense X-ray fluxes to enable the replacement of radioactive sources now widely used for sterilization of medical supplies and foodstuffs. This demonstration will be based on use of available S-band components, although the optimal operating frequency for eCRA could be about 1000 MHz. In any case, the possibility of MW-level average power eCRA beams—even with predicted efficiencies >80%–will depend upon the availability of the required RF sources to drive eCRA. One candidate for this role is the 20-MW peak power two-stage multi-beam 1000 MHz klystron reported elsewhere in this Workshop.

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