§15. High-Power Slow Wave Cyclotron Maser Based on Cherenkov and Anomalous Doppler Interactions

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We demonstrate experimentally the slow wave electron cyclotron maser (ECM) based on cyclotron and Cherenkov instabilities with a moderate beam energy regime less than 100 keV and a relatively high beam current above 100 A. The slow wave structure is a sinusoidally corrugated metallic waveguide and is oversized with the mean diameter, 60 mm, four times larger than the free space wavelength of the microwave output. At resonance, the output RF power is strongly enhanced and the maximum output power of 100 kW with an efficiency of 2 % at 19.5 GHz is obtained for moderately low beam voltage and a relatively large current of 35 kV and 150 A, respectively (Fig.1). The oscillation mode is observed to be a periodic TM_{01} mode. The enhancement of microwave radiation is estimated to be caused by the combined resonance of Cherenkov and an anomalous Doppler shifted electron cyclotron beam mode.

For a high current electron beam, it is desirable and advantageous to drive high-power microwave sources by an axially injection without initial perpendicular electron velocity. In conventional ECMs such as gyrotrons or cyclotron autoresonance maser, the perpendicular velocity of injected beam is a crucial parameter to be adjusted carefully to obtain high beam-to-RF conversion efficiency. On the other hand, our slow wave ECM can be driven by the electron beam only with longitudinal energy, since it is based on the Cherenkov and anomalous Doppler shifted cyclotron resonances. These two interactions are more tolerant of beam velocity spread than fast wave cyclotron interaction and are particularly suited to operation with intense electron beam.

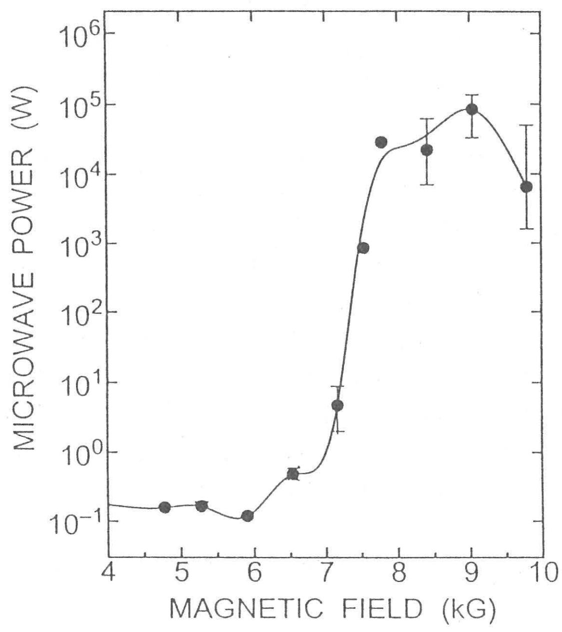

Fig. 1. The microwave output from the slow wave ECM with the beam voltage 35 kV and current 150 A.