

§27. Analysis of the Operation Modes of High-Power Backward Wave Oscillator

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The electromagnetic quantities of slow wave structures (SWS) intended for use in relativistic high power and high frequency operations of BWO have been numerically analyzed. SWSs with sinusoidal axial boundary have been considered for both (a) X-band and (b) oversize or large diameter cases. The finite axial dimension and mismatch effects of the SWS, in either cases, cause the formation of axial mode spectrum due to the quantization of axial wavenumber of the transverse electromagnetic modes. For the X-band SWS, higher order resonant modes are analyzed without beam. The Large diameter BWO (LD-BWO) is analyzed considering an annular beam and the analyses are restricted to fundamental TM_{01} mode only. The dimensions of the SWSs are corresponding to the experimental parameters. For both structures, the inner radius is assumed to vary sinusoidally as $R(z) = R_0 + h \cos(2\pi/z_0)$.

i) X-band overmoded SWS

For this structure, both the fundamental and higher order resonant modes are analyzed in a detailed way without considering beam. Some of the higher order resonant modes show some unusual behavior considerably different from those of fundamental modes [1]. In order to identify the resonant modes experimentally, perturbation technique can be used and the numerical results thus obtained are compared with experimental ones. An example of our analysis and its experimental counterparts are presented in Fig. 1.

ii) LD-SWS

In order to sustain the RF breakdown within the BWO structure, its transverse dimension is made

large. High frequency operation can

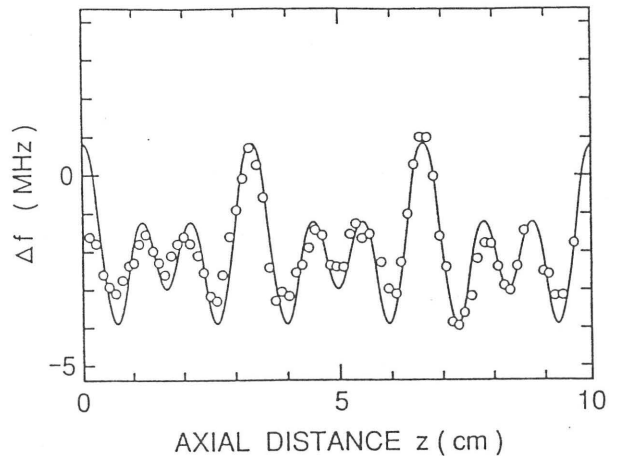


Fig. 1 Perturbed resonant frequencies of $TM_{03}(3\pi/6)$ mode. Open circles represent the experimental results.

be achieved by carefully choosing the corrugation depth (h) and period (z_0) of the structure without decreasing R_0 . Such an oversized SWS is numerically designed for the fundamental TM_{01} mode of operation around 24 GHz. The beam energy $V_b = 65-100$ keV and beam current up to 1 kA are assumed. It has been found that there exists a starting energy of the beam in addition to starting current for initiating oscillation for the finite length SWS. It is consistent with the experimental situations where the beam energy larger than 76.5 keV might be required for oscillation [2].

References

- 1) M. R. Amin et al., "Investigations of Electromagnetic quantities of a finite length slow wave structure", Presented in the meeting of the Physical Society of Japan, Okayama, October, 1993.
- 2) K. Minami et al., "Starting energy and current for a large diameter backward wave oscillator", Presented in the IEEE International Conference on Plasma Science, Santa Fe, USA, June, 1994.