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Advances in Modeling of Beam-Wave Interaction in Multi-Megawatt Gyrotrons[1]

ALEXANDER VLASOV, Naval Research Laboratory

High-power gyrotrons, capable to produce several megawatts of CW radiation in millimeter wave range, are used in many magnetic fusion facilities, and planned to be used in ITER. The gyrotrons employ an interaction between a gyrating electron beam and very high order modes of open cylindrical or co-axial cavities to keep Ohmic losses on cavity walls on acceptable level. Since the gyrotron cavity supports a large number of eigenmodes with different azimuthal and radial indexes many of which are capable of interaction with electron beam at different frequencies. The code MAGY [1,2] has been developed to address the mode competition issue in gyro-devices. MAGY model is based on multi time-scale approach and uses electromagnetic fields expansion into series of eigenfunctions of local transverse cross-section. This approach leads to computationally efficient solution of the Maxwell's Equations. MAGY has been used for design and modeling of gyro-devices in CPI, MIT, UMD, NRL for last decade and demonstrated excellent agreement with experimental data. Modeling of Multi-Megawatt gyrotrons operating at high frequencies (170 GHz and above) presents a new challenge due to the unprecedented level of spectral mode density and higher level of beam current. A co-axial cavity gyrotron has been introduced to reduce this spectral density. To address these computational physics challenges a new MAGY model for mode interaction in gyrotrons with co-axial cavities has been implemented. MAGY has been used to model the FZK (Germany) 170 GHz co-axial gyrotron [3,4]. The results of this modeling will be presented. Further advances in the theoretical models for comparison with the existing experimental data will be discussed.

[1] S.C. Cai, et al, *Int. J. Elect.*, 72, p. 759, 1992.
[2] M. Botton, et al, *IEEE Trans on P S,* 26, p. 882, 1998.
[3] B. Piosczyk, et al, *IEEE Trans. on P S.*, 32, 413, 2004.
[4] A.N. Vlasov, et al, *IEEE Trans. on P S.*, 36, p. 606, 2008.

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