INSERT MISALIGNMENT IN COAXIAL GYROTRONS: PHYSICAL EFFECTS AND NUMERICAL TREATMENT

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ABSTRACT

For the purpose of plasma heating, hollow-cavity gyrotrons with 1 MW output power operate at 140 GHz in Wendelstein 7-X and are developed for ITER at 170 GHz. Higher frequency and/or power requires TE_{mp} operating modes with radial eigenvalues χ_{mp} significantly above 100, which encounter strong mode competition and therefore increased risk of failure during operation.
One possibility to reduce mode competition are coaxial-cavity gyrotrons, where a metallic insert is placed on the gyrotron axis, extending from the electron gun, where it is fixed, through the cavity (where it is longitudinally corrugated) well into the launcher of the quasi-optical mode converter. This approach is under experimental study for a possible upgraded 170 GHz/2 MW ITER gyrotron [1]. For the subsequent tokamak DEMO, frequencies even up to 240 GHz preferably at 2 MW output power per tube are under discussion. Hence, coaxial-cavity gyrotrons for DEMO are under investigation at IHM, alongside with hollow-cavity counterparts [2].
One of the most important challenges of coaxial tubes is that the insert can (and, to a certain degree, always will) be slightly misaligned with respect to the cavity wall, due to manufacturing tolerances. Depending on how large this misalignment actually is, it will lead to a drop in interaction efficiency, mode purity and/or mode stability, and thus in output power and reliability. Since gyrotrons are welded and evacuated after assembly, one might be unable to fully compensate such an internal misalignment in case it turns out to be critical. Therefore one needs to define misalignment tolerances based on realistic simulations beforehand.
This talk gives an overview of possible effects of insert misalignment on electron beam and electromagnetic modes, and how to treat those effects numerically in interaction simulations [3]. Examples are given based on the three-frequency DEMO gyrotron design presented in [4].

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References

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