Validation of Multi-Physics Gyrotron Modeling against Experimental Results

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Gyrotrons used for electron cyclotron heating and current drive in fusion facilities need to operate in long (seconds to hours) pulses, delivering MW-level microwave power at frequencies above 100 GHz. In such gyrotrons, the Ohmic loading of the wall of the resonant cavity is high, typically ~1.5-2 kW/cm\textsuperscript{2} or even higher, and this has always been one of the major technological limiting factors, with respect to output power and efficiency. As a consequence, special attention should be given to the design and performance of the cavity cooling system. In support to this, the MUlti-physiCs tool for the integrated simulation of the CAvity (MUCCA), encompassing the cooling system, the thermal expansion of the cavity, and the interaction between the electron beam and the RF field in the deformed cavity, has been collaboratively developed by Karlsruhe Institute of Technology (KIT) and Politecnico di Torino (PoliTo). The modelling has already been applied to the European 170 GHz, 1 MW Continuous Wave (CW) gyrotron for ITER, addressing nominal operation at design values [1-3]. The very interesting findings, including the possibility of reduced gyrotron performance due to the cavity thermal expansion, call for experimental verification. Therefore, the model is currently being validated against experimental results from the long-pulse (up to 180 s) experimental campaign with the EU ITER CW gyrotron at KIT [4]. Comparison between multi-physics simulation and experiment will be reported and ideas on further refinement of the modeling will be discussed.

Possible exchange: Despite the long experience in long-pulse, MW-class gyrotron development and testing in EU, US, and Japan, advanced multi-physics modeling has appeared only recently. Exchange of views on the influence of the cavity thermal expansion on gyrotron interaction will be very fruitful, using worldwide experimental results to compare short-pulse (ms) operation (non-deformed cavity) with long-pulse operation (deformed cavity). Additional ideas can be exchanged on possible dedicated tests for further experimental validation of the multi-physics modeling.

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References: