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Full-wave simulations for synthetic reflectometry diagnostic development

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In magnetized plasmas, turbulent mechanisms play a crucial role in governing the anomalous transport of energy and particles. These mechanisms are challenging to measure and require high-resolution diagnostics. Microwave reflectometry emerges as a versatile and cost-effective tool capable of measuring electron density fluctuation resulting from MHD or micro-turbulence. On the other hand, reflectometry can benefit from the use of simulations, (i.e. synthetic diagnostic) which aim to support the interpretation of the measurements.

Our synthetic diagnostic FeDoT [1] is based on 2D Finite Difference Time Domain (FDTD) full-wave numerical scheme and uses absorbing boundary conditions. The code is specifically designed to emulate a fixed-frequency reflectometer with a monostatic antenna launching X-mode polarized waves at normal incidence. The code is adapted to run with different turbulence maps, including maps resulting from GYSELA gyrokinetic simulations.

This study focuses on enhancing the reliability of reflectometry data interpretation by investigating the Mazzucato transfer [2], which establishes a linear relationship between acquired phase-shifts and fluctuation level. The investigation includes a thorough assessment of the transfer function's validity domain, employing both 1D (R) and 2D (R, Z) full-wave codes coupled with simplified turbulence maps. This study lays the groundwork for 2D full-wave code verification, which is essential for paving the way for further studies. More precisely, this should enable meaningful confrontation between experimental data and computed structures of turbulence, ultimately advancing our understanding of turbulent mechanisms in tokamak plasmas.

[1] A. Medvedeva, et al. "Development of the synthetic diagnostic for the ultra-fast swept reflectometer". 14th International reflectometry workshop, IAEA (2019)

[2] E. Mazzucato. "Microwave reflectometry for magnetically confined plasmas". Review of Scientific Instruments: 69.6 (1998)

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