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Development of full-wave simulation codes for synthetic profile reflectometry in EAST tokamak

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Microwave reflectometry is a powerful diagnostic that can measure the density profile and will be used in the future fusion devices such as ITER, so understanding of how the reflected signals are affected by plasma perturbations is of prime importance. In EAST, profile reflectometry has been developed as routine diagnostic since 2013, [1]–[3]. In this work, a set of full-wave simulation codes via the finite-difference time-domain (FDTD) method has been developed to implement synthetic profile reflectometry including 1D/2D ordinary mode (O-mode), and 2D extraordinary mode (X-mode) codes. The characteristics of the reflect signal, also known as the time-of-fight (TOF) signal associated with the local density perturbations are studied in both EAST experiments and numerical simulations.
Using the 1D O-mode code, it is well validated that the local density flattening could induce the discontinuity of the simulated TOF signal and an obvious change of reflect amplitude. Experimental TOF signals under different types of MHD instabilities are studied in detail and show agreement with the simulation [4]. Furthermore, a 'dual-reflection'phenomenon prior to an ELM crush is observed in the TOF signals and comparatively studied in the experiment and simulation. Using the 2D X-mode code, it is suggested that this phenomenon is due to the local density peak at the pedestal top leading to the tunneling and partial reflection. The effects of local density peak parameters (amplitude, width and position) on the TOF signals are investigated. From these results, it is concluded that the TOF signal analysis from profile reflectometry can provide a straightforward and localized measurement of the plasma perturbation from the edge to the core simultaneously and, is beneficial for the study of the ELM physics.
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