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Estimation of X-mode reflectometry first fringe frequency using neural networks

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One of the main issues with X-mode density profile reflectometry is the correct determination of the upper cut off first fringe reflection.

The propagation of electromagnetic waves in X mode in plasmas is characterized by two cut off frequency regions that depend on the local plasma electron density and the local magnetic field.

By using the upper cut off region for electron density profile reflectometry group delay measurements, the plasma can be probed from near zero density, ne ≈ 0, up to a maximum density limited by the probing frequency band.

However, due to the broad operational conditions of an experimental nuclear fusion reactor, the first fringe plasma reflection can occur at any probing frequency.

The first fringe reflection is used together with the magnetic field profile to determine vacuum distance between the reflectometer antenna and the start of the plasma. An incorrect estimation not only introduces a radial error but also a group delay error, affecting the shape of the resulting density profile.

A new multichannel X-mode density profile reflectometry diagnostic was recently installed on ASDEX Upgrade [1] to study the edge plasma layers in front of the ICRF antenna by probing the plasma in the 40-68 GHz range. In this work we study how the different operational conditions of the fusion reactor affect the reflectometry raw measurements. We take advantage of the high signal-to-noise ratio of the diagnostic to determine a few raw signal features that are consistent with the observation from the SOL, where the plasma starts to be optically thick. We apply these features to develop an algorithm to estimate and track the variation of the first fringe frequency along a discharge.

Tests show that the algorithm is able to accurately determine the first fringe for most discharges. However, for a small number of unanticipated cases, the algorithm fails, introducing inevitable errors in the density profiles.

We present a new algorithm that uses a neural network approach for the first time for estimating the frequency of the first fringe. A varied training set using similar decision features was carefully selected by experienced reflectometry diagnosticians and used to train the neural network model using the open source software library TensorFlow [2].

Early results show that the neural network model is able to predict the frequency of the first fringe to within the degree of uncertainty of the human diagnostician. The comparison of results using both algorithms is presented. Both algorithms shall be used together to minimize the error of first fringe estimation.

Eligible for student paper award?

Yes

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