Development of the HFS ITER reflectometry

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Abstract

Reflectometry diagnostic in ITER has a great advantage due to the compartibility with the high neutron fluxes and walls spattering, as it uses only metallic waveguides inside the vacuum vessel and deals with the probing wavelength of the order of several mm. In addition the probing of the plasma from the HFS with the lower extraordinary wave gives a unique opportunity to diagnost the plasma core even under flat density profile, predicted now in ITER.

However, in spite of such advantages, the realization of the HFS reflectometry in ITER encounter with a number of serious technical problems, connected with the necessity to integrate the extremely high band waveguide in the given configuration of the vacuum vessel and blankets. These problems include the antenna construction in the slit between the blankets, the several bends and primary and secondary vacuum windows.

In addition to the technical problems a number of physical questions of the reflectometry application to the ITER arise. The first is the design and experimental testing of the high efficient antenna. But the most serious problems arise due to the high level of the phase fluctuation level of the reflected signal, connected with the estimated turbulence level and a flat density profile in ITER. Unfortunately, the estimations of the phase fluctuation level give the values about an order higher then the “natural” limit of reflectometry of 1.5 radians. This will limit the reflectometry capabilities in the density profile measurements and, especially, in the estimation of the turbulence spectrum and observation of the modes in plasma.

The present report will describe the schematics of the HFS reflectometry system and make detailed description of the number critical elements.

The possibilities of the reflectometry for the measuring the density profile in turbulent plasma will be investigated by means of the 2D full-wave simulation code of the reflection of the probing wave from the turbulent plasma. The algorithm of the choosing of the turbulence level and it characteristics will be discussed. It will be shown that at the relative turbulence level of densities fluctuations 0.4% the average delay of the reflected signal do not significantly differs from the unperturbed case, thus showing the possibilities of reflectometry to measure the density profile. The situation with the estimation of the turbulence spectrum and observation of the MHD and TAE modes is much more difficult. Preliminary results of 2D simulations showed that spectrum of reflected signal significantly wider, then the spectrum of density fluctuations. Obviously more simulation are needed to clarify this question.

The presented results showed that in spite of the strong technical limitations it is possible to develop the rather efficient HFS reflectometry ITER diagnostic, working in a wide frequency band.