ANALYSIS OF THE EFFECT OF REFRACTION ON PLASMA DENSITY MEASUREMENTS IN REFRACTOMETRY [[1]](#footnote-1)\*)

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In refractometry, the integral of the plasma density along the probing chord <nl> is determined from measurements of the delay time [1, 2]. In contrast to classical interferometry, in many cases there is no linear relationship between the integral <nl> and the delay time. This is due to the fact that, first, on small machines, for example, on the tokamak T-11 M, to increase the delay time of the signal in the plasma, probing is performed at relatively low frequencies, which entails a nonlinear relationship between <nl> and the delay time. Secondly, in large devices with a sufficiently strong magnetic field, such as ITER, Ignitor, etc., plasma probing will be possible in a fairly narrow transparency window (for an extraordinary, or X- wave), enclosed between the lower cut-off frequency for the X-wave and the frequency of the electron-cyclotron resonance. In ITER the transparency window - waveguide ranges U and E (40...90 GHz), and on an Ignitor–type tokamak, frequencies are in the region of 80...270 GHz, depending on the operating mode of the device and the probing geometry. In conditions when the probing frequency is sufficiently close to the cutoff should be rather strong refraction of the beam in the plasma, which depends on tokamak parameters and on parameters of diagnostic systems – refractometry: probing geometry, used frequencies, parameters of antenna and transmission system, etc.

This report analyzes the effect of refraction in plasma refractometry in the T-11 M, ITER, and Ignitor type machines. The report examines various aspects of the effect of refraction on refractometric measurements: first, this is a change of the trajectory of the probe beam in the plasma, second, the distribution of electron density along the beam path also undergoes changes, and third, due to the deflection of the beam in the plasma, the signal power entering the receiving antenna also changes. At the same time, if in the case of equatorial probing, refraction can be neglected due to its smallness (provided that the plasma density profile is symmetrical relative to the equatorial plane and there is no vertical displacement of the plasma column), then the following must be taken into account when probing vertically. Firstly, it is possible that the position of the plasma cord horizontally is changed during shot, secondly, in modern tokamaks, the electron density gradient in the horizontal direction is usually higher than in the vertical direction (due to the vertical elongation of the plasma cord), and thirdly, in some cases, plasma probing is performed not in the center of the plasma cord (experiments in the T-11 M tokamak). In addition, it is known that the currently calculated discharge scenarios in ITER assume a vertical displacement of the plasma cord in the range from -0.2 to +0.7 m, i.e. in ITER conditions, even when probing along the equator, these effects must be taken into account. The analysis was performed using both well-known software packages for ray propagation analysis (Zemax, etc.) and the methods proposed earlier in [3, 4].

References

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1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/E/ru/HV-Petrov.docx) [↑](#footnote-ref-1)