Abstract

Research works intended to create or develop plasma diagnostic methods are particularly important to control fusion reactions in experimental conditions. It is the precise measurements of basic plasma parameters, such as density or temperature of its components, that are the basis for a better understanding of the mechanisms that will ultimately determine the success of the experiment. Therefore, an inseparable element of any fusion experimental reactor (tokamak or stellarator) are diagnostic systems, without which the studies carried out would not make much sense. In recent years, at the Max Planck Institute of Plasma Physics in Greifswald, the Wendelstein 7-X (W7-X) stellarator started its operation. The W7-X experimental reactor is the world’s largest and most technologically advanced fusion device of the stellarator type (besides the LHD stellarator from NIFS, Japan). As a result, it is one of the more promising research projects, which can make a significant contribution to the greatest industrial progress of our time, that is energy production based on fusion reactions. With the start of research on W7-X, as part of the first operational phase (OP1.1), the Pulse Height Analysis diagnostic system was put into operation as well. The main purpose of this system is to monitor the plasma impurities and provide information on their concentration. What is also important, the data provided by the PHA system can also be used for conducting research related to determining the effective plasma charge (Z_{eff}) and the average electron temperature $<T_e>$.

This doctoral thesis describes issues regarding the influence of electron temperature (T_e) and electron concentration (n_e) profiles on the average electron temperature ($<T_e>$) determined by the use of the method based on fitting a straight line to continuum radiation. Indication of experimental conditions, in which it is possible to estimate the average electron temperature $<T_e>$ with a value close to that in the center (T_{e0}), can make the presented method fully useful by creating a new source of information on one of the most basic and key plasma parameters which is T_{e0}. For this purpose, the research methodology was developed based on the combination of both experimental work in the conditions of stellarator plasma, as well as conducting numerous numerical simulations. Thus, after successful commissioning and the first operation of the pulse-height analysis (PHA) diagnostic on Wendelstein 7-X stellarator during the OP1.1. experimental campaign, it was possible to measure soft X-ray spectra, which were the material for determining the average electron temperature $<T_e>$. The

$\langle T_e \rangle$ parameter was determined from experimental data by the application of a code created in the MATLAB. The above-mentioned code allows the user both to choose the energy range in which the $\langle T_e \rangle$ parameter will be estimated, as well as to exclude any individual spectral lines from the continuum spectrum that could disturb the final result. The analysis of experimental data showed that the time evolutions of the average electron temperature determined from continuum radiation $\langle T_e \rangle$ registered by the PHA system are fully consistent with the time evolutions of central electron temperature (T_{e0}) provided by other diagnostic such as Thomson Scattering (TS) or Electron Cyclotron Emission (ECE) systems in terms of their trends. As part of this analysis, the impact of the Gaunt factor parameter on the determined $\langle T_e \rangle$ has been studied. This was done to improve the accuracy of the results obtained from experimental soft X-ray spectra. Another key part of the dissertation was carrying out several hundred numerical simulations based on the T_e and n_e profiles (parabolic and linear) in a wide range of their central and boundary values. The results from numerical simulations allowed to create 3D surfaces that showed the experimental conditions in which the determined average electron temperature $\langle T_e \rangle$ will be the closest (in value) to the central electron temperature (T_{e0}). In the next step, it was also possible to create characteristics illustrating the impact of T_e and n_e profiles on the range of the plasma radius from which radiation will have the greatest impact on the determined $\langle T_e \rangle$. What is important, comparing experimental results with predictions based on numerical simulations indicates the consistency and the same trend of behavior. Thus, the presented qualitative analysis confirmed the scientific thesis defined at the beginning of the dissertation assuming that both the shape of T_e and n_e profiles, as well as their boundary values have an impact on the average electron temperature determined from the spectra provided by the PHA system. Therefore, while interpreting the experimental results physically (especially given the reference value $\langle T_e \rangle$ to T_{e0}), this type of information should be taken into consideration.