Determination of the averaged $Z_{\text{eff}}$ for the W7-X plasma based on the PHA spectra

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The information about the ion effective charge, $Z_{\text{eff}}$ and impurities concentration in plasma is a crucial issue in fusion research. The paper presents two methods for determination of $Z_{\text{eff}}$ of Wendelstein 7-X (W7-X) plasma based on the collected pulse height analysis (PHA) spectra. The PHA system on W7-X measures spectra in the wide energy range, from about 0.5 up to 20 keV which allows for observation of light (like carbon, oxygen), medium (like sulfur, chlorine, argon) and high Z- elements (like iron, nickel, copper) \cite{1}. The spectra consist of Bremsstrahlung, recombination and linear contribution of radiation. The first method is based on simulations of observed spectra. Using the created computer code, simulations of X-ray spectra for given concentrations of impurities in plasma were made. Compatibility between the measured and calculated spectra was a measure of the correctness of the assumed concentrations. Based on these data, the averaged values of $Z_{\text{eff}}$ along line of sight, were calculated. The second method is similar to this one used in the visible range for $Z_{\text{eff}}$ determination from Bremsstrahlung emissivity measurements \cite{2}. However, in the soft X-ray region also recombination radiation plays a role. For determining the $Z_{\text{eff}}$ value the free-bound emissivity is therefore extracted from the continuum radiation by the simulation of experimental spectrum. The obtained $Z_{\text{eff}}$ value corresponds to the averaged one along the PHA diagnostic line of sight. The results will be compared with $Z_{\text{eff}}$ values obtained from the measurements for visible bremsstrahlung continuum at W7-X \cite{3}.

\begin{thebibliography}{9}
\bibitem{1} M. Kubkowska et al. Review of Scientific Instruments 89, 10F111 (2018)
\bibitem{2} M. Krychowiak et al. Review of Scientific Instruments 79, 10F512 (2008)
\bibitem{3} A. Pavone et al. Journal of Instrumentation 14, C10003 (2019)
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