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ANALYSIS OF SOFT X-RAY SPECTRUM ON TOKAMAK T-15MD DURING POWER START-UP *)

[1]Ryzhakov D.V., [1]Shestakov E.A., [1,2]Ideal R.

[1]NRC «Kurchatov institute», Moscow, Russia, Shestakov_EA@nrcki.ru
[2]NRC MPEI, Moscow, Russia

Soft X-ray spectrometry at the tokamak is used to analyze the electron distribution function in the plasma, determine the composition and amount of heavy impurities, and determine the electron temperature and its profile.

During the first experiments on the T-15MD tokamak [1] in the autumn 2023, the first results of measurements of the spectral intensity density of soft X-ray radiation were obtained. The measurements were carried out using a multichannel soft X-ray spectrometer based on a Si(Li) detector in the radiation energy range of 2–20 keV [2]. The spectrometer is located in the equatorial plane of the tokamak, while the observation chord of the detector passes in the horizontal direction at an angle of 7.5° through the center of the vacuum vessel.

The main feature of the T-15MD tokamak discharges during the power start-up is the use of microwave radiation both to initiate breakdown and to heat the plasma. From the analysis of the obtained spectra it follows that in plasma discharges the velocity distribution function of plasma electrons cannot be described only by the Maxwellian distribution function. As a rule, the shape of the spectrum allows us to assume a Maxwellian velocity distribution of plasma electrons with a certain fraction of suprathermal electrons. In discharges where the thermal component of the spectrum can be reliably separated from the suprathermal spectrum, the electron temperature of the plasma is 1.5-3.5 keV depending on the conditions and stage of the discharge. Analysis of the suprathermal part of the radiation indicates the development of accelerated electron beams, which is further confirmed by measurements of suprathermal and hard X-ray radiation in the energy range 30 keV - 10 MeV [3].

The presence in the spectrum of the characteristic emission of certain impurities, the corresponding lines of argon (after conditioning the vacuum vessel with a glow discharge in argon) and stainless steel components - manganese, chromium, vanadium and iron, is also shown, which indicates an intense gradient and accelerated electrons with intra-chamber components.

References

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