New approaches in X-ray spectroscopy for experiments with femtosecond PWt laser facilities

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Nowadays, the study of nature and properties of matter (plasma) formed under the influence of ultra-intense laser pulses is of great interest, both from the point of view of fundamental knowledge about the nature of our universe and from the point of view of practical application as a powerful emission source of X-ray, gamma and corpuscular radiation in medicine and applied problems. Plasma formed under the influence of high-contrast laser radiation with an intensity of 1E21 - 1E22 W/cm^2 is characterized by short lifetimes of 1 - 3 ps in the extreme state, high energy densities and temperatures of the order of 2-5 keV. One of the most important approaches for investigating the extreme matter state and its emission properties is X-ray spectroscopy with high spectral resolution. It enables the measurement of the most important plasma parameters, the estimation of the degree of ionization and the efficiency of energy conversion into X-rays (energy 0.5–25 keV, wavelength range 0.5–19 Å) and the investigation of various nonlinear effects that occur in ultra-relativistic laser plasmas. In this work, the results of the application of X-ray spectroscopy approaches to the study of steel foil plasmas generated by femtosecond laser pulses with an intensity up to 5E21 W/cm^2 are presented. This work presents a comprehensive study of femtosecond laser plasma generated by ultra-high-power laser pulses. Experimental results are compared with PIC calculation results. The possibility of the formation of a plasma with an energy density of 1.2 GJ/cm^3 and a pressure of 12 Gbar in the interaction region was demonstrated.