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Spectroscopic evaluation of a strong magnetic field induced in the interaction of relativistic intensity laser pulses with nanostructured targets

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During relativistic laser-plasma interactions, super-strong magnetic fields of the GigaGauss could develop. In this work we studied property of plasma generated in the interaction of ultra-high intensity of ~ $(1 – 3)\cdot 10^{21}$ W/cm^2 J-KAREN-P laser pulses [1] with targets based on Si sub-micron meter size rods assembled to different compositions of periodical structures formed by means of unique method developed at Kyoto University [2].

Due to high laser contrast (10^{12}) it is expected that rods practically were not destructed by the prepulse and the plasma with near solid density was created, that have been evaluated with simulations [2]. The existence of the hot plasma fraction with $N_e = (2.5 – 5)\cdot 10^{23}$ cm^{-3} was confirmed by two spectroscopic methods: (a) through the relative intensities of Si XIV Ly_α resonance line and its satellites, and the benchmarking modeling of the overall spectra of Si containing spectral range of H-like (n = 2, 3) and He-like (n = 2 – 5) transitions; (b) by identifying the Langmuir-wave-caused L-dips in the experimental profile of SXIV Ly_β line and analysis of its shape and positions.

The theory of L-dip structure provides a diagnostic tool for accurate measurement of N_e and the electric field of the Langmuir waves (LW) [3, 4]. From the L-dips positions we deduced the electron density at the surface of the relativistic critical density. From the halfwidth of the L-dips we obtained the amplitude of LW. From the shift of the mid-point within the pair of the L-dips, we determined the presence and the field strength of a Low-frequency Electrostatic Turbulence (LET). For determining the magnetic field, we performed modeling of the entire shape of the Ly-beta line profile. The best fit to the experiment was obtained for the magnetic field B = 0.9 GG (Fig. 1). The root-mean-square field of the LET was found to be F_{LET} = 2 GV/cm. (Fig. 1).

The results of this work may open up the way to enhance x-ray spectroscopic methods for precise measuring electron density and magnetic field developing during relativistic laser-plasma interactions.

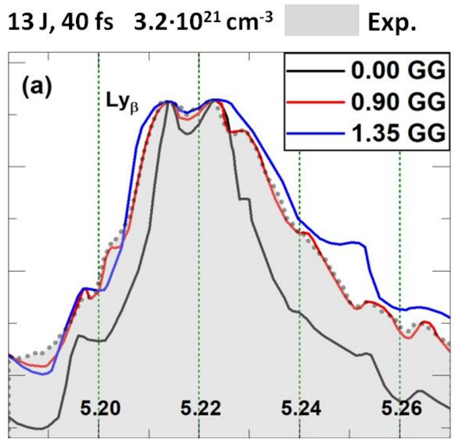

Figure 1. Modeling of the entire shape of the Si Ly_β line profiles, focusing at how the magnetic field affects the broadening of the line. Experimental spectrum (shaded plot) is a good agreement with simulations for the magnetic field B = 0.9 GG.

References

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