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Modification of K-line emission profiles in laser-created solid-density plasmas

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X-ray emissions in the keV energy range have shown to be suitable radiation to investigate the properties of laser-created solid-density plasmas [1, 2]. We use the modifications of inner shell transitions due to the environment to characterize these plasmas.
A theoretical treatment of spectral line profiles based on a self-consistent ion sphere model is applied on moderately ionized mid-Z materials, such as titanium, silicon and chlorine.
We observe large contributions of satellite transitions due to M-shell ionization and excitation. To determine the composition a mixture of various excited and ionized ionic states embedded in a plasma has to be considered. Plasma polarization effects that cause shifts of the emission and ionization energies are taken into account.
K-line profiles are calculated for bulk temperatures up to 100 eV and free electron densities up to 10^{24} cm^{-3} in order to analyze recent measurements with respect to the plasma parameters of electron heated target regions. Moreover, in high-intensity laser-matter interactions, inevitable prepulses are likely to create preplasma and shocks within the target before the main pulse arrives. We investigate the influence of density gradients due to prepulses on the spectral profiles. Further, radial bulk temperature distributions as well the composition of the created warm dense matter are inferred [3, 4].

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P23.
NATALIE, a multidetector diagnostic to characterize laser produced particle beams: applications.

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Ultra High Intensity lasers produce energetic particles such as electrons, protons, photons within a large domain of energies. In a range between a few MeV to few tens of MeV, these beams may open new opportunities to study nuclear isomer production in plasma [1] in relation with astrophysical problems. Such studies require the knowledge of the particle energy and angular distributions to quantify possible future experiments. For this purpose, we have developed a standalone integrated data acquisition system to characterize proton and electron beams (converted into photons via bremsstrahlung) using nuclear activation techniques. This system called NATALIE (Nuclear Activation Technique for Analysis of Laser Induced Energetic particles) is composed of sixteen NaI detector pairs used to count the activity of various samples activated via (γ,xn) or (p,n) reactions for example. The setup is based on a coincident technique which allows β^+ activity measurements with very low background and leads to accurate nuclear activation yields determination. Geant4 simulations are used at different steps of the data analysis to deduce the energy and angular distributions of the laser-induced particle beams from the experimental data. Two applications are presented as illustrations regarding the characterization of electron and proton beams.

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P24.

Investigation of copper X-ray spectra on SOKOL-P laser facility at intensities of 10^{17}-10^{19} W/cm^2

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Energy of the laser pulse interacting with solid and gas targets partially transmits to fast electrons, which in turn slowing-down in target, create a continuous and characteristic radiation. Investigation of this radiation is important for studying the processes of generation and transport of fast electrons in target material.

On 20 TW picoseconds laser facility SOKOL-P, the research of copper targets continuous X-ray spectrum was conducted in the range of photon energies of 0.6-3000 keV and yield of Cu-Kα characteristic line was measured. A spectrograph with flat crystal (LiF d = 2.15 Å) was used to measure the Kα-radiation of copper. Registration of the spectrum was carried out on a CCD camera.

Front-side measurements were performed for targets of 35 and 50 μm thickness. Yield of Cu-Kα practically does not depend on the intensity of laser radiation in the range of three orders. Measurements from the back side were conducted for targets of 35 μm thickness. They show a monotonic increase of the line yield depending on the intensity with saturation at about 10^{18} W/cm^2.

Measurement of laser plasma continuous spectrum in the energy range 0.6-4.5 keV was carried out using X-ray spectrometer based on spherical mirrors of total external reflection. In combination with X-ray mirrors, the filters that allow registration the radiation in five narrow energy regions were used.

The spectral distribution of soft X-rays in the energy range 0.6-4.5 keV is characterized by the effective electron temperature of ~ 0.5 keV.

The hard X-rays spectra measurement in the energy range 25-90 keV was carried out at the front of a target by K-filter method using spectrometer with semiconductor detectors DDR 18/0.5. The X-rays with energies above 100 keV were detected using gray lead filters method by three-channel spectrometer based on photoelectronic multiplier FEU-60 with CsJ (Tl) scintillators.

Spectral distribution of X-rays (ε> 100 keV) is characterized by effective temperature of electrons in the hundreds of keV diapason, changing the value of Teff from 200 keV at $I = 3 \cdot 10^{17}$ W/cm^2 to 600 keV at $I \sim 10^{19}$ W/cm^2. In 20-100 keV range of quanta energy the X-ray spectra have a nonmonotonic character with maximum value at about $5 \cdot 10^{11}$ keV / keV at energy of 50-60 keV.