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High-repetition rate relativistic electron generation from micro-droplets at $10^{16}\ W/cm^2$

Angana Mondal [1,2], Sheroy Tata[1], S.V. Rahul[2], Feiyu Li[3], William Trickey[4], John Pasley[4], Zhengming Sheng[3,5], Debobrata Rajak[2], Ratul Sabui[2] , Soubhik Sarkar[1,2], Ram Gopal[2], J.Jha[1] and M. Krishnamurthy [1,2]

[1] Tata Institute of Fundamental Research, Mumbai, [2] Tata Institute of Fundamental Research , Hyderabad, [3] Department of Physics, University of Strathclyde, [4] Department of Physics, University of York, [5] Laboratory for Laser Plasmas and School of Physics and Astronomy, Shanghai Jiao Tong University

e-mail (speaker): angana.mondal@gmail.com

Laser-matter interaction using solid, liquid and gaseous targets have been envisaged as ideal pulsed sources of energetic electrons and X-rays radiations. Experiments, thus far, have deemed the requirement of relativistic laser intensities ($> 10^{18} W/cm^2$) mandatory for hot electron (temperature >100 keV) generation. However, the commercial implementation of such sources for applications like electron and X-ray-radiography, require a reduction in the laser intensity and an increase in the operation rate.

We present here a novel mechanism of generating electrons up to 6 MeV from Methanol micro-droplets using a 2 mJ, kHz laser system. Though mass-limited or pre-structured solid targets are know result in electron yield enhancement [1-3], the maximum electron temperature at this intensity is still about 50 keV. In comparison, using dynamically structured 15 um droplets we demonstrate here the generation of a dominant temperature of 200 keV and a relativistic MeV temperature at $4 \times 10^{16} W/cm^2$. The findings were corroborated with both electron and bremsstrahlung X-ray measurements. The dominant electron temperature (200 keV) scaling as a function of laser-intensity, I, is observed to vary as $I^{1.6}$. This scaling surpasses the ponderomotive scaling by a factor of 3 and that of resonance absorption by a factor of 5.

From the angular distribution measurements, these electrons are observed to have backward directed beam like emission oriented along $\pm 50^o$ with respect to the incident laser. These electrons and X-rays seem to have beam like characteristics, where the yield and directionality can be controlled by modulating the laser parameters. With such directed emission confined to the laser polarization plane, we demonstrate near single shot electron radiography. The achievable imaging resolution being ~ 13.6 um. X-rays up to 200 keV, emitted directly from the drop, are also shown to be ideal for high-resolution, shot acquisition imaging and tomographic study of biological and metallic samples.

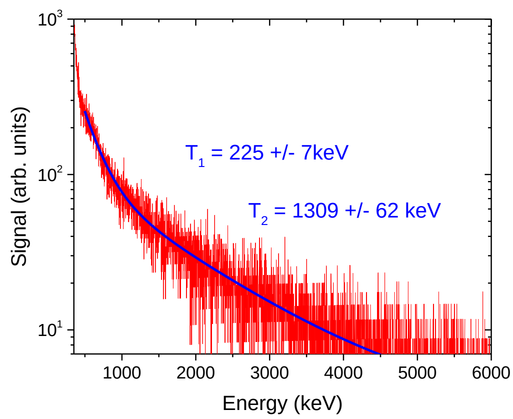

Figure 1. Bremsstrahlung X-ray spectrum acquired using a scintillation detector. A 6mm Pb filter has been used to to avoid low energy X-rays and pile-up effects in the X-ray measurements

References

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