Highly Nonlinear Inverse Compton Scattering

C. Fruhling[1], W. Yan[1], Grigory Golovin[1], Daniel Haden[1], Ping Zhang[1], Jun Zhang[1], Baozhen Zhao[1], Cheng Liu[1], Shouyuan Chen[1], Sudeep Banerjee[1], and Donald Umstadter[1]

Department of Physics and Astronomy, University of Nebraska-Lincoln, Lincoln, Nebraska 68588, USA
donald.umstadter@unl.edu

The motion and scattering of free electrons in ultra-intense electromagnetic fields is an area of interest in both fundamental and applied research [1]. Experiments can now test decades-old theories of electrodynamics as well as lead to the development of compact sources of hard x-rays, which have unique properties. Previous experiments have observed phenomena in the weakly relativistic case ($a_0 \geqslant 1$) [2,3]. In ultra-intense fields (a_0 >>1), the anomalous electron trajectory is predicted to produce a spectrum characterized by the merging of multiple high-order harmonic generation into a continuum. This may also be viewed as the multiphoton Thomson scattering regime analogous to the wiggler regime of synchrotron light generation. Thus, the light produced reflects the electrons behavior in an ultra-intense lase field. We discuss the first experimental tests in the highly relativistic case ($a_0 = 15 >> 1$). The experiment required the use of two laser pulses. The first pulse was used to generate 300 ± 10 MeV electron beams carrying 5± 2 pC of charge via laser wakefield acceleration. The second pulse was tightly focused with an f/2 off-axis-paraboloid to an intensity of 7×10^{20} W/cm^2, corresponding to an amplitude of the normalized vector potential a_0~15 and scattered off the electron beam. Distinct radiation patterns with elliptical spatial profile and a broadband x-ray spectrum extending beyond 20 MeV were observed, which are indicative of the anomalous electron motion in ultra-intense laser field and multiphoton scattering.

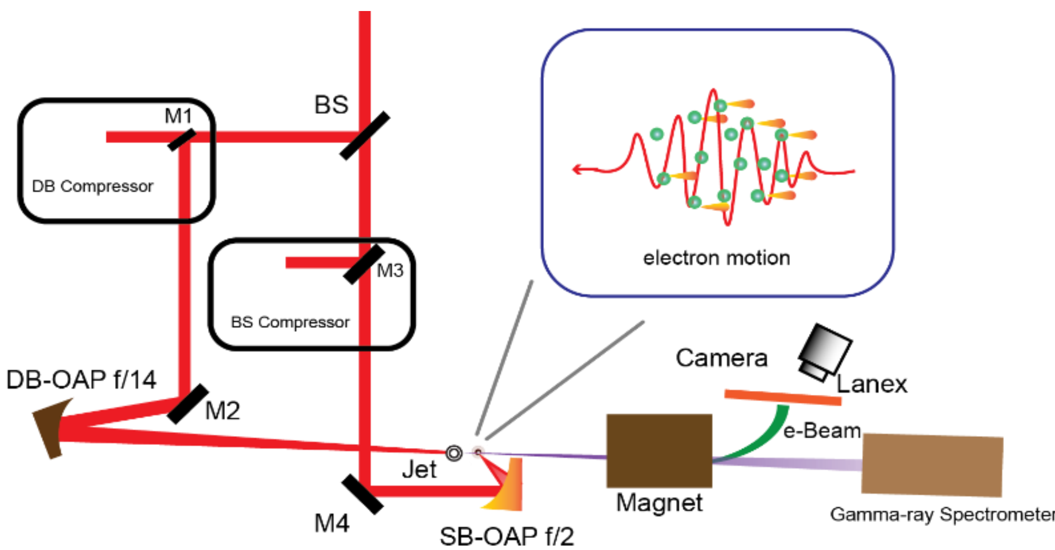

Fig. 1: Layout of the experimental setup. Two laser pulses from the DIOCLES laser system are used, the first to generate a high-energy electron beam and the second to scatter of the electron beam and produce x-rays. The electron beam is imaged on a scintillator and x-rays are measured spatially using a voxelated CsI and spectrally using a Compton spectrometer.

References

[1] D. P. Umstadter, Contemporary Physics, **1** (2015).
[2] G. Sarri, D. Corvan, W. Schumaker, J. Cole, A. Di Piazza, H. Ahmed, C. Harvey, C. H. Keitel, K. Krushelnick, and S. Mangles, Phys. Rev. Lett. **113**, 224801 (2014).
[3] K. Khrennikov, J. Wenz, A. Buck, J. Xu, M. Heigoldt, L. Veisz, and S. Karsch, Phys. Rev. Lett. **114**, 195003 (2015).