BETATRON RADIATION FROM A SELF-MODULATED LASER-WAKEFIELD ACCELERATOR

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The High Energy Density science facilities such as OMEGA, the National Ignition Facility, and in the future the Laser Mega Joule (LMJ), are now uniquely able to recreate in the laboratory conditions of temperature and pressure that were thought to be only attainable in the interiors of stars and planets. To diagnose such transient and extreme states of matter, the development of efficient, versatile and fast (sub-picosecond scale) x-ray probes with energies larger than 50 kilo-electronvolts has become essential for HED science experiments on these specific facilities.

We will present results from a recent experiment performed using the Titan laser (150 J, 1 ps) at the Jupiter Laser Facility, LLNL, showing evidence of Betatron x-ray production in the self-modulated regime of laser wakefield acceleration.

When a 0.5-1 ps laser pulse with an intensity approaching 10^{20} W/cm^2 is focused on a gas target (electron density 10^{19} cm^{-3}), electrons can be accelerated via the self-modulated laser wakefield (SMLWF) regime and the direct laser acceleration (DLA) regime. In SMLWF acceleration, electrons are accelerated by the plasma wave created in the wake of the light pulse, whereas in DLA, electrons are accelerated from the interaction of the laser field with the focusing force of the plasma channel. Experimentally, these two regimes can be distinguished by looking at the laser spectrum transmitted through the gas cell with an optical spectrometer. If the SMLWF mechanism dominates, ($<10^{20}$ W/cm^2), the transmitted laser spectrum exhibits intense Raman satellites which measured shifts depend on the electron plasma density.

Although Betatron radiation has been observed with picosecond-scale lasers in the DLA regime [1, 2], for normalized vector potentials a_0 greater than 10, this experiment constitutes the first observation of Betatron radiation in the SMLWF regime, for $a_0 \sim 1$-3. This was made possible by the addition of a long focal length optics (F/10), favorable for guiding laser pulses in gas targets. We will show a detailed Betatron x-ray source characterization, as well as electron spectra above 200 MeV and forward laser spectra indicating a strongly self-modulated laser wakefield acceleration regime.

[1] S.P.D. Mangles et al, Phys. Rev. Lett., 94, 245001 (2005).
[2] S. Kneip et al, Phys. Rev. Lett., 100, 105006 (2008).

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