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Measurements of Ionization States in Warm Dense Aluminum with Femtosecond Betatron Radiation from a Laser Wakefield Accelerator

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Study of the ionization state of material in the warm dense matter regime is a significant challenge at present. Recently, we have demonstrated that the femtosecond duration Betatron x-ray radiation from the laser wakefield acceleration of electrons is capable of being employed as a probe to directly measure the ionization states of warm dense aluminum via K-shell line absorption spectroscopy [1]. In order to apply the radiation for such an application, a Kirkpatrick-Baez Microscope is used to selectively focus the radiation around the 1.5 keV photon energy range onto a 50-nm free-standing aluminum foil that is heated by a synchronized 800 nm laser pump pulse. The transmitted x-ray spectrum is spectrally resolved by a flat Potassium Acid Phthalate (KAP) Bragg crystal spectrometer. Here we report the results of the first-time direct measurements of the ionization states of warm dense aluminum using this Betatron x-ray probe setup. Measurements of the ionization states were taken at two pump fluences and various time delays to observe the evolution of the warm dense matter state. Plasmas spectroscopic modeling associated with 1D hydrodynamic simulation is being carried out to interpret the ionized charge distributions from the measured K-shell absorption lines. Details of the measurements and simulations will be presented.
[1] M.Z. Mo, et al., Rev. Sci. Instrum. 84, 123106 (2013).

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