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Few-cycle Optical Probing of Laser Wakefield Acceleration Experiments

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Several applications of a few-cycle optical probe-pulse (fc-probe) in Laser Wakefield Acceleration (LWFA) experiments on the JETI 40 TW laser system in Jena, Germany will be described. This research is motivated by the need for diagnostics of the plasma wakefield with micron-scale spatial and femtosecond-scale temporal resolution to gain a deeper understanding into the physics underlying the injection and acceleration processes as well as the need to benchmark numerical simulations which have so far been the only source for such detailed information.

Several experimental setups using the fc-probe pulses were implemented in the last two experimental campaigns in 2014 and 2015 allowing for various measurements to be performed. Electron plasma density distributions were measured interferometrically using a Mach-Zehnder type interferometer, and an achromatic quadri-wave lateral shearing interferometer. Shadowgraphic imaging techniques were used to investigate the evolution of the wakefield in self-injection and ionization-injection regimes, asymmetries in the wakefield due to laser asymmetries (i.e. asymmetric focal spot and pulse front tilt), birefringence of the plasma's refractive index due to strong magnetic fields, and the feasibility of recording the temporal evolution of the wakefield in a single pump-probe interaction.

Primary author: Mr SCHWAB, Matthew (Friedrich-Schiller-University Jena)

Co-authors: Mr BLINNE, Alexander (Theoretisch-Physikalisches Institute Jena); SÄVERT, Alexander (Institute for Optics and Quantumelectronics, FSU Jena); Mr SEIDEL, Andreas (Helmholtz Institute Jena); Mr CORVAN, Darragh (Queens University Belfast); Mr HOLLATZ, Dominik (Institut für Optik und Quantum Elektronik); Mr DING, Hao (Ludwig-Maximilians-Universität München); Prof. KALUZA, Malte (University of Jena, Helmholtz-Institute Jena); Prof. ZEPF, Matt (Helmholtz Institute Jena); Mr GILJOHANN, Max (Ludwig-Maximilians-Universität München); Dr EVANGELOS, Siminos (Max-Planck-Institut für Physik komplexer Systeme); Mr KUSCHEL, Stephan (Helmholtz Institute Jena); Mr HEINEMANN, Thomas (Institute for Experimental Physics, University of Hamburg); Mr ESCHEN, Wilhelm (Institute für Optik und Quantumelektronik Jena)

Presenter: Mr SCHWAB, Matthew (Friedrich-Schiller-University Jena)

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