Interferometric measurement of the cumulative density depletion in laser-driven plasma filaments (Chair of Photonics and Ultrafast Laser Science)

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Laser-driven plasma filaments are commonly used in a two-color THz generation scheme, providing broadband radiation from a photocurrent of accelerated electrons in the plasma channel. Bandwidths spanning from 1 THz to 200 THz [Matsubara, 2012], electric fields in the MV/cm region [Oh, 2014] and up to 640 mW average power have been reported [Buldt, 2021].

Recently, cumulative effects in laser-induced plasma filaments have been studied theoretically and experimentally [Wang, 2023]. At high repetition rates and high pulse energies, a fast decrease of the electrical breakdown voltage in air has been observed for high repetition rates, revealing an unobserved regime of nonlinearity in the filament characteristics. Due to a possible impact on the efficiency and bandwidths of THz generation in laser-driven plasma filaments, an experimental study of the cumulative characteristics is required for further theoretical understanding. A supposition to explain the experimental findings in [Wang, 2023] is a decrease of the gas density as consequence of volumetric heating.

In this Hands-On Module, you will investigate the gas depletion in the plasma filament by a phase-resolved interferometric imaging of a collinearly coupled laser, accumulating a phase change due to the refractive index change in the density hole. You will either carry out equilibrium or time-resolved measurements by a Mach-Zehnder interferometer. The CCD images will be analyzed by a 2D-FFT based algorithm for phase-resolved imaging of the density hole at repetition rates from 10 kHz to 100 kHz at an average power of up to 500 W (Trumpf Dira 500-10). A description of a similar setup has recently been published in [Valter, 2023].

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