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Spatiotemporal filament characterization - Towards transient atom dynamics

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Filaments are an interesting phenomenon caused by high-intense laser pulses in various media. If a femtosecond laser pulse exceeds a certain critical peak power, the laser beam will experience ongoing self-focusing due to the Kerr effect, causing an intensity-dependent nonlinear refractive index n2, as the self-focusing enhances itself. Eventually, the self-focusing beam exceeds the ionization threshold of the medium and plasma is generated. The plasma leads to a defocusing of the beam, so that the intensity of the beam is lowered until the ionization threshold is not exceeded anymore. With enough energy, the beam can self-focus and then be defocused by the plasma again in many more iterations. If the self-focusing and the defocusing balance each other, the beam stays focused over a distance much longer than the Rayleigh range with a clamping intensity of around 50 TW/cm2 and is called a filament. Because of its generation process the filament inherently shows strongly nonlinear spatial and temporal dynamics which lead to interesting effects like intensity spiking, where the clamping intensity is exceeded by far, or self-shortening of few-cycle laser pulses, in which the spectrum of the pulse broadens significantly with a nearly flat spectral phase.

We present the first experimental approach to investigate the spatial and temporal dynamics of a filament simultaneously using the common d-scan pulse characterization technique and a 2D- interferometer. Later, this technique can also be applied to investigate transient atom dynamics in strong light fields.

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