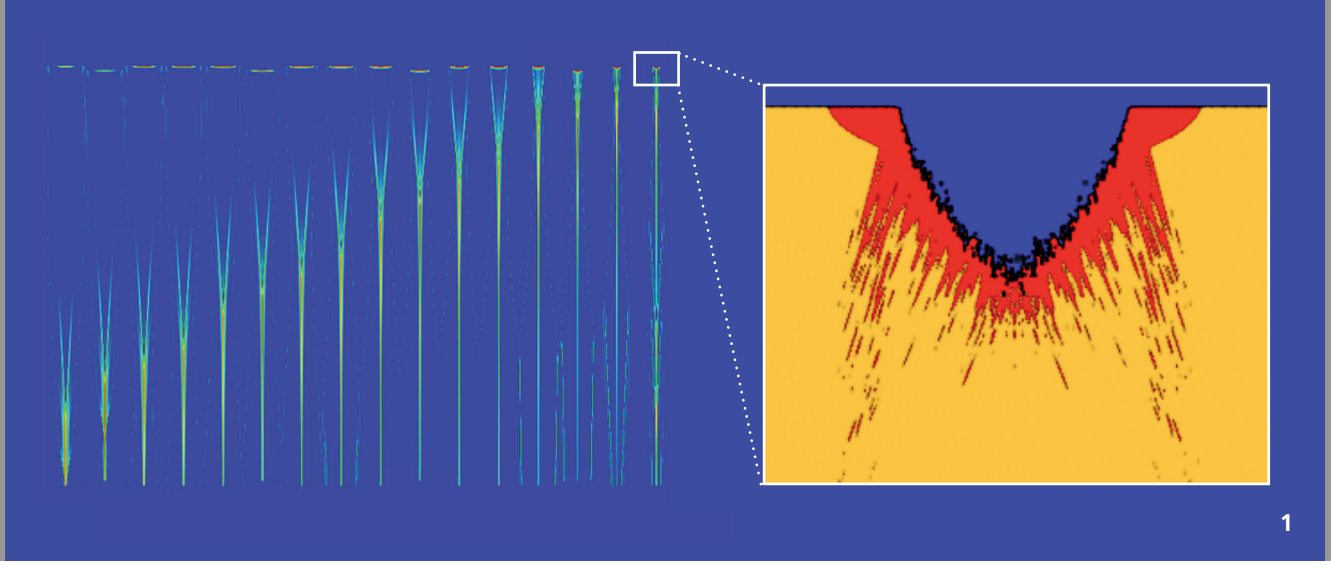

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# MODELING AND SIMULATING THE GENERATION OF OPTICAL FILAMENTS WITH USP LASER RADIATION

## Task

When (semi-) transparent materials are irradiated with ultrashort pulsed laser light, filament structures (i.e. modifications covering a wide area in the propagation direction and with a greatly limited extension perpendicular thereto) can be generated in the material volume. With enough time and effort, an experimental procedure can principally examine how the technical parameters influence the formation and characteristics of optical filaments; however, the physical causes and mechanisms remain hidden without the supporting explanation of a numerical model. Therefore, mathematical-physical models and their numerical implementation (simulation) are essential tools to enable users to systematically explore filament structures.

## Method

The existing simulation code to describe the nonlinear absorption, propagation and ablation has been expanded to include the effect of self-focusing, thus allowing the description of the optical filament as well as the investigation of parametric dependencies of this formation.

## Result

The expanded simulation code is in excellent agreement with experimental results both in the description of dielectric material removal as well as of induced optical filaments modifications in the volume of the material. The newly acquired possibilities have already been used to reproduce the influence of parametric variations (e.g. focal position variation) on optical filaments investigated in laboratory experiments in the context of a numerical calculation (see Figure 1).

## Applications

The numerical tools created and findings derived from this work – of the physical mechanisms – are essential so that filament formation can be used adequately or its influence appropriately in laser manufacturing processes such as filament cutting and in-volume material modification (e.g. as the writing of waveguides).

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*1 Simulated filaments and ablation while varying the focal position (Detail: enlarged ablation contour).*



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