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Filamentation and multiple filamentation in in fused silica

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Propagation of high-power femtosecond laser pulses in transparent materials can lead to filamentation. Filamentation occurs due to the Kerr-focusing of the laser pulses in nonlinear medium. Plasma defocusing effect prevent the colapse of the laser pulse and the balance between Kerr nonlinearity and plasma defocusing leads to filamentation. For the first time, we observed multiple filamentation in fused silicaa in interaction of short laser pulses (50 fs-100 fs) using high-resolution three-dimensional FDTD simulations. We show a map of our simulation results in terms of laser energy and laser waist size (NA). Our investigations show that for NA (<0.65) multiple filamentation can occur when the power is above(3.3p_{cr}) the critical power for self-focusing; for tighter focusing conditions only one filament forms. For laser pulses with lower NA, the laser pulse focuses due to nonlinear Kerr effect and ionizes the medium.and the first filament appear. When the plasma is produced, it changes the refractive index of the medium and as a result the trailing part of the laser pulse defocuses. The intensity in front of the laser pulse drops and the ionization process stops. As the pulse propagtes farther, it focuses for the second time, the intensity becomes above the ionization threshold and the second filament appear. Increasing NA results in void shape structure formation in the bulk of fused silica. Our results agrees well with experimental results of (Sudrie et. al. PRL 2002, Yamada et. al. Courier et. al. PRB 2005).

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