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Filamentation and beam-reshaping in a 2D quadratic nonlinear medium

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In quadratic media, modulation instabilities (MI) seeded by high nonlinearities can occur within the second harmonic generation (SHG) process [1]. As a result, the output beam wavefront is broken and many spatial solitary waves can be excited, thus leading to severe beam quality degradation which is detrimental for many applications. In our experiments, we demonstrate that this limitation can be circumvented by operating in the strong conversion regime, so that a smooth bell-like beam shape can be retrieved for the second harmonic (SH) beam. To show this, we injected wide collimated pump beams at 1064 nm in quadratic crystals. By increasing the pump intensity, at the output face of a KTP crystal we first observed the generation of a spatial filament, and then a multi-filamentation process of the SH (Fig.1(a)). An example of SH intensity statistics is given in Fig.1(c). In a PPLN crystal, thanks to its stronger conversion efficiency, we observed that filamentation can evolve towards a bell-shaped SH beam at very high pump intensities, above 17 GW/cm² (Fig.1(b)). Such unexpected improvement of the output brightness was verified by near- and far-field measurements seen in Fig.1(d). Spatial beam reshaping was accompanied by spectral broadening around the SH, covering the whole visible domain (Fig.1(e)). Although the generation of a single polychromatic filament was discussed in Ref.[2], we here unveil a new nonlinear beam propagation regime, controlled by pump intensity. For moderate intensities the SH breaks into multiple filaments, whereas at high intensities the SH may regain its original brightness. Beam cleaning and visible supercontinuum generation in quadratic crystals may allow for new light sources in numerous applications, ranging from multispectral LIDAR to nonlinear fluorescence microscopy. This work was supported by the ERC (740355).

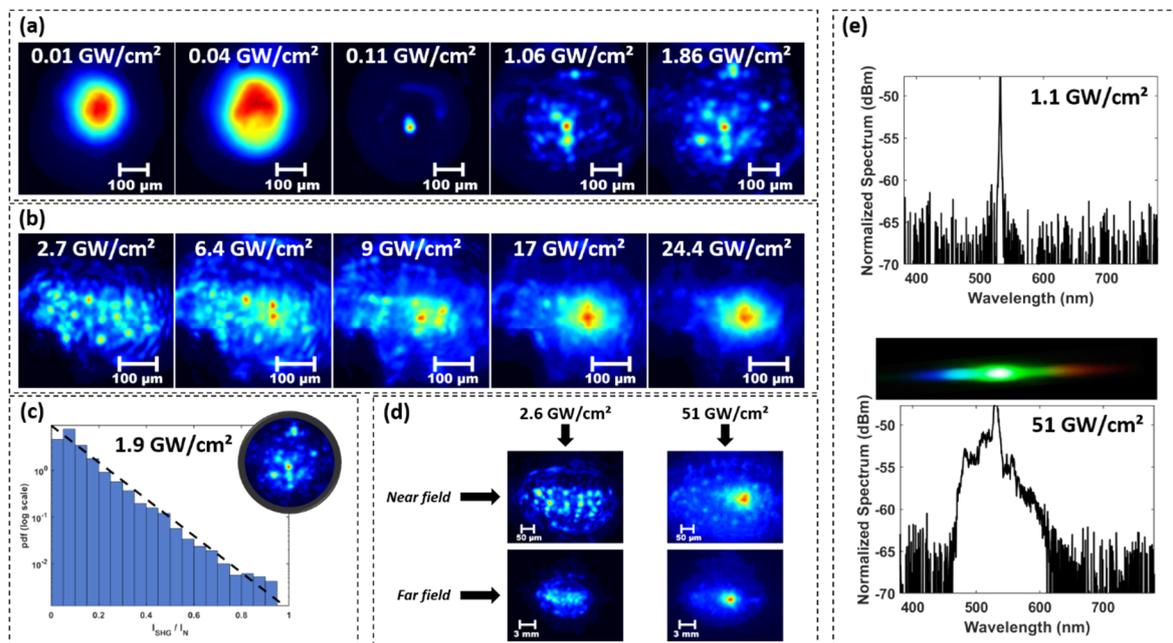


Fig. 1 (a,b) Spatial KTP (a) and PPLN (b) output SH beam evolutions, vs. input pump intensity. (c) Statistics of the filamented KTP output SH intensity for an input pump intensity of 1.9 GW/cm². The dashed curve shows the analytical probability density function (PDF) of a Rayleigh speckle pattern [3]; blue bars are experimental results. (d) Near- and far-field PPLN output SH beams, for relatively weak (2.6 GW/cm²) and high (51 GW/cm²) pump intensities. (e) PPLN output spectrum broadening, for a pump intensity of 51 GW/cm², compared to the low pump intensity spectrum (1.1 GW/cm²).

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