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# Laser filamentation of a femtosecond pulse in air at 400nm

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**Abstract:** Quantitative measurements of the properties of laser filaments at 400nm are presented. Included are measurements of the conical emission spectra, as well as the filament conductivity. Comparisons are made for these phenomena with 800nm filaments.

**OCIS codes:** (010.1300) Atmospheric propagation, 190.3270 Kerr effect

## 1. Introduction

Nonlinear propagation of ultrashort laser pulses in air has been a subject of great interest in recent years, with a large amount of work being done at 800nm due to the availability of broadband IR laser materials. Recent studies have begun to examine the nonlinear propagation of laser pulses at wavelengths other than 800nm [1,2]. In this paper we present what to the best of our knowledge is the first rigorous measurements of the characteristics of laser filaments at 400nm.

## 2. Experimental Setup

The laser system used for the measurements was a Ti:Sapphire 5TW custom design built for Sandia National Laboratories by Continuum Corporation. The laser was run at 800nm with a compressed energy of ~20mJ, in a pulsewidth of 50fs. The frequency conversion to 400nm was performed with a 1mm thick BBO crystal, and the residual 800nm light was removed by taking multiple reflections off of dielectric mirrors coated to be high reflectors for 400nm. The conversion efficiency was ~30%, resulting in a beam energy of 6mJ at 400nm. The beam was then allowed to propagate freely over a range of 15m, without the use of any focusing or beam shaping optics.

## 3. Results

### *3.1 Basic Properties*

With 6mJ of energy in the blue, a cluster of 2-3 filaments formed within the first 5m from the BBO crystal, and the cluster propagated for 3-5m on average. Using the filament to ablate a gold substrate demonstrated a filament diameter of 150μm. Energy measurements yielded 400 – 450μJ present in two filaments, suggesting an average of ~200μJ per filament. However visual inspection of burn patterns produced by the filaments on paper indicates that one filament was much stronger than the other one.

### *3.2 Conical Emission Properties*

The divergence angle of the conical emission from the 400nm filament was measured to be 3.5mrad (full angle). The spectral content of the conical emission shows significant broadening from the linear propagation case, as is shown in Figure 1a. Figure 1b shows the spectral content of the conical emission from a filament generated by the red seed beam from the same laser before the BBO crystal. As can be seen, the red conical emission is biased towards the blue side of the spectrum, while the blue emission is biased towards the red,

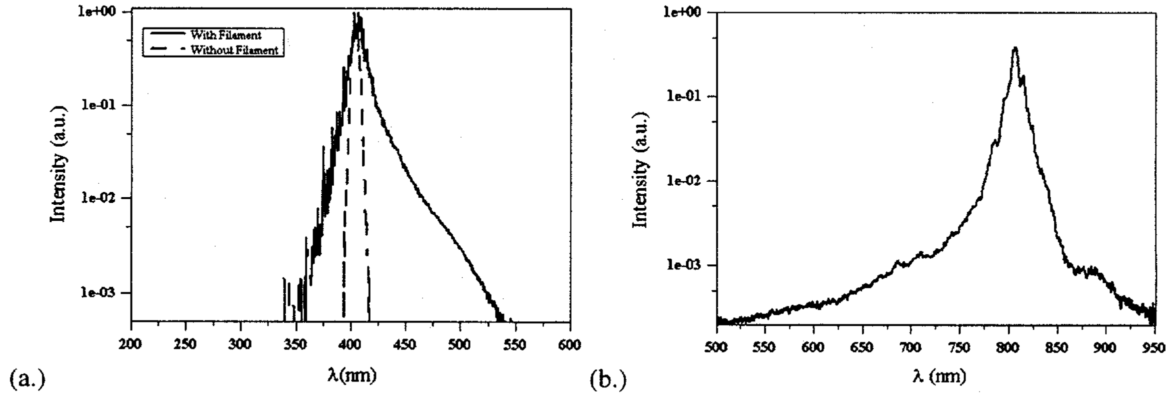


Fig. 1. (a.) Comparison of the 400nm spectrum with and without filament. (b.) Spectrum of the 800nm filament and conical emission.

### *3.3 Conductivity Measurements*

The conductivity of the blue and red filaments was measured using a method similar to that proposed in Ref. [3]. The corresponding traces are shown in figures 2(a) and 2(b). As can be seen from the figures, the 800nm filament produced a slightly larger signal than the 400nm filament (1.1V vs. 1V), implying that the electron density in the ionized plasma column was slightly higher for the 800nm filament. It is interesting to note however, that a measurement taken with the same apparatus on a single filament produced by a similar laser system (20mJ, 200fs) produced a signal that was only 40mV. This implies that laser parameters such as pulsewidth play a more crucial role in the ionization dynamic than wavelength in the visible region.

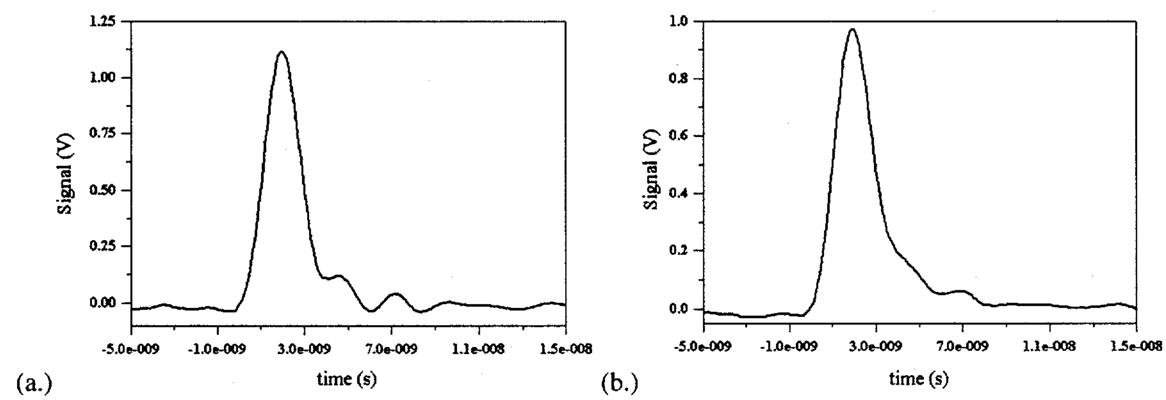


Fig. 2. (a.) Conductivity signal for the 800nm filament. (b.) Conductivity of the 400nm filament.

## 4. References

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