Coherent Control of Four-Wave Mixing Gain

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Outline

- Filamentation Basics
- Filamentation Reduction--Theory and Experiment
- Two-Beam Experiment: Self-Diffraction
- Two-Beam Experiment: Conical Emission
- Future Work and Conclusions

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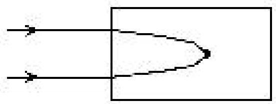
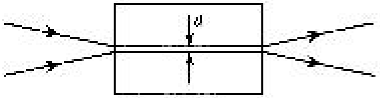
Filamentation Basics

For a material with a real, positive nonlinearity, there is a given power (P_{cr}) above which propagation leads to significant changes in the beam.

Self-Focusing, $P > P_{cr}$



Self-Trapping, $P = P_{cr}$



Filamentation, $P >> P_{cr}$

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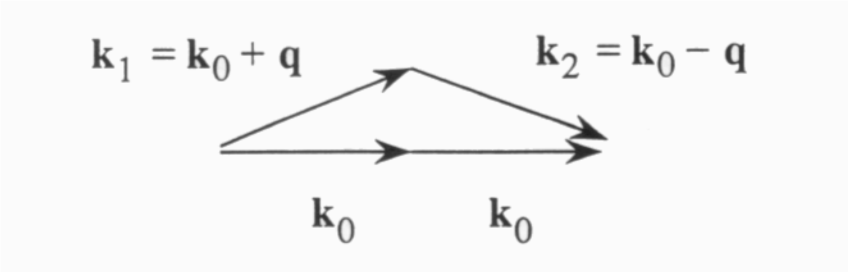
Filamentation Basics

Filaments Grow From Perturbations (classical or quantum) on the Wavefront Via a Near-Forward Four-Wave Mixing Process:



Energy is Depleted From the Main Beam and Added to the Side Modes, With Gain Dependent on q:

$$A_1(z) = (A_1^+ e^{g_+ z} + A_1^- e^{g_- z}) e^{i\Delta k z/2}$$

$$\mathbf{g = q\,(n_2E^2/n - q^2/4k^2)^{0.5}}$$

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Filamentation Reduction Theory

Let A_1 and A_2 be the side-mode amplitudes:

$$A_1(z)=\tfrac{1}{2}\left[A_1(0)+\frac{\kappa}{g}A_2^*(0)\right]e^{gz}+\tfrac{1}{2}\left[A_1(0)-\frac{\kappa}{g}A_2^*(0)\right]e^{-gz}$$

$$A_2^*(z)=\tfrac{1}{2}\left[A_2^*(0)+\frac{g}{\kappa}A_1(0)\right]e^{gz}+\tfrac{1}{2}\left[A_2^*(0)-\frac{g}{\kappa}A_1(0)\right]e^{-gz}$$

where: $\kappa=\frac{6\pi i\omega}{nc}\chi^{(3)}A_0^2$ **and** $\kappa/g=i$

If set the relative side-mode phases such that: $\frac{A_2^*(0)}{A_1(0)}=i$

then side-modes will experience no gain.

R. W. Boyd and G. S. Agarwal, Phys. Rev. A 59, 2587 (1999).

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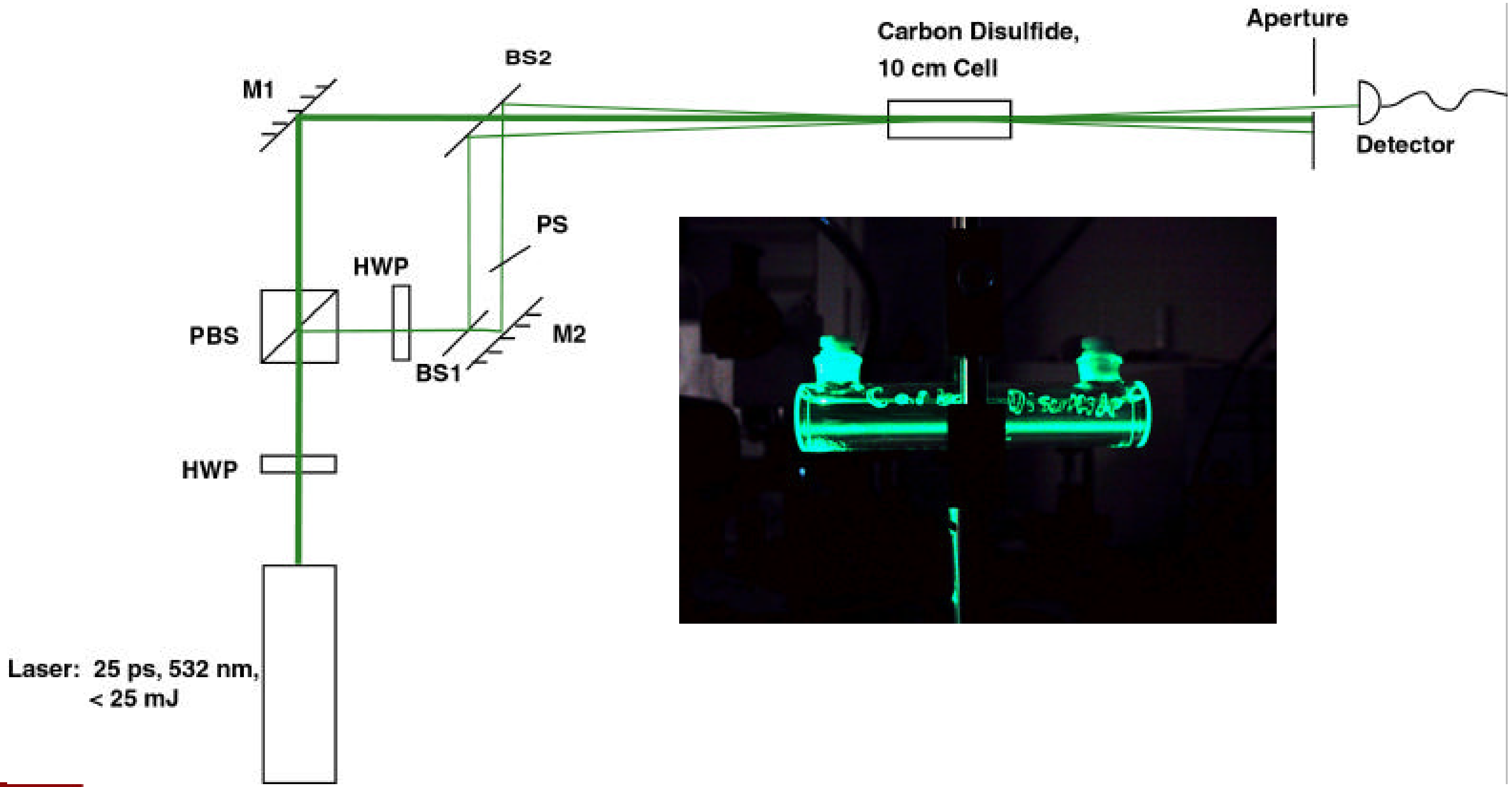
Filamentation Reduction Experiment



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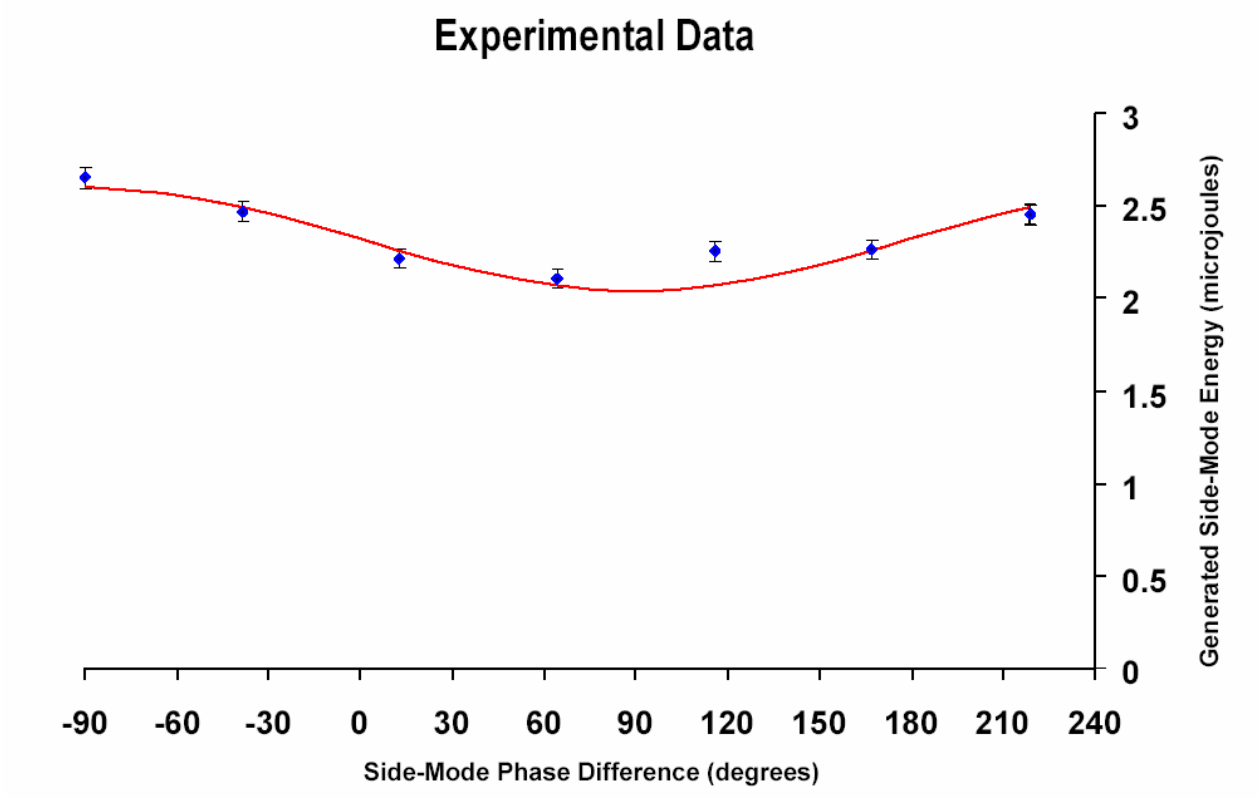
Filamentation Reduction Data



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Two-Beam Experiments

- **Use of two intersecting beams to reduce filamentation**
  - **Maillotte et al., Opt. Comm. 109, 265 (1994)**

- **Experimental & theoretical studies of pattern generation from two intersecting beams:**
  - **Kauranen et al., JOSA B 10, 2298 (1993)**
    Theoretical treatment
  - **Chalupczak et al., Opt. Comm. 111, 613 (1994)**
    Experimental treatment in barium vapor

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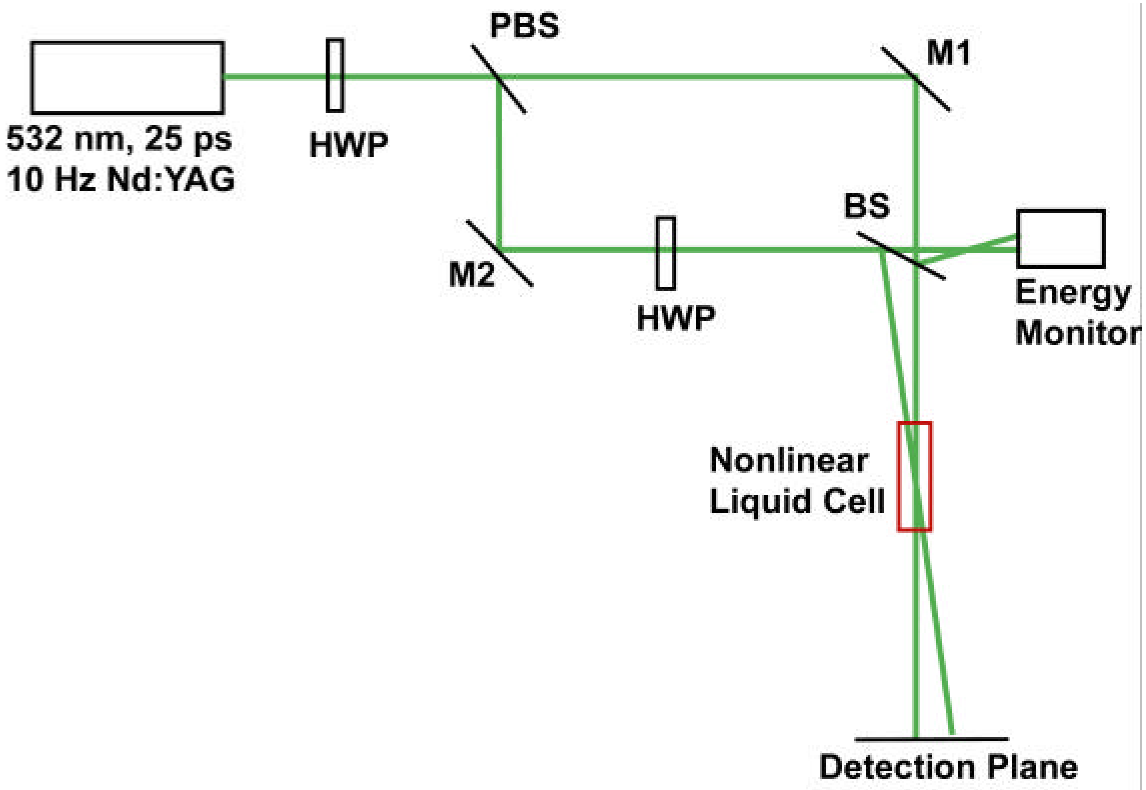
Two-Beam Coupling Experiments



- Used 3-cm and 10-cm cells
- Used CS_2, CCl_4, and toluene
- Pulse intensities ~ 1-80 MW/cm^2
- Crossing angles ~ 0.003-0.04 rad

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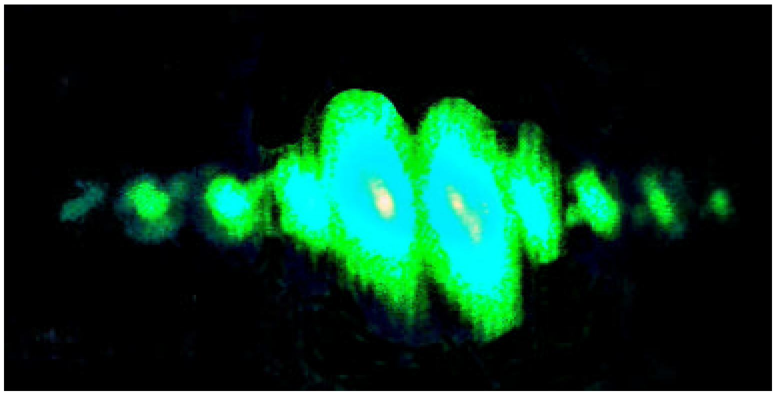
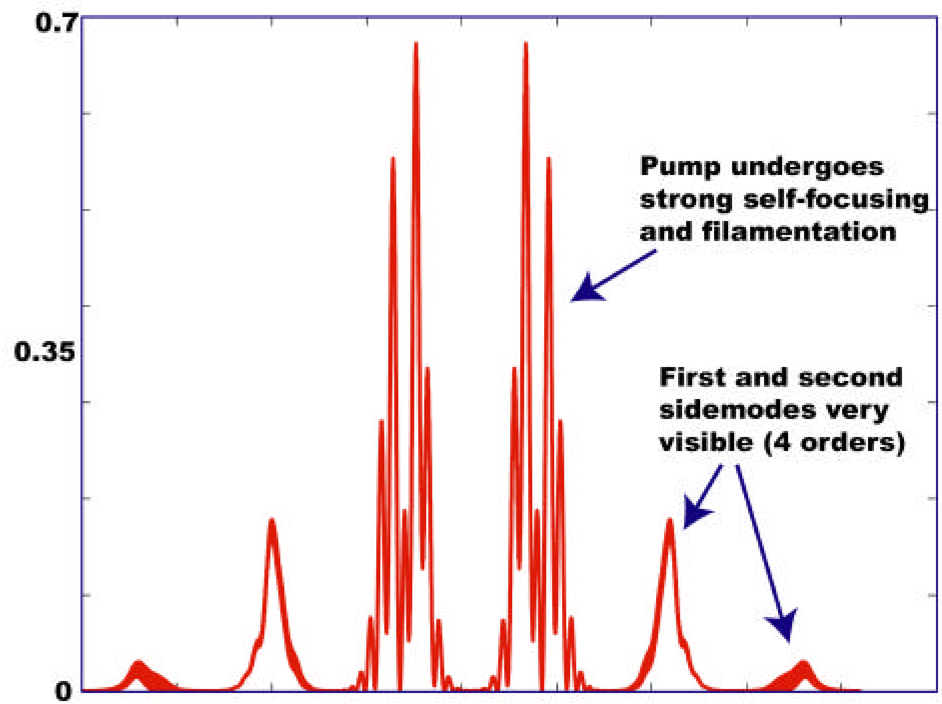
Two-Beam Coupling: Self-Diffraction



- Transverse intensity profile output:



10-cm CS_2 cell
q = 3.2×10^{-3} rad
I = 11.3 MW/cm^2 (each)
w_o = 2.32 mm

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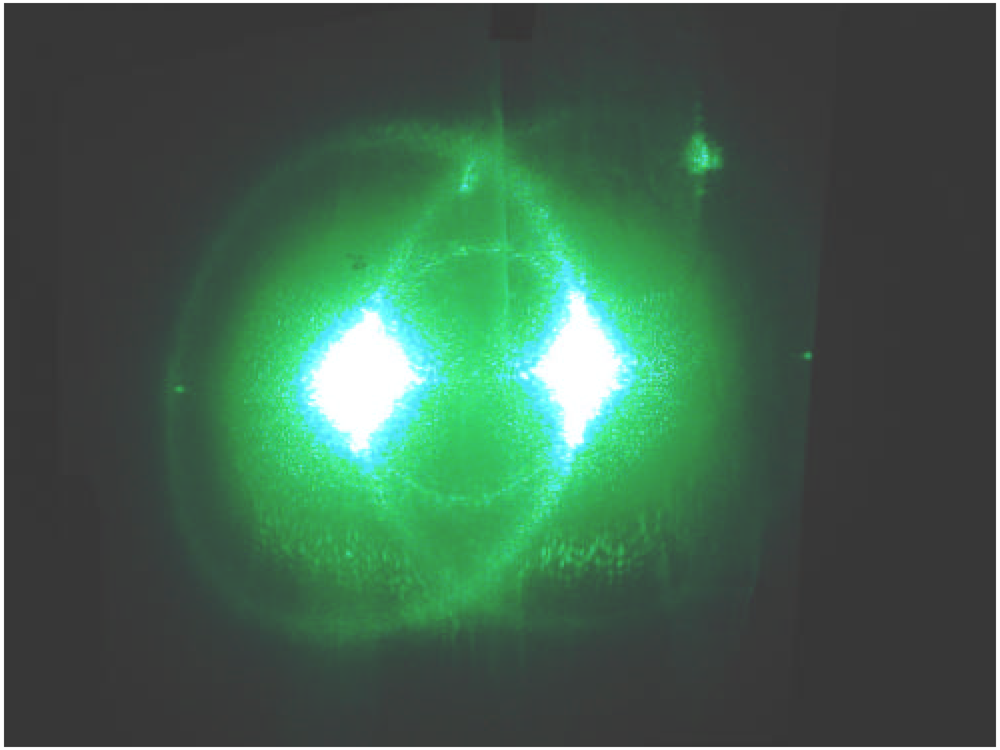
Two-Beam Coupling: Conical Emission



- At "large" angles (~ 0.03 rad), cones of light are observed

- Two types: cones centered about one beam and pass through the other, and cones connecting two beams (TBECE)

- Properties of the cones are primarily dependent upon beam which they intersect

- Clearly observable thresholds

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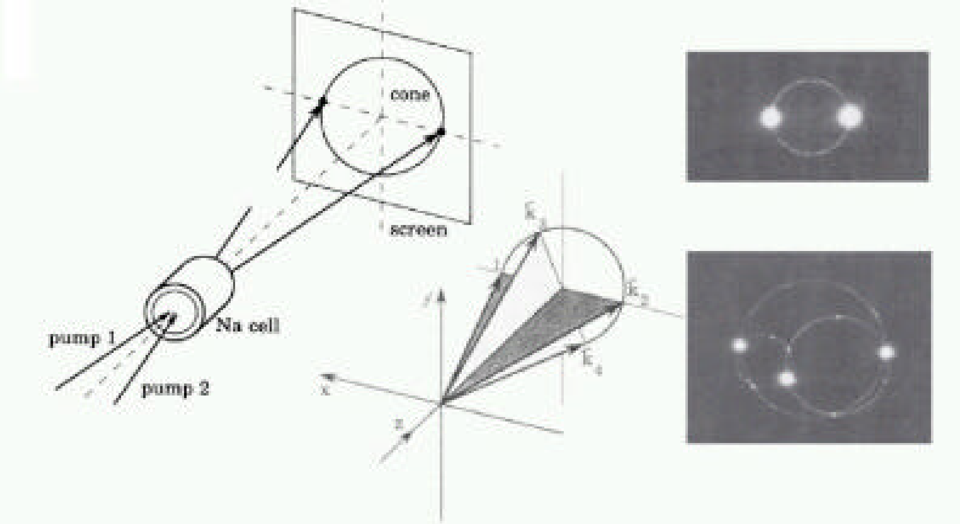
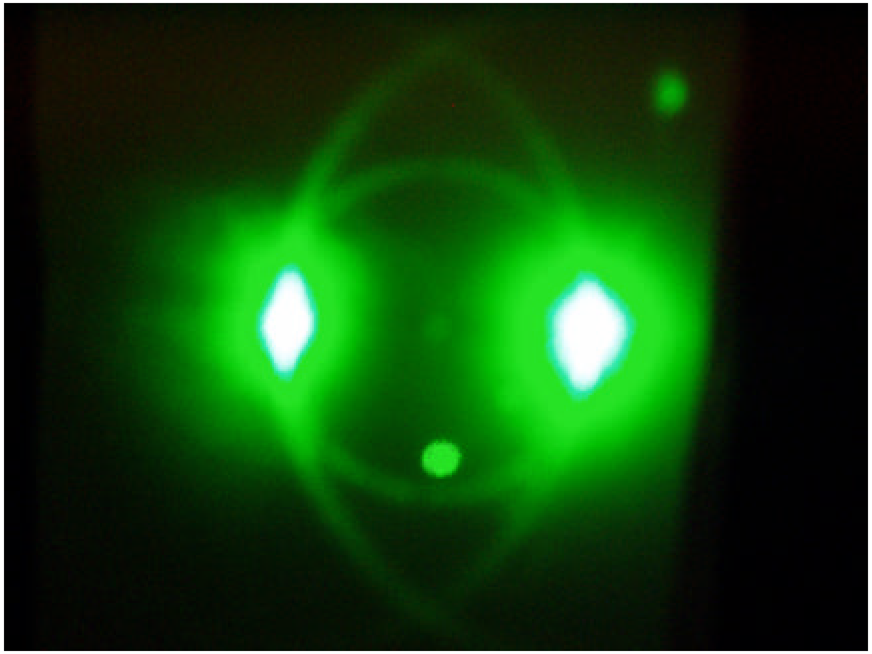
Two-Beam Coupling: Conical Emission



Kauranen et al, Opt. Lett. 16, 943, 1991; Kauranen and Boyd, Phys. Rev. A, 47, 4297, 1993.



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Possible Future Work

- Optimize filamentation reduction experiment
- Explore other methods of filamentation reduction
- Investigate quantum-induced filamentation
- Search for correlations in two-beam generated patterns

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Conclusions

- Demonstrated a method for filamentation reduction
- Studied related two-beam interactions in nonlinear liquids
- Witnessed self-diffraction, two-beam excited conical emission, and seeded spatial modulation instability

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