Generation of intense few-cycle pulses from the visible to the mid-IR

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Abstract

Both of my projects dealt with generation of few-cycle pulses and increasing efficiencies. My first project involved generating Bessel beams to improve the efficiency of the propagation of Gaussian Beams through Hollow Core Fibers (HCF) which naturally have an electric field with Bessel Modes. My second project involved the generation of few cycle pulses in the range of 5 – 10 microns using a process called Difference Frequency Generation.

Terminology

Axicon: conical lens that creates a Bessel Beam
Bessel Beam: a circular beam with ring like structure
Hollow Core Fiber: a glass rod with a small hollow core that is used to guide light.

Optical Parametric Amplifier (OPA): Non-linear device that takes pulsed laser light and produces two beams; a signal (1050 – 1550 nm) and an idler (1600 – 2500 nm).
Difference Frequency Generation (DFG): takes two beams (signal and idler) and creates one beam with a wavelength between 3 microns and 12 microns.

Experimental Setups

Figure 1 (Left): An axicon from electrooptics.com. Figure 2 (Right): A Bessel Beam we took a picture of 200 mm in front of the axicon with a color bar showing a scale of the colors and their intensities.

Results

The transmitted power through a 250 micron fiber with just a 500 mm lens is 2.32 mW. The power before the fiber is 3.72 mW. This gives an efficiency of 57.6%. Transmitted powers and efficiencies of different diameter fibers with the axicon are shown below.

With our DFG setup we were able to confirm that Difference Frequency Generation was occurring through our DFG crystal by observing Phase Matching.

Conclusions and Future

The Bessel Beam from the axicon coupled through a 250 mm fiber almost as well as just the lens. However, we expect to improve the transmission efficiency by changing the focusing conditions and the fiber diameter. As soon as the Bessel Beam travels through the fiber more efficiently, we can use this method to send pulse beams through the fiber to make setups like my DFG setup more efficient. As far as my results for DFG go, we were able to create 10.5 mW light at 9.7 micron (mid-IR) wavelengths which is an awesome result. In the future, we are going to adjust our setup to better control the phase matching of the signal and idler in order to create higher power DFG beams.

Goals

My goals for my projects are:
• Generate an aligned Bessel Beam with an Axicon
• Propagate a Bessel Beam through an HCF and measure the power
• Quantitatively characterize our experimental Bessel Beams
• Create a setup to prove the generation of mid-IR pulses (5-10 micron)
• Measure efficiency as a function of angle of DFG type II crystal in mid-IR region

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