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Report On Experiments and Data Collected

The two projects that I had for the summer were to efficiently couple a Bessel Beam from a 178 degree axicon into a 250 micron diameter, 3 feet long hollow core fiber and to create Difference Frequency Generation through an AgGaS2 (silver thiogallate) crystal and optimize the power coming out of the crystal.

Our final experimental setup for the axicon project used a 15 mW Helium Neon continuous wave laser. The laser would shoot down the table and reach an Nd wheel and a post for Nd filters. The Nd wheel and filters would be used to block light when we needed to take pictures. Otherwise, we set the Nd wheel to allow all light through. A mirror was placed after the Nd to send the laser light 90 degrees counterclockwise. There is a second mirror placed ahead of mirror one to send the laser light another 90 degrees counterclockwise. A third mirror is placed ahead of the second to send the laser light approximately 135 degrees clockwise. Finally, a fourth mirror is set to send the laser light approximately 135 degrees counterclockwise (a drawing of these mirrors, as well as the rest of the setup, is given on page 23 in my lab book). After the fourth mirror is a set of two plano-convex lenses placed such that they create a 4 times magnified culminated beam. Next, the laser light travels through a 500 mm convex lens for 14 inches, followed by a 178 degree axicon. After the axicon, a 250 micron diameter, 3 meter long hollow core fiber is placed 3 and 2/3 inches away. The light entering the fiber is 231 microns in diameter. We made this diameter measurement by taking images and measuring in OriginLab (see page 25 in my lab book or slide 6 of my final presentation).

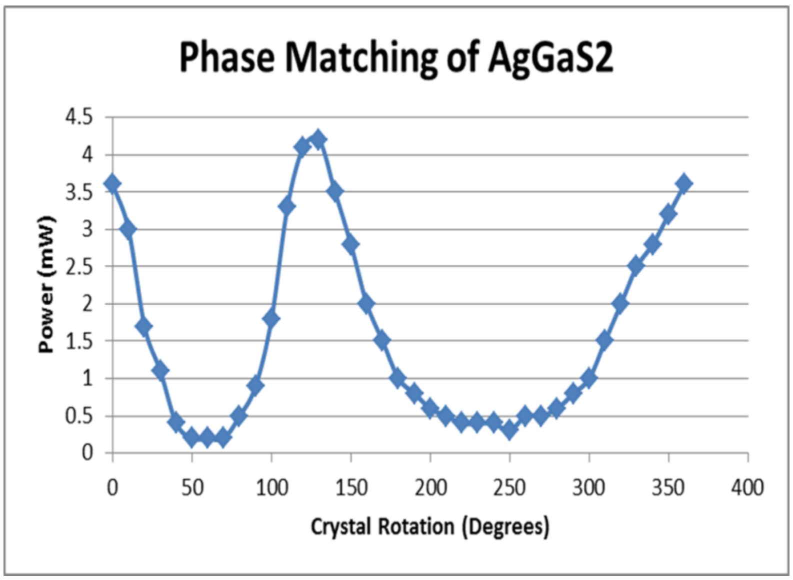
Before finding the efficiency with this setup, we decided to first find the efficiency through a fiber with just the 500 mm lens. The power before the hollow fiber, with and without the axicon, is 3.72 mW. After sending the light through the fiber and aligning, we found a power of 2.32 mW without the axicon. This results in an efficiency of 57.6%. We then put the axicon back into the setup and measured a power of 2.08 mW with an efficiency of 55.9%. Out of curiosity, we then attempted to couple the same beam through five other fibers with diameters of 300 microns, 350 microns, 400 microns, 450 microns and 500 microns. Our results are in the table below:

Fiber Diameter	Transmitted Power	Efficiency
250 microns	2.08 mW	55.9%
300 microns	0.36 mW	9.68%
350 microns	0.78 mW	21.0%
400 microns	0.77 mW	20.7%
450 microns	0.48 mW	12.9%
500 microns	0.40 mW	10.8%

Now there is two key points that are important to these results. First, the transmitted power of 2.08 mW we got for the 250 micron fiber was a continuous improvement. Each new try, we got a better transmitted power. Thus, with a bit more tweaking that power of 2.08 mW can be a much larger power. Second, the 300 – 500 micron fibers were 4 feet long instead of 3 feet. Thus, we would get much higher powers through the other fibers if we used 3 feet long fibers for them.

The setup for Difference Frequency Generation used 800 nm, 30 femptosecond, 2 mJ pulse light from KLS. The light was sent through the OPA in KLS and the signal and idler were adjusted in the OPA by Derrek. The signal and idler coming out of the OPA had a combined energy of 0.5 mJ with a power of 1 W. After the OPA, the aligned beams were sent through the AgGaS2 crystal to create the DFG beam. Following the crystal was a germanium window that only transmits 3-12 micron light (DFG beam) and blocks the signal and idler. The blocked signal and idler were sent to a beam block while the DFG beam continued through the window and onto a power meter to measure the power.

With a 1470 nm signal and a 1750 nm idler, we were finally able to detect DFG after the crystal. The energy split between the signal and idler was 83% signal and 17% idler. The wavelength of DFG created was 9200 nm. With crystal rotation, we found that the signal and idler were most in phase around 0 (or 360) and 130 degrees as shown below:



We were able to optimize the power of DFG with the signal at 1450 nm and the idler at 1705 nm. At these wavelengths, the energy split was 66% signal and 34% idler. The wavelength of the DFG beam was 9700 nm and the AgGaS2 crystal was rotated to 134 degrees. As a result of all this, we achieved a maximum power of 10.5 mW.

Our last result came from removing the DFG crystal and adding a 0.8 mm thick calcite crystal. The power after the germanium with the calcite crystal was 1.0 mW. After removing the calcite, the power after the germanium was 1.2 mW. This result told us that the calcite is aligned such that the signal and idler lose overlap in time.