Building an Optical Parametric Chirped-Pulse Amplifier
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Abstract

In this thesis, we show both the theoretical framework, as well as the experimental realization of an optical parametric chirped pulse amplification system. This laser system will be used to perform research on laser ablation of tin in the femtosecond regime. Additionally, we show such an amplification system provides a way to amplify short femtosecond pulses across a large wavelength range to high energies. This is realized by exploiting a nonlinear effect called difference frequency generation, also called optical parametric amplification. In this process, two laser beams interact in a nonlinear manner to produce a laser beam at the difference frequency. Thereby, photons from the laser with the highest frequency are split in two photons, one with the difference frequency of the two interacting beams, and one at the frequency of the lowest frequency input beam. This then results in energy transfer from a high intensity laser to two other beams, of which one is amplified and one is generated.

The optical parametric chirped-pulse amplifier that has been partially realized during this thesis amplifies a 80 fs pulsed laser with a wavelength of 1560nm at a repetition rate of 100 Hz. The pump laser for the amplification process has a 1064nm wavelength. Therefore, the resulting difference frequency beam will have a wavelength of 3.4 micrometer. Before amplification, the 1560nm beam is chirped, reducing the peak power to prevent optical damage. Two out of the three amplification stages have been completed during this thesis. In three amplification stages the 1560nm beam is expected to have an energy of 30mJ within a pulse duration of 140 fs. Results from the first two stages show amplification to the mJ level, providing sufficient energy to seed the third stage and obtain 30mJ pulses. By introducing mismatch between the spectral amplification regions of these two amplification stages, we have managed to amplify with a 43nm bandwidth. Such a bandwidth is sufficient to recompress the amplified pulses back to 140 fs. These amplified pulses have not been compressed back to the shortest possible duration. However, we have shown recompression of unamplified pulses traversing the complete laser system to 180 fs.

In the near future, the third and final amplification stage will be finished, and its output will be compressed and characterized. Expecting 30mJ of pulse energy, that should be plenty to start tin ablation experiments in the femtosecond regime.