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Concepts for scaling peak power & average power of few-cycle laser sources

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Strong field driven processes can best controlled with carrier envelope phase stabilized laser pulses consisting only of a few oscillations of the electric filed. The most straight forward and therefore most widespread way to reach this goal is post-compression of multicycle lasers. Especially at high powers, hollow-core fibers (HCF) became the work horse in the strong filed community. Even though more complex, an alternative route are laser sources that directly emit pulses with as little as only two optical cycles at FWHM of the envelope. We are simultaneously pushing both competing approaches to investigate their corresponding pros and cons at the highest performance level. On the HCF side, we demonstrated transmission efficiencies between 70-80% for several meter long HCFs enabling single step compression factors >30 [1]. Current tests for power scaling are at the level of 50mJ energy for 200fs input pulses or beyond 300W of average power, respectively. For much higher peak powers, the HCF might become impractically long, thus other solutions are desired. Therefore, we developed the approach of frequency domain optical parametric amplification (FOPA) [2]. This concept holds the current world record of IR few-cycle laser sources with an output energy of 30mJ within 2 cycle duration (12fs) at 1.8m wavelength [3]. We will also discuss prospects and difficulties dealing with half kW (500W) level Yb laser sources as the pump for the FOPA [4]. [1] "Direct compression of 170-fs 50-cycle pulses down to 1.5 cycles with 70% transmission", Jeong et al. Scientific reports 8, 11794 (2018). [2] "Frequency domain optical parametric amplification", Schmidt et al. Nat. Commun. 5, 3643 (2014) [3] "2.5 TW, two-cycle IR laser pulses via frequency domain optical parametric amplification", Gruson et al., Opt. Exp. 25, 27706 (2017). [4] "Highly stable, 54mJ Yb-InnoSlab laser platform at 0.5 kW average power", Schmidt et al., Opt. Exp. 25, 17549 (2017).