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Towards exawatt pulses using advanced methods in stimulated Raman backscattering

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The maximum extractable energy of conventional chirped pulse amplification (CPA) laser technology is limited by the damage threshold of laser components, which is in the order of $10^{12} W/cm^2$. Amplification by Stimulated Raman Back Scattering (SRBS) in plasma has the potential to overcome these limitations allowing theoretically maximum intensities of 10^{16} –$10^{17} W/cm^2$, which is the prerequisite for realizing exawatt-class laser systems. Amplification is achieved when two counter propagating beams overlap in plasma is such a way that a plasma density echelon is produced by the beat wave to allow scattering of the "pump"pulse into a "seed"pulse. To achieve the highest possible conversion efficiency it is necessary to overcome a few bottlenecks, and present solutions which also work for not always ideal operation conditions of the laser system:

i) The bandwidth of linear growth SRBS is limited and does not support the generation of very short pulses. However with Vlaslov Code simulation we have identified conditions for the laser pulses (chirp and intensity) and the plasma parameters to provide broad band amplification, The predictions have been verified in an experiment showing amplification over a spectral range sufficient for generating sub-20 fs pulses

ii) To counteract instabilities in the plasma, the red-shifted seed pulses need to surpass certain energy levels. In another series of experiments we employed Raman up-shifting in a molecular gas with Bessel shaped beam for realizing energetic red-shifted seed pulses with an excellent beam quality, and is very robust against fluctuation of the energy and beam profile of the laser

iii) Amplification with SRBS has been demonstrated mainly with pump pulse energies in the multi-J range. As it has been discussed in the literature, a large volume uniform plasma is necessary for further increasing the pump pulse In a recent experimental campaign at PHELIX/GSI we studied the possibility of energy scaling of SRBS. Special emphasis was laid onto the gas target and the role of an additional ionizing pulse to create a uniform plasma, also for a fluctuating laser. Preliminary results of the energy scaling experiment with fast ionization control at PHELIX/GSI will be presented at the conference.

Summing up, SRBS is a promising route for the generation of exawatt laser pulses. As it will be shown in our contribution, a few of the problems have been solved, but further efforts are necessary to realize the next generation high intensity laser systems.

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