# Efficient Raman laser amplification with short pulses

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Amplification of the ultrashort pulses is limited by the damage threshold of optical components used in the laser system. For multi-PW laser system, the components like for example gratings in the compressor have to be very large, they are difficult to produce and expensive. An alternative is to use the plasma medium, where the energy from a longer higher-frequency pump pulse can be transferred to a short lower-frequency seed pulse via stimulated Raman or Brillouin scattering. The plasma medium can support much stronger fields and the maximum intensity threshold is increased by several orders of magnitude. On the other hand, the efficiency and stability of these processes are limited by the growth of unwanted instabilities.

We concentrate on the stimulated Raman scattering and propose an efficient and stable way how to transfer energy between two laser pulses. Two most common high power laser systems are considered here. These are a higher energy Nd:Glass system delivering a longer pulse which serves as a pump pulse and a lower energy Ti:Sapphire laser system which delivers a short seed pulse. To make such configuration feasible, either the seed pulse frequency must be decreased below the one of the pump pulse or the pump pulse must be converted to higher frequency. In this contribution, we consider the later one and we assume that the pump pulse is frequency doubled using a thin KDP crystal like in [1]. In such a case, the frequency mismatch between the pump and the seed pulse implies a relatively dense plasma where the interaction becomes unstable on a short time scale. To suppress the growth of instability, the interaction time between the laser pulses and the plasma medium is shortened to few hundred femtoseconds and the intensity of the both pulses is relatively high so that the energy transfer is relatively efficient on the very short time scale. Using this approach, we can achieve about 60% conversion efficiency from the pump pulse to the seed pulse in our 1D Particle-in-cell simulations using the code EPOCH. The results are also confirmed in 2D simulations as it turns out that multi-dimensional effects like filamentation and self-focusing are not important on the short time scale of the interaction.

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## References

[1] M. Hornung *et al.*, Appl. Sci. **5**, 1970–1979 (2015)