Short pulse mid-infrared amplifier for high average power

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Abstract

A high repetition rate high pressure CO_2 laser amplifier was developed for amplifying picosecond 10 micron laser pulses. The laser design as well as experimental results will be reported.

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A high repetition rate high pressure CO_2 laser was developed for amplifying picosecond 10 micron pulses. This laser operates at a pressure of up to 10 atm. Pressure broadening of the individual ro-vibrational lines causes an overlap of neighbouring transitions. This causes a large amplification bandwidth of approximately 1.0×10^{12} Hz. If the relationship $\Delta t\Delta\nu \geq 0.4$ is used then pulses as short as 0.5 ps can be amplified. The gain bandwidth can be increased by using isotopic mixtures and consequently this will allow pulses shorter than 0.5ps to be amplified. Gas lasers are to a large extent free from optical non-linearities permitting amplification of multi-terawatt pulses without pulse chirping. The energy that can be extracted is ~30mJ/cm^2.

Laser driven electron accelerators based on 10 micron radiation has some advantages compared to the more conventional devices based on 1 micron lasers. The primary advantages are the following: The pondermotive potential is proportional to λ^2 and the phase-slippage distance and the laser accelerator structures are proportional to λ. Energies of up to 15J per pulse in 3 ps can be produced by CO_2 oscillator-amplifier chains [1],[2]. This means that intensities of approximately 10^{18} W/cm^2 10 micron spot resulting in an electric field of 30GV/cm in the focus of a 10 micron laser.

High pressure CO_2 lasers were developed in the 70's and 80's and are notorious for being unreliable and difficult to operate. However, the laser presented here is based on excitation scheme, an LC-inversion circuit with a single stage magnetic pulse compressor, developed for commercial TEA CO_2 and Excimer lasers. This laser was designed with internal heat exchangers and internal catalysts and fans. This means that it can be operated for extended periods of time at high pulse repetition rate in a closed loop configuration. The fact that it can be operated in a closed loop configuration also opens up the possibility of using rare isotopes. This laser is as reliable and as easy to operate as a normal TEA-CO_2 laser. Pulse repetition rates of more than 200Hz can be achieved. To our knowledge this is the highest pulse repetition rate that has been reported for a high pressure CO_2 laser. The measured small signal gain on the system is approximately 2%/cm.

References

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