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Simplified analysis of double-pass amplification with pulse overlap and application to Nd:YVO₄ laser

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Optics Communications 255 (2005) 297-303

Abstract

We derive simple and convenient expressions for two-pass saturated amplification with pulse overlap. These have the same form as the single-pass Franz Nodvik equations but with a factor of two in front of the cross-section for stimulated emission. The predicted decrease in energy extraction efficiency when there is pulse overlap compared with sequential passes agrees well with earlier numerical modelling. This approach has been extended to analyse a two-pass Nd:YVO₄ amplifier (diode pumped 2mm long 1% doped crystal) operated with nanosecond pulses delivered at rates up to 20kHz and taking account of the Gaussian beam profile. An estimate of $\gamma = 1 \times 10^{15} \text{cm}^3 \text{s}^{-1}$ for the up-conversion macro-parameter was found to provide a consistent value for the length-averaged gain coefficient and the effective gain lifetime of the amplifier for the pump conditions used.

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