Digital laser mode amplification using Nd: YAG amplifier

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ABSTRACT

In this work we demonstrate the output power amplification of the generated higher-order modes from a digital laser by using an extra-cavity Nd: YAG amplifier. The diode-pumped solid-state digital laser (DPSSDL) generates fundamental higher-order modes by encoding and displaying a digital hologram on a phase-only spatial light modulator (SLM) that acts as an end-mirror of the laser resonator cavity. The amplifier was designed in such a manner that when higher-order modes enters the Nd :YAG amplifier they will experience higher gain which would translate to increase the power of the mode when it is transmitted through the amplifier.

INTRODUCTION

The DPSSDL has attracted widespread attention due to ability of generation on-demand laser modes [1]. Diode lasers are the preferred pump for high power lasers, due to better frequency stability, higher efficiency, higher brightness and long operational life time [2]. The laser uses an SLM to generate modes in order to avoid the use intra-cavity phase elements (IPE) in the cavity to generate modes, since the IPE are inconvenient since they are manufactured for a fixed mode.

The DPSSDL has a power limitations, since the end-mirror of the resonator is an SLM, which have low damage threshold. Due to the SLM's efficiency and low damage threshold, the output beam of digital laser is restricted in power, this raised a need to increase power output of beam.

EXPERIMENTAL SETUP

Figure 1 represents a plano-concave DPSSDL resonator that is end-pumped with a multi-mode fiber coupled diode laser, for generation of higher-order $LG_{p,l}$.

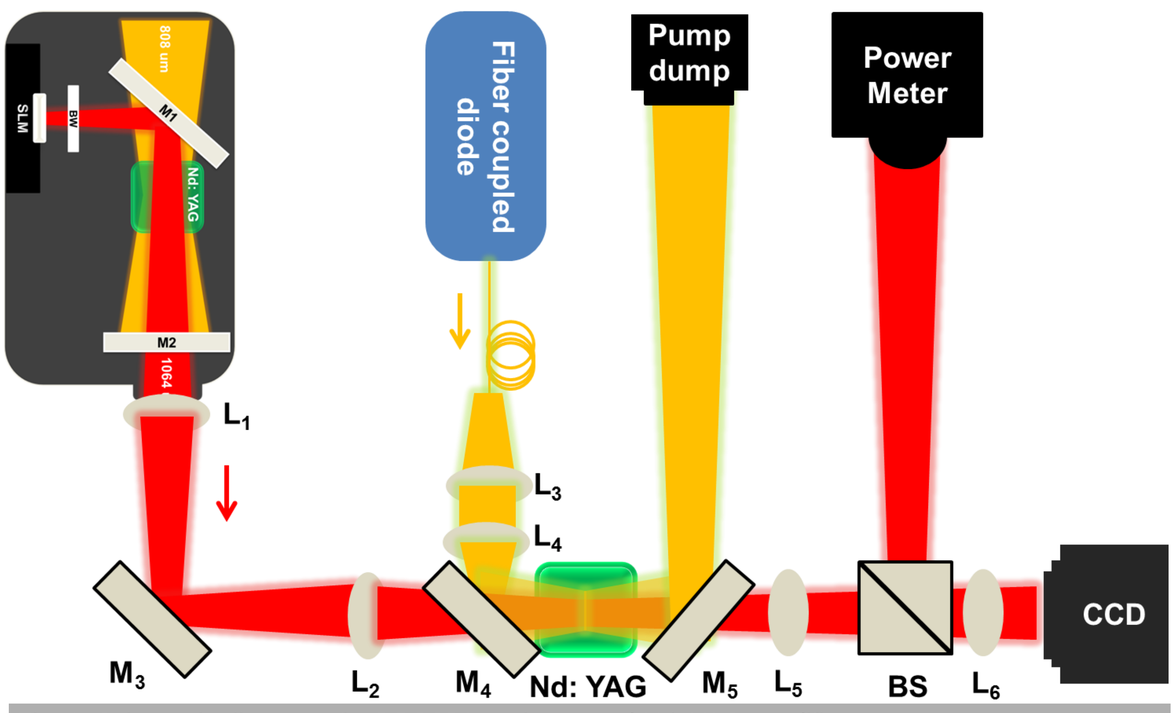

Fig .1: Schematic diagram of a DPSSDL and external Nd: YAG amplifier.

This enabled the selection of on-demand output higher-order LG mode by dynamically changing the displayed hologram shown in Fig. 2. The SLM was calibrated to realize that a full phase cycle from 0 to 2π was represented graphically by grey-scale colors ranging from white to black, in 256 levels (8-bit encoding).

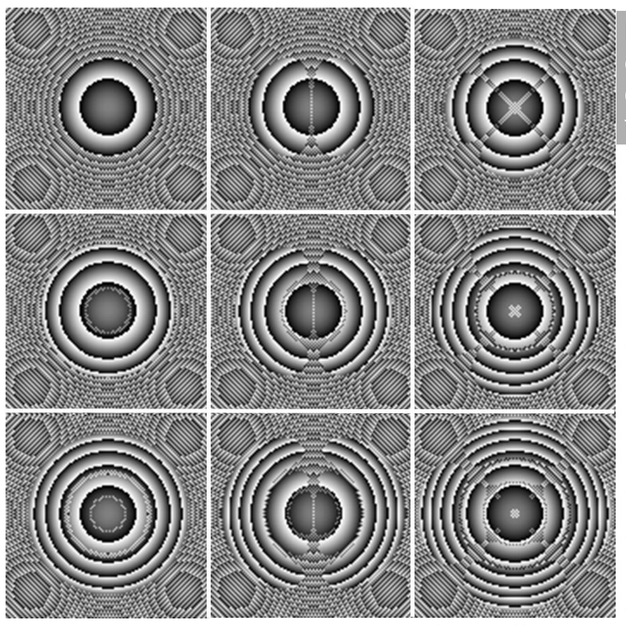

Fig. 2: Computer generated holograms encoded as a pixelated grey-scale image for generating $LG_{p,l}$ modes. Rows represent p=0 to 2, and column represent l=0 to 2.

The laser beam was transmitted out of the cavity through an output coupler mirror (M2) and was relay imaged using lens L_1 and L_2 to the external Nd: YAG. The Nd: YAG amplifier was pumped with a multi-mode fiber coupled diode laser, that deliver a maximum power of 70 W, with central wavelength of 808 nm. The mirror M_5 was used to separate residual pump light and amplified $LG_{p,l}$ beam. In addition, a beam profiler was used to observe the amplified LG beam and a power meter was used to measure the amplified LG beam power.

RESULTS

The seed intensity profiles of the input $LG_{p,l}$ modes are shown in Fig. 3(a). The amplified seed intensity profiles are also illustrated in Fig. 3(b), the profiles shows a high degree of similarity compared to the seed $LG_{p,l}$ modes.

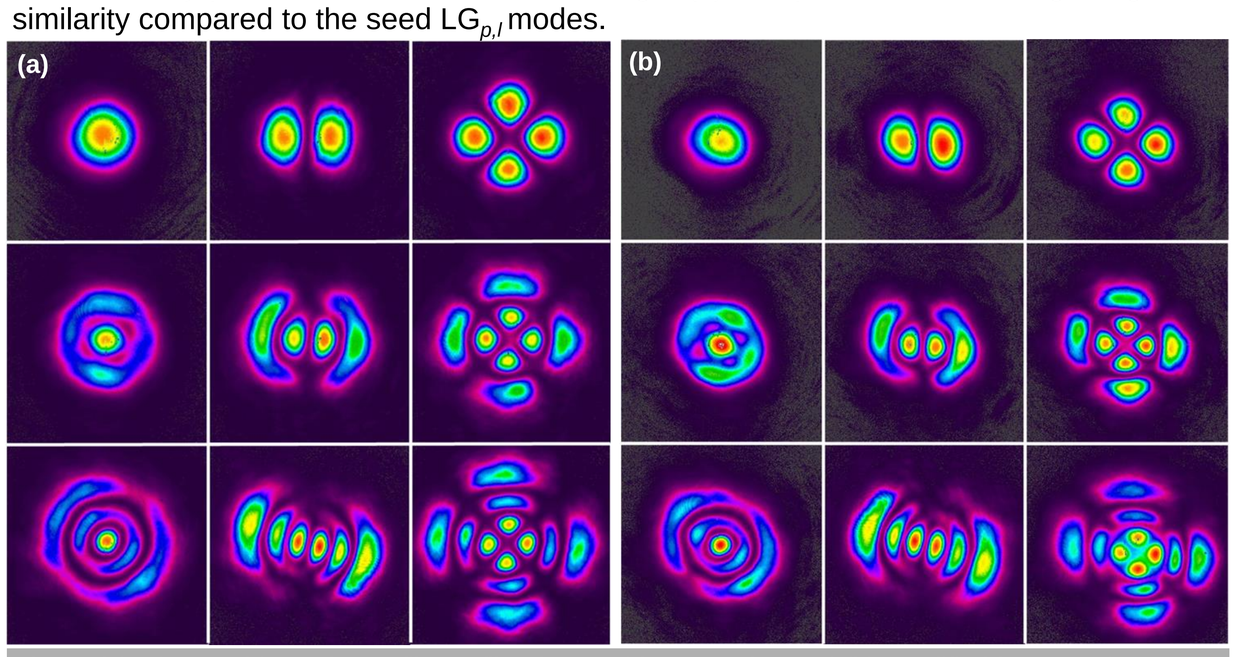

Fig .3: (a) Observed intensity profile profiles for seed laser modes and (b) amplified laser modes. Rows represent p=0 to 2, and column represent l=0 to 2.

Furthermore, we studied the efficiency of the Nd: YAG amplifier, including the laser diode power dependence of to slope efficiency for $LG_{2,2}$ mode, results are shown in Fig. 4(a). The slope efficiencies, mode sizes and amplification percentage were studied for $LG_{p,l}$ at 60 W, results are shown in Fig. 4(b), Fig. 5(a) & Fig. (5b).

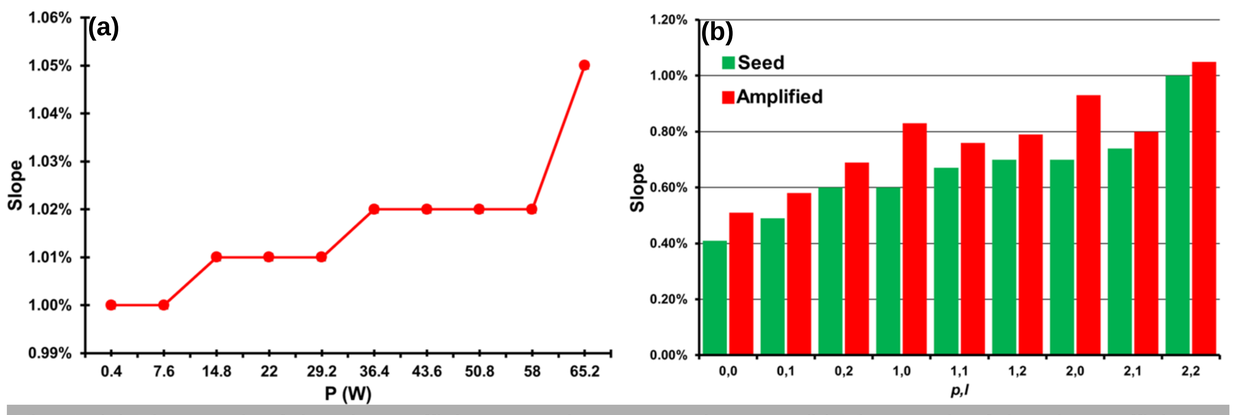

Fig .4: (a) The graph of the slope efficiency against pumped power. (b) The graph of the slope efficiency against mode order.

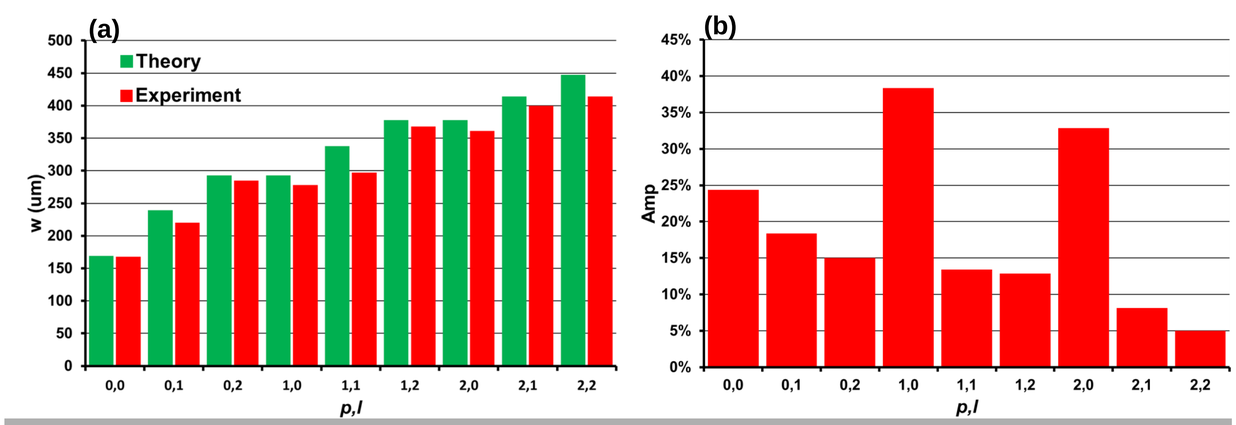

Fig .5: (a) Beam radius at the centre of the amplifier and (b) amplification percentage (Amp) against mode order p,l .

CONCLUSION

In this poster, higher-order $LG_{p,l}$ laser modes were successfully amplified through a diode-pumped Nd: YAG crystal. By matching the pump size and the seed laser modes. For $LG_{2,2}$, the seed laser is mismatching the pump, as the result the intensity profile of the seed laser is not similar to amplified seed laser mode to some degree. In future, one need to perfectly match the pump with the seed laser mode.

REFERENCES

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