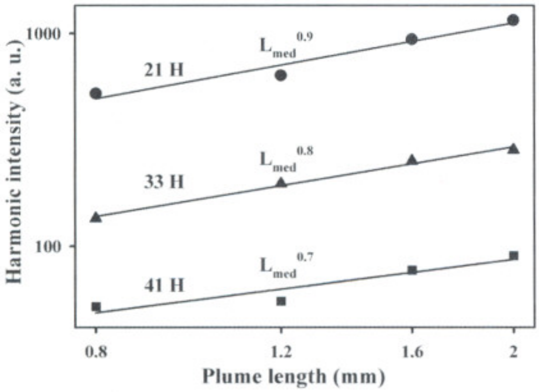

Fig. L.9.1: Variation of the harmonic intensity with the plasma plume length

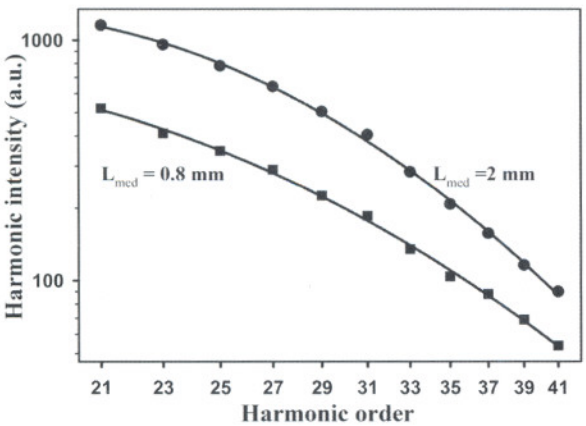

Fig. L.9.2 : Harmonic intensity variation with the harmonic order, for two lengths of the plasma plume.

The above results have been explained from the propagation of harmonic radiation in dispersive and absorptive media. As the laser beam propagates through the medium and produces harmonics, phase mismatch (Δk) between the laser pulse and harmonic radiation may increase with length. There are mainly four factors that contribute to Δk: 1) atomic dispersion, 2) plasma dispersion, 3) Gouy phase shift, and 4) intensity dependent dynamical phase shift in nonlinear dipole moments. Using these, the scaling of harmonic intensity with medium length was calculated. The intensity scaling exponent ß was observed to be ~1.1, 0.9 and 0.8 for 21st, 33rd and 41st harmonic orders respectively. These values are quite close to those observed experimentally. [For more details, please see *H. Singhal et al, Phy. Rev. A, **79**, 023807, 2009*]

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L.10: Development of high power diode-side-pumped CW Nd:YAG laser

A high-power, diode-pumped CW Nd:YAG laser, using copper-coated optically pumped cavity generating 1210 W of output power, has been developed in the Solid State Laser Division of RRCAT. For this laser, the diode pump power was 2400 W, which corresponds to an optical slope efficiency of 55% and an optical conversion efficiency of 50%. These efficiencies and power are the highest reported to the best of our knowledge using a single ϕ 6mm x 150 mm Nd:YAG rod.

Figure L.10.1 shows a cross-sectional view of the pump cavity of the laser. There was a reflective coating over the flow tube to trap the pump light within the flow tube by multiple reflections, for efficient utilization of the pump radiation. Copper coating was used instead of gold coating for two reasons: a) copper has excellent adhesion on the glass substrate, b) it has higher reflectivity than gold around the diode emission wavelength of 808 nm. In order to avoid any oxidation of copper, a thin chromium layer was coated over copper layer. The laser pump head consisted of 0.6% doped Nd:YAG rod which was surrounded by a copper-coated quartz flow tube on the outside surface with three narrow windows of 1.5 mm width and 120 mm length, in three-fold angularly symmetric directions. Three linear diode modules were positioned 0.2 mm away from the periphery of the flow tube at angles of 120° with respect to each other, to pump the Nd:YAG rod over a length of 120 mm. With this configuration, the pump light gets directly coupled into the gain medium. Each module had ten 1-cm long diode laser bars. The maximum output power of each diode laser bar was 80 W. The diode laser bar had an in-built micro-channel cooled heat sink, requiring a minimum water flow of 300 ml per minute (lpm) for efficient heat removal. All the diodes were connected in series and were operated by a constant current, controlled power source. Chilled de-ionized water was used as the coolant for both, the diode and the laser rod. The calculated Reynolds number and the heat transfer coefficient are 17,700 and 3.3 W/cm^2-°C, respectively, for the measured flow rate of 11 lpm. The emission wavelength of the diode laser bar was maintained at the peak of the absorption band of Nd:YAG laser crystal near 808 nm, by adjusting the coolant temperature. Considering the thermo-mechanical properties of Nd:YAG crystal, theoretically allowed maximum heat dissipation (i.e fracture limit) is 200 W/cm. The actual maximum pump power line density was 240 W/cm. Assuming that 40% of the pump power is dissipated as heat (under no lasing condition) in the laser rod, the laser can be considered to be operating close to 50% fracture limit. The laser resonator was formed by a plane high reflection (near 100%) mirror, and an 80% reflectivity plane output coupler, separated over a distance of 180 mm. The measured thermal focussing coefficient was 5.46 D/kW. The beam quality factor (M^2) of the laser was around 110. The overall size of the laser head is 225 x 220 x 250 mm^3.

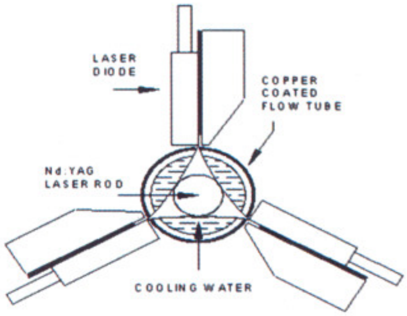

Fig. L.10.1 A cross-sectional view of the pump cavity.

Figure L.10.2 shows the performance of the laser for multimode operation versus the total diode pump power. Fig.L.10.3 shows the photograph of the system in operation.

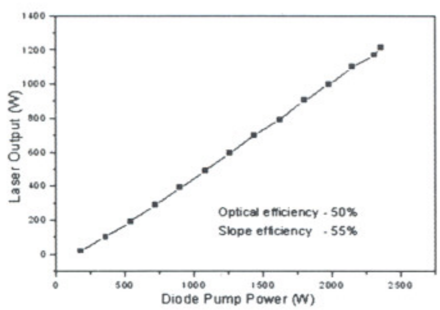

Fig. L.10.2. Laser performance for multimode operation versus the total diode pump power.

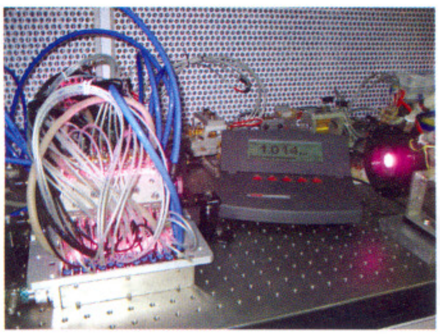

Fig. L.10.3. A photograph of the laser system in operation.

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L.11: Role of location and orientation of Pockels cell in a laser resonator cavity

Location and the orientation of the Pockels cell (i.e. the orientation of the crystallographic axes of the crystal with respect to the plane of polarization of the beam incident on the Pockels cell), along with other active Q-switching elements in a resonator cavity, can affect the cavity Q-value and the polarization state of the output. This was experimentally studied and analyzed using Jones matrix formalism in Solid State Laser Division of RRCAT.

The effect of position of all active Q-switching elements namely polarizer, Pockels cell, and $\lambda/4$ plate were studied in two positions, one in the output leg, and the other in the feedback leg of the resonator as shown in the Figs.L.11.1 and L.11.2. In each configuration, two sets of experiments were conducted by swapping the location of Pockels cell and the $\lambda/4$ plate. The effect of Pockels cell rotation on the hold off condition of the cavity and the

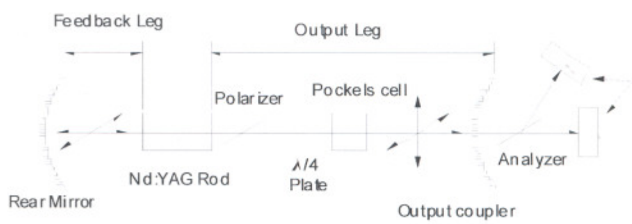

Fig. L.11.1: Resonator with the Pockels cell kept after the polarizer and before the λ/4 plate in the output leg

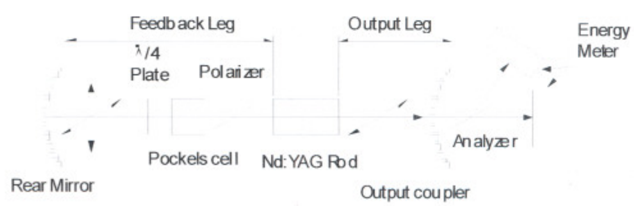

Fig. L.11.2: Resonator with the Pockels cell kept after the polarizer and before the λ/4 plate in the feedback leg

polarization state of the output was monitored for each configuration. Rotation of the Pockels cell can affect objective of achieving the low Q-value, under the "no voltage on the cell" condition. This may lead to the depopulation of the exited state and hence inefficient Q-switched pulse. Jones vectors for the configuration are J1 and J2 respectively and they are given by: