Experimental Realization of Nd-YAG Laser

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The Nd-YAG (Nd^{3+} ions doped in $Y_3Al_5O_{12}$) laser is a commonly used lasing system that emits laser radiation in the wavelength $\lambda = 1064$ nm. The fundamental components of any lasing system consists of an active medium, pump source (typically a diode laser is used) and an optical cavity resonator. In this experiment, we proceed to measure the absorption spectra of Nd-YAG crystal to determine the dependence of diode laser wavelength on its temperature. In addition, we also perform measurements to determine the lifetime of the $^4F_{3/2}$ metastable state. For subsequent plans, we plan on investigating nonlinear phenomena such as second harmonic generation, in addition to TEM modes along with the experimental implementation of Q-switching using a passive Q-switch i.e. Cr-YAG crystal.

INTRODUCTION

LASER stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. It is a source of highly directional and intense light, with the emitted radiation being monochromatic and coherent in nature.

In our discussion, we shall deal with a particular type of laser called Neodymium Yttrium Aluminium Garnet (Nd-YAG) laser. This laser has various medical and scientific applications especially in spectroscopy and surgery. Here, we shall discuss the working principle of a general laser and Nd-YAG laser in particular. Afterwards, the experiment along with the relevant setup is described and results inferred.

EXPERIMENTAL SETUP

Here, we proceed to describe the setup of our experiment consisting of various optical elements, an optical rail for their subsequent placement.

Diode Laser (Module A): This module contains a diode laser with an emission spectrum containing 808 nm (1) light. The corresponding power is maximum at $20°$ C with a value of 500 mW. It is controlled via a *Peltier's element* which controls the injection current and temperature of the laser. As shown in **??**, it is attached to the adjustment holder (2) which is further attached to the carrier (3). This helps us fix the laser onto the optical rail.

In our setup, the temperature can be varied between $15°$ C and $35°$ C. The fine precision pitch screws (4 & 5) are used to micro-adjustments in order to align the optical axis of the diode laser with the overall mechanical axis of the optic rail.

Collimator (Module B): This module contains a collimator unit whose main task is to supply a parallel beam of light from the original divergent beam originating from the diode laser. It (1) consists of a three-lens system housed within a body with a large aperture and a focal length of 8 mm. It is mounted onto the holder (2) as shown in **??**. The holder is then fixed onto the optic rail of the setup.

Focussing Unit (Module C): Shown in **??**, this module consists of a focussing unit needed to focus the collimated beam of light originating from the collimator onto the crystal (which is to be mounted onto module D). The lens (1) has a focal length of 60 mm and is mounted onto a 25 mm click holder (2). This is further placed and fixed on the optic rail of the setup.

Adjustment Holder (Module D): Shown in **??**, this module contains an adjustment holder (3) for housing the Nd:YAG crystal (2) onto an exchangeable mount (1). The crystal itself is polished on one of its ends to form a plane-parallel mirror. This polished coating is highly reflective for the emergent wavelength of light (1064 nm) and hence forms the left resonator of the entire optical cavity (to be mounted subsequently). This polished end of the crystal is placed to face the focussing unit. This mirrored coating is such that it is transparent to the 808 nm emission from the diode laser. The other end of the crystal is coated with an anti-reflection layer for 1064 nm light in order to keep the losses in the resonator cavity low. This end is also coated with a highly reflective layer for 532 nm light, in order to allow the outward propagation of corresponding green light out of the resonator cavity for the second harmonic generation experiment.

The crystal is placed in the exchange mount, which is mounted onto the corresponding adjustment holder. This is then fixed onto the optic rail. The fine adjustment screws help in aligning the resonator mirror in a way that the common optical axis of positioned perpendicularly to the mirrors.

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This is an acknowledgement.

[1] Svelto, O. and Hanna, D. C. (1998). *Principles of lasers*, volume 4. Springer.