Measurement of the Time Constant of Nd:YAG Rod

Ke Li, Jerome Jahn

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1 Experimental Procedure

In this part of the experiment, we measured another important characteristics parameter of a Nd: YAG rod, the decay time constant of the spontaneous emission. To do so, we measured emission of the 1064 nm radiation emitted by the laser rod on the oscilloscope, from the falling edge (37% of the maximum voltage)of the fluorescence signal determine the time constant of the spontaneous emission. During the experiment, a long-pass filter is used to filter the noise wavelength from laser dioder, ensuring the oscilloscope only output measurement result of the Nd:YAG emission wavelength of 1064 nm. We also increased the gain of the pump laser, giving more accuracy to the data. In this part of the experiment, the pump laser was pumped optically in periodical rectangular signal.

2 Experiment Result

We measured 5 set of data with 10 data points to determine the decay time constant. The measurement result is shown in Table 1.

Index	V Volatge (mV)	37%V (mV)	$Deltat$ (μs)
1	88.8	32.856	190 ± 30
2	90.4	33.45	220 ± 30
3	89.6	33.152	220 ± 30
4	89.6	33.152	235 ± 30
5	89.6	33.152	220 ± 30

Table 1: Decay Time Constant Measurement Result

From the data above, we could find the average value of the decay time constant is: $217 \pm 30\mu s$. The literature value of the decay time constant of spontaneous emission of a Nd:YAG rod at 1064 nm is $\tau = 250\mu s$.(2)

Using Füchtbauer-Ladenburg equation, we may estimate the lasing cross section of the Nd:YAG rod:

$$\sigma = \frac{\lambda^4}{8\pi n^2 c\tau} G \tag{1}$$

where G is the effective emission band width , λ is the emission wavelength, and n is the refractive index of Nd:YAG rod . Taken the gain bandwidth the value of $120GHz$, λ the value of 1064 nm, the refractive index of Nd:YAG rod 1.8197,and our measured result of τ, we have: $\sigma = 2.853 \times 10^{-19} cm^2$.

The uncertainty of our calculation can be found from the relation below:

$$\Delta Sigma = sigma \frac{\Delta\tau}{\tau} = 0.396 \times 10^{-19} cm^2 \tag{2}$$

Our final finding of σ is thus: $2.853 \pm 0.396 \times 10^{-19} cm^2$.

3 Discussion

Compare with the literature value, our measurement of the decay time constant of the spontaneous emission of Nd:YAG rod deviates from the theoretical value of $250\mu s$, with a percentage of error of 13.2%. This further influences our calculation result of the lasing cross section. However, due to the influence is not very significant, our calculation result of σ is very close to the theoretical value of $3.0 \times 10^{-19} cm^2$, with a percentage of error of 4.86%, and the error falls into our the uncertainty range of our measurement.

We estimate that the source in the error of our measurement comes from possible misalignment of the cavity system, and the noise of our output voltage coming from increasing the gain of the pump laser.

4 Reference

Marcus Junghanns. *Nd:YAG Laser*. Abbe School of Photonics. March 2017.

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