From-Scratch Alignment of a Q-Switched Nd:YAG Laser

1. Principles of a Q-Switched Laser
2. Cavity construction and choices
3. Alignment procedure
4. Results
Q-Switch Basics

- Fast Q-switching
- Slow excitation mechanism
- Inherently pulsed
- “Giant Pulse” – very high intensity
Gain Medium

- Nd:YAG is the textbook 4-level laser example
- Solid state: broad energy band N3
- Slow N2 decay + Fast N1 decay: large inversion with long lifetime
- Flashlamps used for excitation

Insert picture from Milloni and Eberly here.
(p.304 or p.415?)
Q-Switch

- Pockels Cell & Polarizer
- Cell: Voltage controlled waveplate
- $\lambda/4$: End mirror?

- $\lambda/2$: Transparent to the cavity
- Optic axis must be aligned properly!
Resonator Choices

- Unstable Resonator design
  - Low gain: build intensity from many passes
  - High gain: few passes, fill medium with mode

- Total reflector: convex
- Diffraction spot output coupler, flat mirror (?)
Alignment Methods

- Pre-align the mirrors
- Pre-adjust the pitch and yaw of the Pockels cell
- First round of threshold and holdoff adjustments
- Clean up output mode
- Lather, Rinse, Repeat.
Pre-adjustment

- HeNe: rough position for the mirrors.
- Berry’s “black sandwich”
- Crossed polarizers across a birefringent crystal (the Pockels cell)
- Yields orientation of optic axis of crystal

First Threshold/Holdoff

- Threshold: minimum lamp energy to see lasing
- Holdoff: maximum lamp energy before Pockels cell “leaks”

- The cavity must be aligned to the cell...
- …and the cell must be aligned to the cavity.
- Iterative alignment procedure: adjust the cell for both threshold and holdoff, then the cavity, then the repeat.
Output mode

- Post-It Notes™ have many uses… infrared will slightly burn the glue…
- Normal incidence on output coupler → Poisson spot

- Mode is important!
- Improve the mode slightly, but be careful!
- Holdoff extremely sensitive to mirror alignment; avoid large power output in breakthrough mode
Sadly, I wasn’t able to construct a least squares fit to the data as recorded. I did guess & check a Gaussian pulse till it looked like it fit; Each blue pulse has a FWHM of 3.22 ns.

Verified as reflections from walls
Final Threshold/Holdoff

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References

Introduction to Modern Optics, Grant R. Fowles, (Dover, 1989)
http://www.olympusmicro.com/primer/techniques/polarized/polarizedintro.html