Gooch & Housego
ENABLING PHOTONIC TECHNOLOGIES

Operation Manual

POCKELS CELL ALIGNMENT IN A Q-SWITCHED LASER

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Contents

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Warning: Precautions for eye safety must be exercised when operating a high power laser. Blindness can result from direct exposure to the laser output. Even indirect exposure such as viewing a diffuse reflection of an invisible infrared or ultraviolet beam can cause eye damage. Use precaution avoiding electrical dangers. The high voltage applied to the Pockels cell is typically 3.5 kV and could cause serious injury. Flash lamp circuitry can cause electrocution.

An alignment laser such as a small He-Ne laser or a collimated visible diode laser is required for the alignment of a Pockels cell Q-switch. The first step is to align this laser to the Q-switched-laser resonator cavity. If the laser resonator is badly out of alignment or the components are being assembled to form the resonator, it is necessary to first position the components.

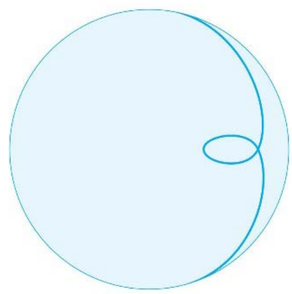
1: Rough positioning of resonator components

A rail on which the components are attached and the mounts used to hold the components on the rail usually determine the optical centerline of the laser. Some people prefer to use an off-center spot on the resonator mirrors to allow easy repositioning to a new spot on the mirror if laser damage occurs. The alignment laser beam should be directed through one of the end mirrors into the laser rod and other cavity components. Some components such as mirrors may have a wedge that will deflect the alignment beam and the resonated laser beam. It is necessary to propagate through these wedged components to accurately position the following components.

2. Alignment of resonator components

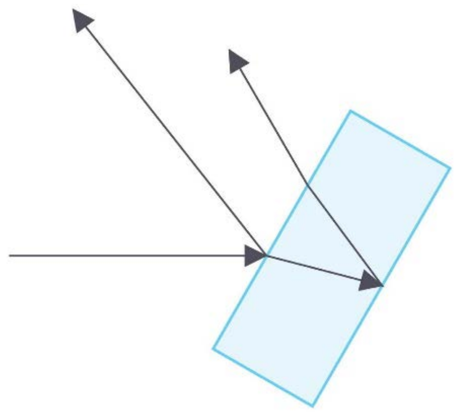
After the components have been roughly aligned, or with a laser for which the alignment was not significantly disturbed, it is next necessary to make the alignment beam parallel to the laser rod axis.

Direct an expanded and collimated alignment laser beam through the laser rod, and look for reflection from the side of the rod. These reflections from grazing incidence of the rod sides usually appear as cusps or loops as shown below.



Adjust either the laser rod or the alignment beam to make these loops and cusps disappear. Now the alignment beam accurately follows the optical centerline of the laser rod. There may be limiting apertures that prevent the laser beams from striking the edges of the laser rod. In that case adjust the alignment beam and rod to make the beam pass through the center of the apertures.

The next step is to align the Q-switched laser cavity mirrors. This is done by obtaining a retro-reflection from the mirror surface. In doing this it is necessary to clearly differentiate the front and back surface reflections of the mirror. The front and back reflections can be discerned by tilting the mirror at a large angle, as shown in the sketch below.



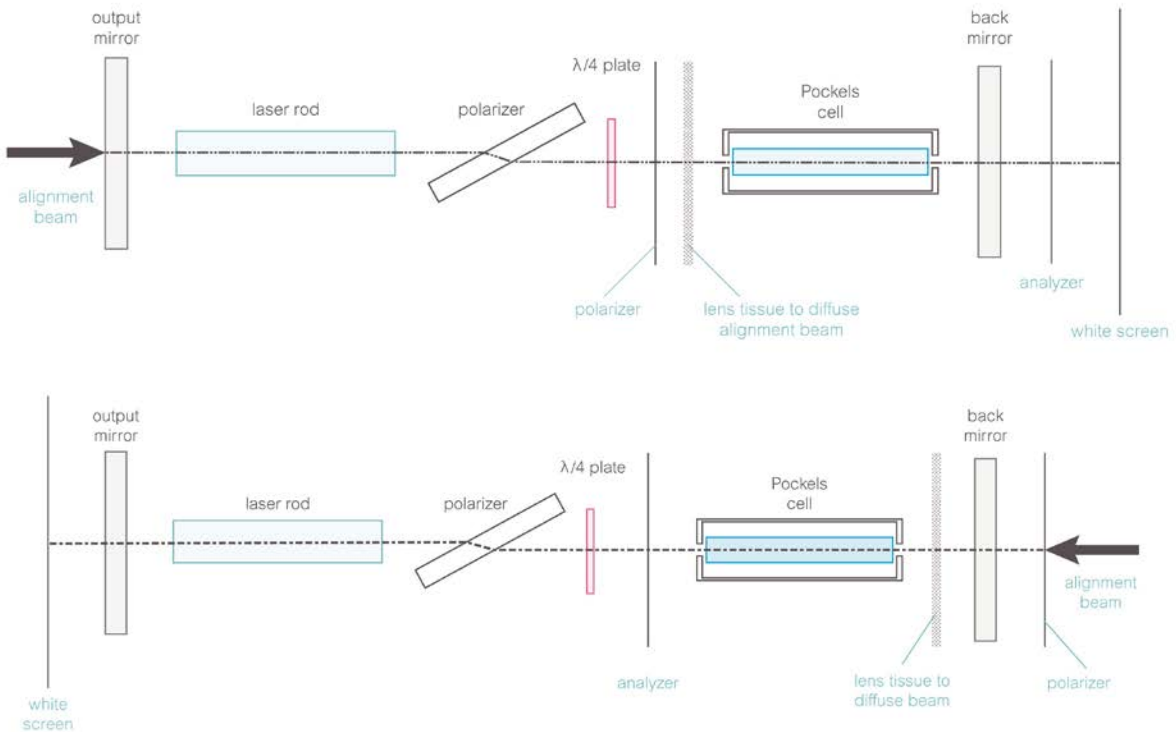
Propagating the alignment beam through a small hole in a piece of cardboard helps in the viewing of the return reflection. All components in the laser resonator should now be centered on the alignment beam.

The angular orientation or roll of the polarizer and quarter-wave plate (if one is used) should now be adjusted. Polarization may be accomplished with a thin film polarizer or polarizing prism.

The direction of electric field polarization is usually set either vertical or horizontal. If a quarter-wave plate is used, the fast and slow axes of the waveplate should be set at 45° to the direction of polarization.

3. Pockels cell alignment

If only the Pockels cell is being replaced in a Q-switched laser system that was in alignment, it is highly likely that adjustment of the mirror on the side of the Pockels cell opposite the laser rod will need to be adjusted. This is because there may be a deliberate wedge in the cell or a small residual wedge. The mirror alignment is done by transmitting an alignment laser beam normal to the surface of the mirror not being adjusted and adjusting the other mirror for a retro-reflection of the alignment beam. The alignment beam is also required for adjustment of the Pockels cell orientation. The Pockels cell is manufactured to have the electrical connectors pointing either parallel or perpendicular to the direction of polarization of the Q-switched laser. The front-to-back direction in which the cell is placed in the Q-switched laser makes no difference in most applications.



Schematic illustration of a typical Q-switched laser system with components added for Pockels cell alignment.
Two schemes for Pockels cell alignment are shown. Green labels identify the alignment components. The polarizer, analyzer, lens tissue, and alignment beam must be removed before operation of the Q-switched laser.

The next step in is to align the optic axis of the crystal within the Pockels cell parallel to the resonator centerline and alignment beam. This is achieved by passing the alignment laser beam through the cell with no voltage applied. For this step the Pockels cell is placed between crossed polarizers. Polaroid film can be used for alignment but must be removed before operation of the Q-switched laser.

If the alignment laser is polarized or the polarizer in the Q-switched laser is effective at the alignment laser wavelength, one or both of the additional polarizers may be unnecessary. A piece of lens tissue or similar material placed in the alignment beam before the Pockels cell will provide some divergent scattering and also allow a portion of the alignment beam to be directly transmitted.

After transmission through the crossed polarizers and Pockels cell, the alignment beam should impinge on a solid background, such as a piece of paper. The isogyre/isochromate pattern, which looks like a Maltese cross (isogyre) surrounded by a series of dark rings (isochromates), should be visible on the paper. Align the pitch and yaw of the Pockels cell to center the isogyre/isochromate pattern on the direct portion of the alignment beam.

The illustration (bottom left) is a sketch of a slightly misaligned isogyre/isochromate pattern with the directly transmitted alignment laser beam represented by the dark spot.

It is necessary to determine which Pockels cell parameter is most important for your application, ICR or VCR. ICR refers to “intrinsic contrast ratio” and VCR refers to “voltage contrast ratio”. ICR, as the name states, is the contrast ratio intrinsic to the material. Again, as the name implies, VCR refers to the contrast ratio voltage applied to the cell. In most applications, holding off laser oscillation before Q-switching is of greatest concern, and the mode of operation determines the relative importance of ICR and VCR in laser performance.

As a general rule, if the Q-switch is holding off the beam with no voltage applied, ICR is your important value. Conversely, VCR is probably your primary measurement if the Q-switch holds off the beam by applying voltage.

We strongly recommend against using the Q-switch with the voltage continuously applied. For some Pockels cell materials, such as KD*P, there is a tendency for conduction paths to develop between the electrodes on the crystal. Pulsing the Pockels cell with a small duty cycle (i.e. normally voltage-off mode) significantly prolongs the Pockels cell lifetime.

Unless you are building or modifying a Q-switched laser, the mode of operation is determined by the existing laser design. Several modes of operation are common, and it will be necessary to refer to the Q-switched laser manual to determine the mode of operation for your system.

Here are some of the possibilities:
(a) A quarter-wave plate is used with the Pockels cell. The beam passes through the polarizer, the wave plate and the Pockels cell, is reflected at the cavity mirror and is transmitted back through the cell and wave plate to the polarizer. Two passes through the quarter-wave-retardation plate result in 90° rotation of the polarization and rejection of the beam at the return pass through the polarizer. When quarter-wave voltage is applied to the Pockels cell the effect of the retardation plate is cancelled, and there is high transmission at the polarizer.

(b) A variation of the first method is to slightly misalign the Pockels cell so it acts as a quarter wave plate. Again when voltage is applied the retardation is cancelled and there is high transmission at the polarizer.

(c) Quarter-wave voltage is applied to the Pockels cell a short time before pumping of the laser creating a quarter-wave retardation. Voltage is removed to Q-switch the laser.

(d) Voltage is continuously applied to the Pockels cell and removed only to Q-switch the laser. After Q-switching the voltage again builds up to the quarter-wave voltage.

4. Alignment while operating the high power laser

After the preliminary alignment with the He-Ne laser, remove the additional elements such as polarizing sheet, lens tissue and white screen from the cavity. Optimize the alignment of the resonator mirror of the Q-switched laser while operating in the long-pulse mode, i.e. with the Pockels cell/polarizer combination set for maximum transmission and no Q-switching. It is best to start at low pump powers and check to determine that there are no grossly misaligned components or clipping of the beam.

Next, operate the Pockels cell for maximum loss and make adjustments of voltage and/or cell alignment to hold off laser oscillation without Q-switching. Obtain the best Q-switched performance by adjusting timing and/or voltage and/or Pockels cell alignment. It may be necessary to repeat these steps or return to the preliminary alignment procedure to achieve best Q-switched performance.

For operation in the mode of no voltage applied before Q-switching, there is usually a small range of angular adjustment in which the Pockels cell will completely hold off laser oscillation. It is best to operate at the center of that range. Next, the voltage and delay of voltage application are adjusted for the best pulse shape (i.e. avoid multiple pulsing) and maximum output energy. If you are operating in the voltage on mode, the order of adjustments should be changed somewhat. As in the previous procedure, the isogyre should be centered first with the laser off and no voltage applied.

Next, operating the laser with voltage applied, but no Q-switching, adjust the voltage for the best hold off. This is usually the center of the range in which the laser oscillation is completely held off. The Q-switching delay is then adjusted for best pulse shape and maximum output energy. At this point, small iterative adjustments in alignment, voltage, and delay can be performed to optimize laser performance.

For further information

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