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Precise alignment of a longitudinal Pockels cell for Q-switch operation Nd:YAG laser

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Sumario. La imprecisión en centrar correctamente componentes ópticos, especialmente en el caso de láseres de Nd:YAG de alta ganancia, podría producir la aparición de radiación láser parásita fuera de eje capaz de causar serios daños a la óptica del sistema entre ellos a la celda Pockels. Se reporta el alineamiento longitudinal preciso de una celda Pockels por la modulación de la polarización de la radiación láser a través de un arreglo experimental de dicroísmo circular. El procedimiento se basó en el uso de un analizador a 0º o 45º del eje de la celda, lo que permite ajustar la sincronización del Q-switching para mejorar la forma del pulso, maximizar la energía de salida y reducir considerablemente la perdida de simetría del spot.

Abstract. The failure to accurately center optical components may, especially in the case of high gain of the Nd:YAG lasers, produce strong parasitic off-axis laser action capable of causing severe component damage typically to the Pockels cell. We report a precise longitudinal alignment of the Pockels cell by modulating the laser polarization using an experimental setup of circular dichroism. This procedure is based on the use of an analyzer at 0° or 45° of the Pockels cell axes, and it allows us to adjust the Q-switching delay for best pulse shape, maximum output energy and to reduce the lack of symmetry of the spot laser considerably.

Keywords. Pockels cell, Nd:YAG Laser, Circular dichroism, Q-switching laser.

1 Introduction

The development of ultra short laser pulses and new detection techniques which allow a very high time resolution has brought about an impressive progress for study of fast processes. In order to obtain a single powerful pulse of a flash lamp-pumped laser, instead of the irregular sequence of many spikes, the technique of Q-switching was developed, which is based on electro-optical or acoustic-optical modulators. Particularly in a Nd:YAG laser a Pockels cell between two crossed polarizers acts as Q-switch.

This paper describes a precise alignment of the longitudinal Pockels cell inside the laser resonator, for generates single pulses of 6 ns (FWHM) pulse duration with a repetition rate of 10 Hz and 400 mJ single pulse energy. The correct alignment of the Pockels cell allows to modulate the laser polarization using an experimental setup of circular dichroism, which generates the correct mode-locked Nd:YAG laser.

2 Experimental set-up

A laser system with a plane-concave resonator and active/passive mode locking was used. Figure 1 show a picture of the Q-switch used. The refractive index along one transversal axis can be changed by applying an electrical field. Where there is no voltage applied over the

Pockels cell, the material is isotropic, then the light passes though without and change in phase between the transversal axes [1,2].

The crystal axes of the Pockels cell and the quarter wave plate is aligned 45 degrees relative to the polarization axis of the polarizer. Optical alignment is performed using a He-Ne laser, which is fixed on the laser optical bench and enter into the resonator through the M_1 mirror, assuring that the He-Ne beam correspond exactly to the center of both the rod faces. This is checked inserting close to the He-Ne laser a suitable partial diffuser, such as a single sheet of “Kleenex paper” or “Kodak Lens Cleaning Paper”. Moving it through the He-Ne beam, can be observed both the attenuated beam and the scattered light clipped to a cone by the rod.

The M_2 gaussian mirror is vertically translated in order to align with the He-Ne beam the graded reflectivity coating located on the mirror center. Then the two mirrors are angular aligned looking at the reflections, as for any other laser.

It follows the insertion of the Pockels cell and quarterwave close to it, in or degrees and optimize its axis rotation looking for the maximum threshold of spurious spiking [3]. Then the Pockels cell is inserted, disabled electrically, and a first alignment can be done with the He-Ne beam.

Next step is to use a second He-Ne laser polarized, which enter into the resonator through the M_2 mirror. This beam should coincide exactly with the first He-Ne beam. This way, the roll of the polarization sensitive components must be aligned with respect to each other for maximum performance.

If necessary, precisely align the laser rod, polarizer and quarter-wave plate. In our case, is definitely true to have an iteration of yaw, pitch and roll [4].

To align the optic axis of the crystal within the Pockels cell parallel to the resonator centerline, pass the alignment laser beam through the cell and with the Pockels cell between two crossed polarizers, (Figure 2). A translucent plastic bag was used for provides some divergent scattered light and also allows a portion of the alignment beam to be directly transmitted.

3 Results

The role of the plastic bag piece is to give rise to a large range of wave-vector directions. For a given direction of the wave vector, characterized by angle φ, the principal polarization directions are φ and $\varphi+\pi/2$. As a consequence, the beams whose misalignment is in the direction of the polarizer axis or in the direction of the analyzer axis remain unchanged and are blocked by the analyzer, which gives rise to a dark cross, Figure 3. If everything is perfect, the light wave vector **k** would be along the Pockels Cell *z* axis. However, here we are interested in the effect of a slight misalignment and we suppose that k_x, k_y <<1, and $k_z \approx 1$.

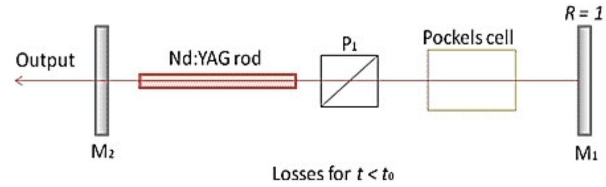

Figure.1. Schematic arrangement of the Q-switch in cavity

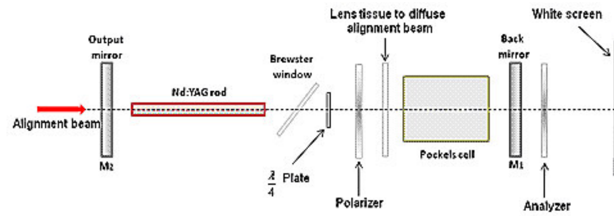

Figure.2. Illustration for obtain an isogyre/isochromate patern.

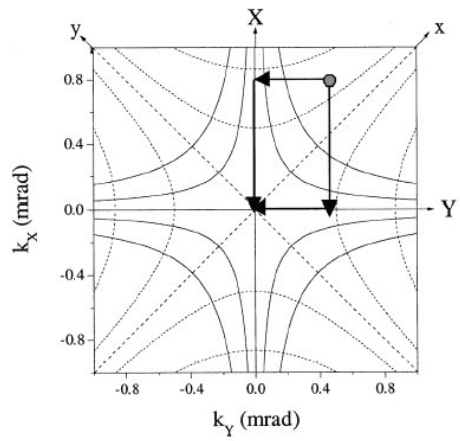

Figure. 3. Representation of the (k_x, k_y) plane.

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Figure. 4. Photography of the isogyre pattern observed with set-up. The dark cross and the concentric circles are clearly visible.

Then we take into consideration the other directions of propagation, the beams undergo a dephasing given by the birefringence of the Pockels cell, $\Delta n(2\pi L/\lambda)$, which causes the polarization to become elliptic. When this dephasing is equal to a multiple of 2π, we again observed an extinction of the light. The condition for the first extinction of the light can be written as,

$$k_x^2 + k_y^2 = \frac{\lambda}{L\Delta n} \qquad (1)$$

where L is the cell thickness, and one can observe a series of concentric dark circles, as are visible in Figure 4. By placing the direct laser beam (without the diffusing plastic) at the center of this figure, one can easily achieve good precision for the wave-vector direction.

The resulting isogyre/isochromate pattern, a Maltese cross (isogyre) [5,6] 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 center corresponds to a perfect alignment of the Pockels cell.

A measurement of single pulses of 6 ns, with a repetition rate of 10 Hz, was measured with an APD detector and an oscilloscope Tectronix of 1 GHz.

3 Conclusions

Good alignment was achieved, which improved the alignment precision by 3 orders of magnitude. A Pockels Cell is utilized as a (circular) polarization modulator, and it has been shown that a slight misalignment of this cell could induce defects in the Q-switching delay for best pulse shape, output energy and to reduce the lack of symmetry of the spot laser considerably. The used method assures a stable single-pulse nanosecond from Q-switching of Nd: YAG laser.

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