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Physical Optics Modeling of Modal Patterns in a Crossed Porro Prism Resonator

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ABSTRACT
A physical optics model is proposed to describe the transverse modal patterns in crossed Porro prism resonators. The model departs from earlier attempts in that the prisms are modeled as non-classical rotating elements with amplitude and phase distortions. The salient elements of the model are discussed in detail, and the model predictions compared to experimental data for the case of an unstable crossed Porro prism resonator with a polarizer as an output coupler. The model correctly predicts the formation of the observed petal patterns often observed from such resonators.

PORRO PRISM RESONATOR
The transverse field distribution of a pulsed Nd:YAG laser with porro prism resonator was investigated experimentally.

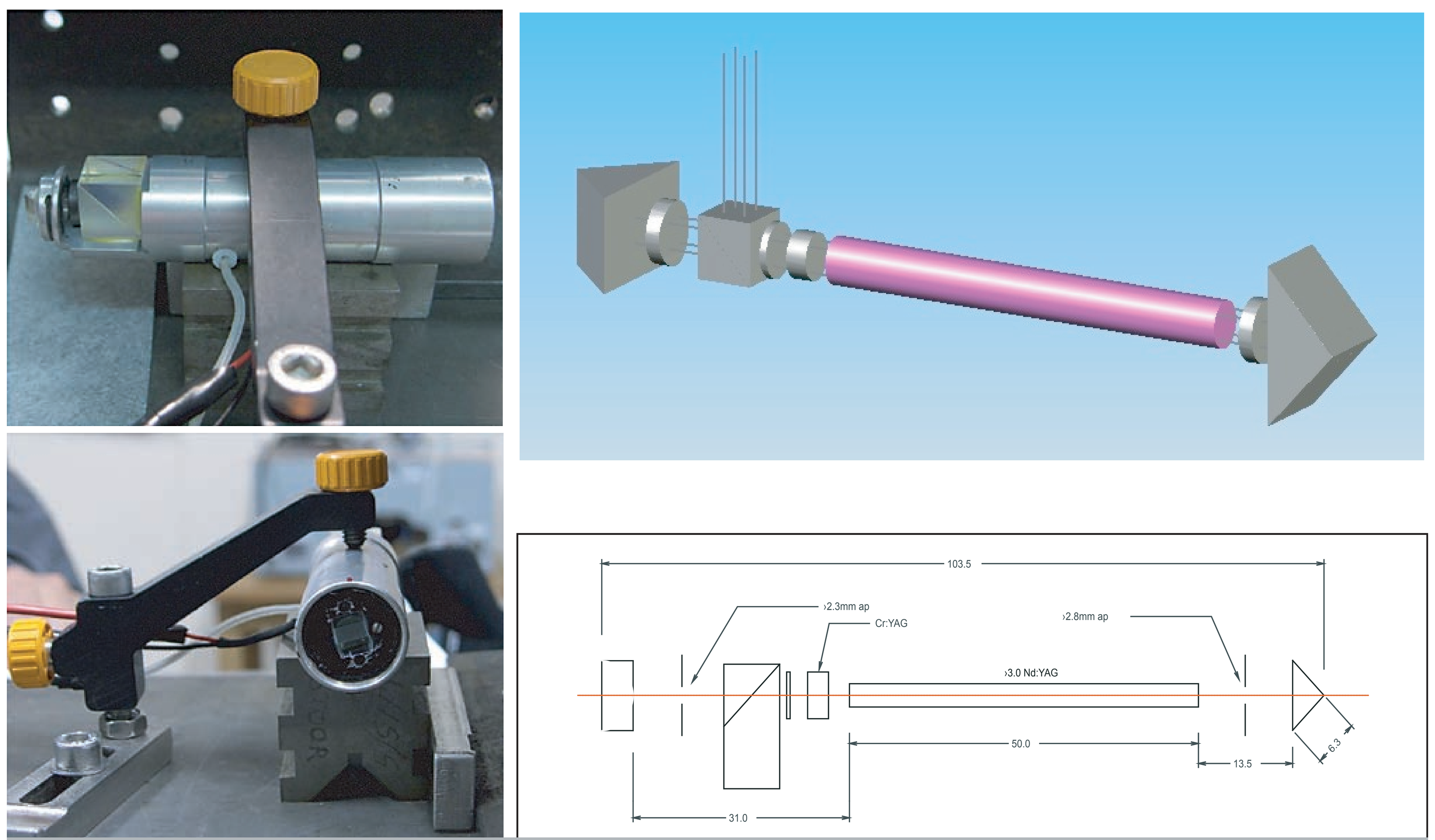

Figure 1: The porro prism Nd:YAG laser with passive Q-switch

The resonator mentioned above has next field (see Figure 2) distribution and main goal of these investigations is founding reason of this behaviour of transverse field distribution of pulse.

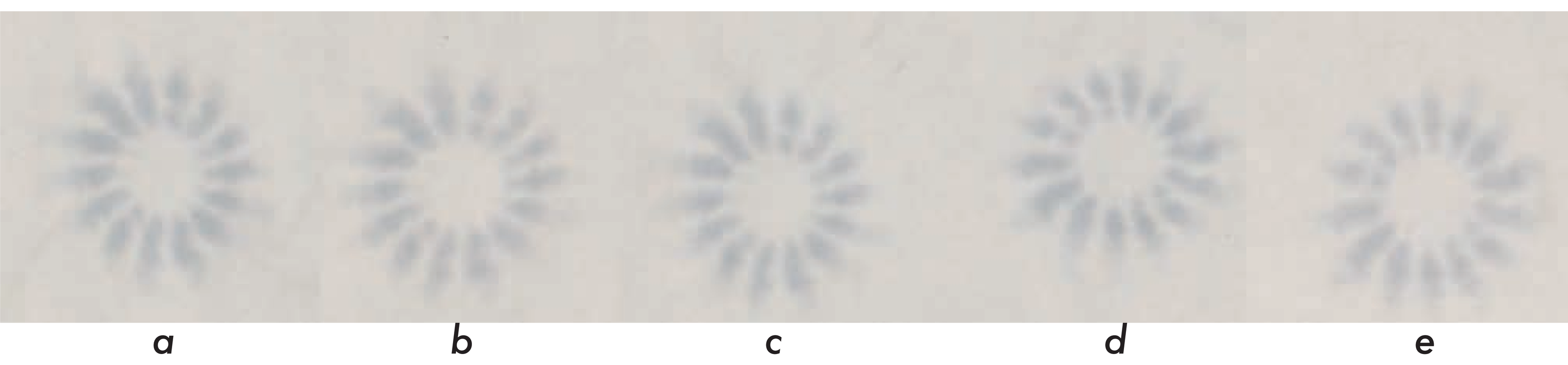

Figure 2: The output field of the porro prism laser with varying pump power. The angle between the porro prisms was 13 degrees. The capacitance of the laser power supply was 18.8 μF, and the voltage was 690V, 670V, 650V, 620V and 600V respectively

For investigation field distribution of porro prism resonator we used next experimental result (see Figure 3).

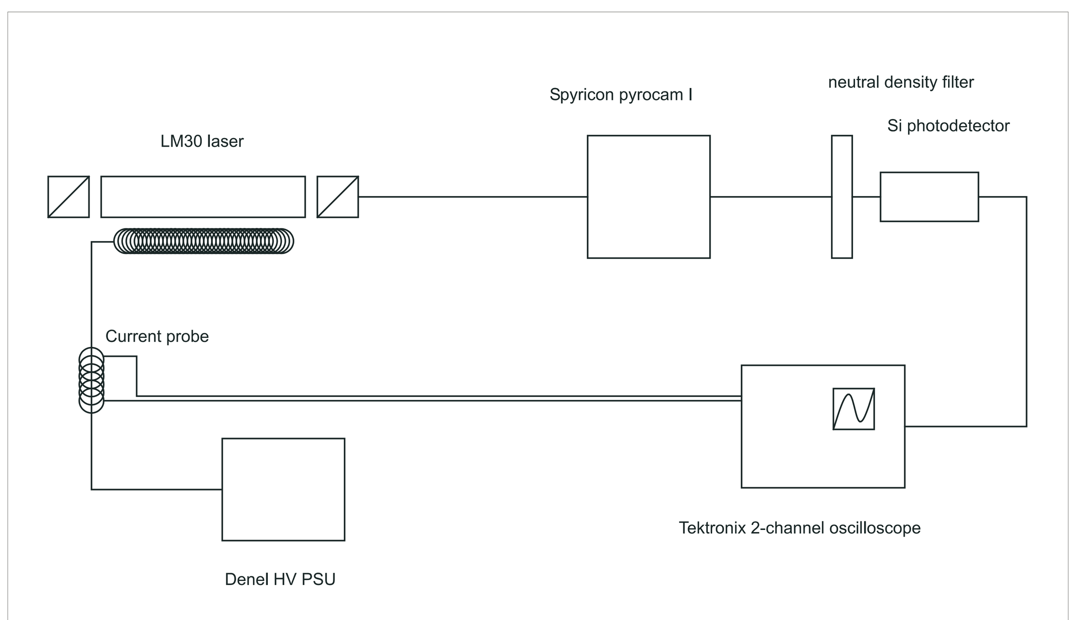

Figure 3: Schematic of experimental setup

BEAM STRUCTURE INVESTIGATION
We can assume that the behaviour of the transverse field distribution of the pulse can be explained by the losses at the apexes of the Porro prisms. These losses can have any nature, diffraction losses, losses imperfect apex and others.

To confirm this assumption a number of experiments were carried out in which the angle between the porro prisms was changed. Burn paper and a Spiricon camera were used to observe the changes in the transverse field distribution. The results of these experiments can be seen in Figure 4. To get a visual impression of the change of field with angle, an image of the transverse field distribution was taken only at angles which gave the output field a petal form.

At angles between these discrete values the field distribution pattern was too complex to attempt to explain the transverse distribution of the pulse in this resonator.

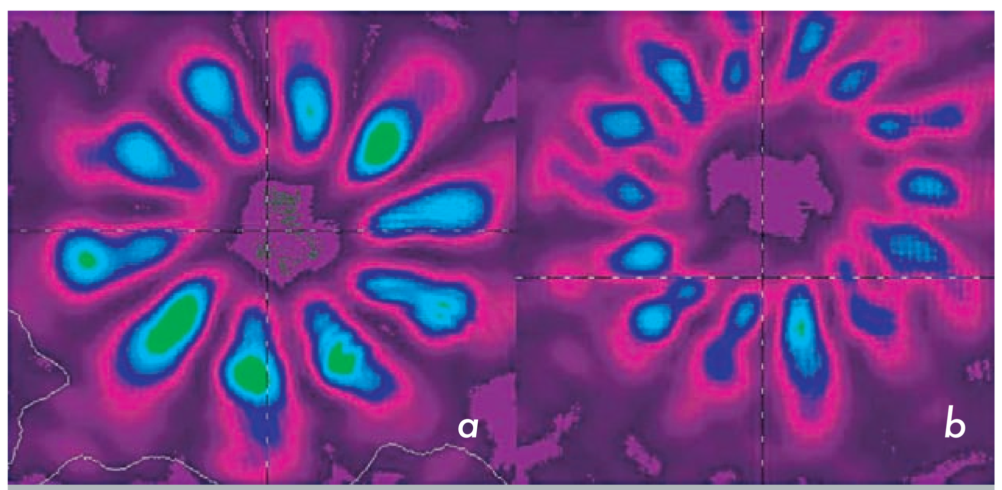

Figure 4: Transverse field distribution of the output pulse of the Porro prism laser with the angles between Porro prisms (a) 18 degrees (b) 13 degrees

This resonator was also modelled in GLAD, taking the losses at the porros apexes into account. The results of this simulation can be seen in Figure 5.

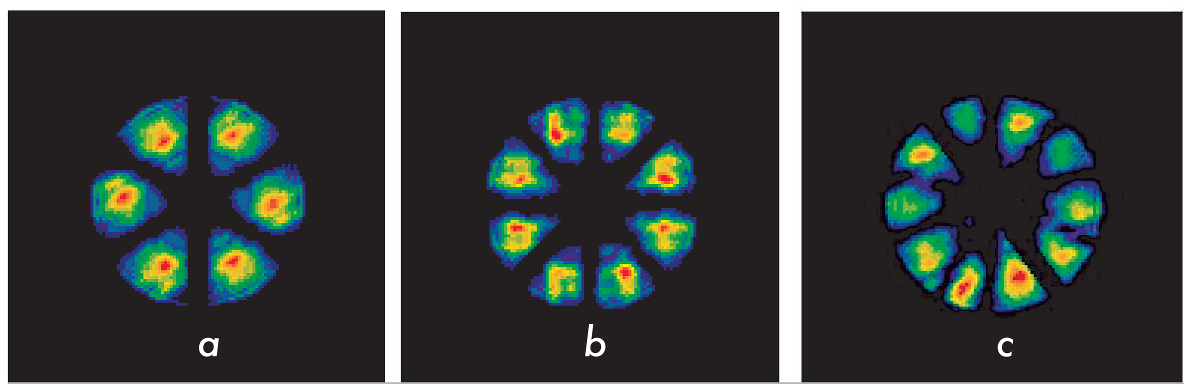

Figure 5: The transverse field distribution of the output pulse of a porro prism laser produced by the GLAD simulation. The angles between the porro prisms were (a) 30°, (b) 45°, (c) 36

For this calculation we have considered the changing of roof angle for field insight resonator and consequently the modification of losses on these roofs.

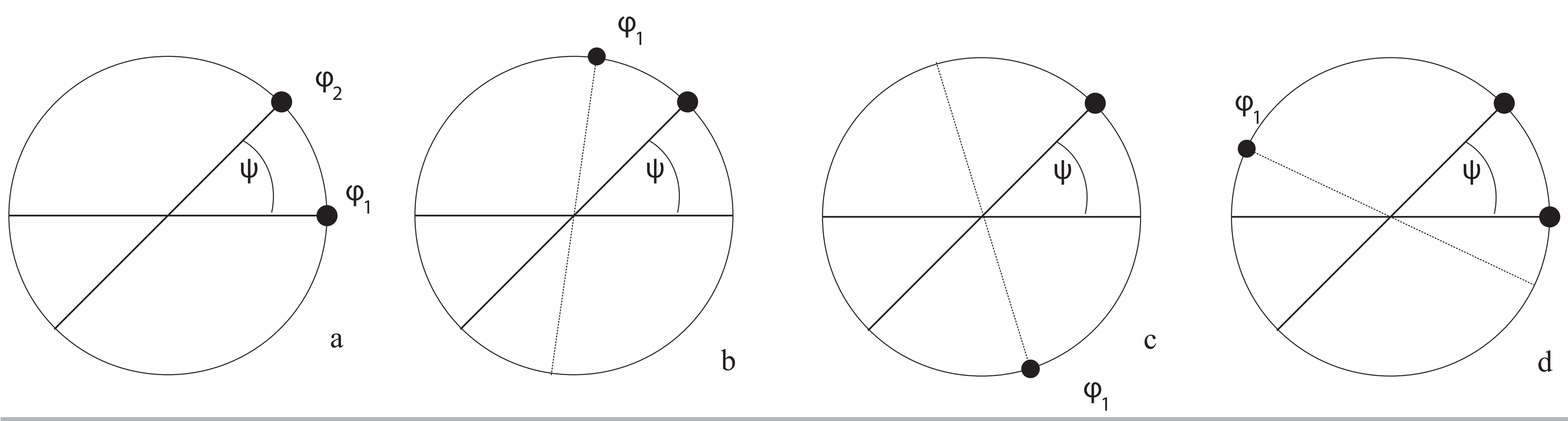

Figure 6: (a)The roofs of two porro prisms. (b-d) The modification of roof angle for both porro prisms after (b) 1 passes, (c) 2 passes, (d) 3 passes

From figure 6 we can calculate modification of porro prism roof angle after any numbers of posses. The equations for modification of roof angle for both porro prisms are

$$\varphi_1 = 2(-1)^n \psi Floor(0.9 + \frac{n}{2})$$

$$\varphi_2 = 2(-1)^{n-1} \psi Floor(0.4 + \frac{n}{2}) + \psi$$

n- the number of reflections, φ1, φ2 - angle of losses of first and second roof, ψ - angle between porro prisms.

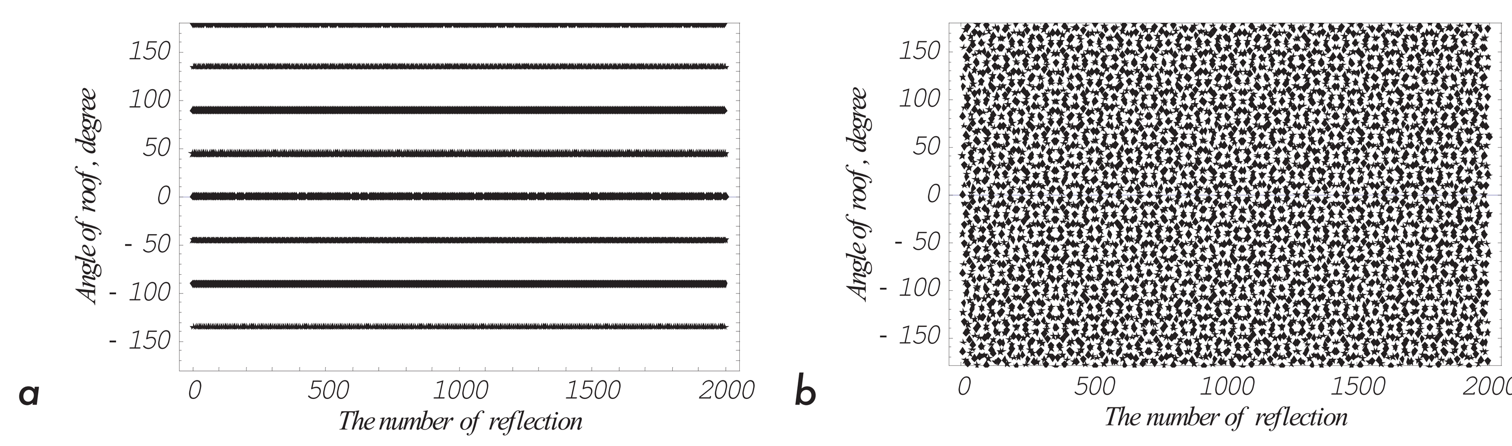

Figure 7: The plots of "Mathematica" simulation of roof angles. The angles between porro prisms are (a) 45 degree, (b) 7 degree

On figure 7 plots of modification of roof angle are presented. We can see the angle on figure 7 (a) has limited discrete values only and on figure 7 (b) can has any value. Consequently, for an angle between porro prisms corresponding to figure 7 (a) we can have spots field distribution.