1:15 pm

CFP2 Passive transverse-mode-locking in a photorefractive oscillator with saturable absorber

Baruch Fischer, Ofer Werner, Moshe Horowitz, and Aaron Lewis
Department of Electrical Engineering
Technion—Israel Institute of Technology, Haifa 32000, Israel

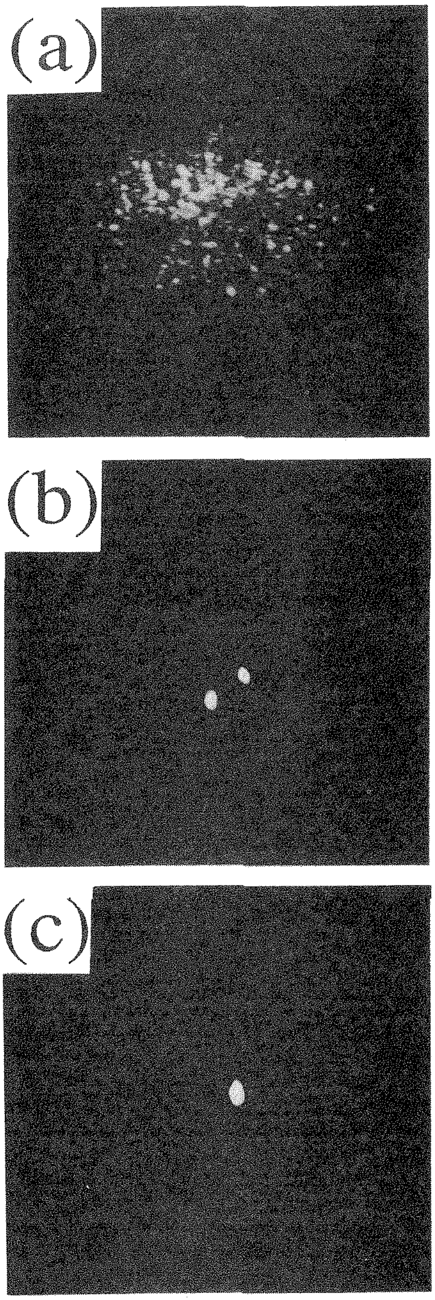
Passive mode-locking of lasers is based on the insertion of a saturable absorber (SA) into the laser cavity. The SA encourages oscillation in short pulses, where the light intensity is large and the loss in the absorber is minimized. We could consider, however, another way for obtaining energy compression by using the transverse dimension of the oscillating beam in the cavity rather than the longitudinal one. In this case, transverse mode-locking would give a reduced cross section with high power density, which would result in continuous oscillation with low loss in the SA. This scenario is, however, problematic and was not considered in the past because it required the oscillator to support a very large number of transverse modes with low losses.

Here we show that such transverse self-organization of an oscillating beam is obtainable. In the demonstration we used a special resonator formed by two photorefractive double-phase conjugate mirrors (DPCMs). Such a phase conjugate resonator can support a large number of transverse modes. The SA was a film of bacteriorhodopsin in a polymer matrix. Its low saturation intensity of (10 − 100) mWatts/cm^2 is compatible with typical beam intensities used in photorefractive oscillators.

The behavior of the oscillation between the nonlinear mirrors without the SA in the cavity was independent of the power. With the SA in the cavity for high power oscillating beams (hundreds of mWatts), the cross section at the SA location was large. This is shown in Fig. 1 and is similar to the situation without the SA in the cavity. The beam between the mirrors (with two lenses in the cavity) was quasi-collimated with a nonhomogeneous cross section of *(20–30) mm^2 and was built up from many amplified* noise components. This is the "transverse non-locked" (or "transverse cw") oscillation. However, when the oscillation power was lowered (to ~ 2 mWatt in a typical experiment), the cross section of the oscillating beam near the location of the SA collapsed into few small areas (filaments), as shown in Figs. 1b and 1c, or into several dots or sometimes into lines. Further reduction of the power caused a further decrease of the area and the number of filaments in the SA region. This strong dependence of the oscillation structure on beam intensity was the key difference in behavior exhibited by the oscillator with SA, as opposed to the behavior without SA.

We can interpret the self-organization process as the self-locking of many transverse modes in the cavity (with a degenerate frequency) such that their superposition gives the collapsed cross section. This was allowed by the nonlinear mirrors (the DPCMs), which could support the many modes or the needed complex wavefronts of the oscillating beam. We note that an "active" aperturing is also possible in our experiment (and it was demonstrated in the past), which results in an oscillation that exactly fits its cross section to the reduced shape of the aperture.

In conclusion, we have demonstrated a self-transverse-mode organization effect, using a cavity with two photorefractive mirrors (DPCMs) and a bacteriorhodopsin for saturable absorption.



CFP2 Fig. 1. Cross sections of the oscillating beam at the SA plane with the saturable absorber (SA) in the cavity: (a) for the non-locked case (high oscillation power), (b) for the locked case with low oscillation power, (c) for the locked case with further lowering the oscillation power.