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Authors
Sucha, G.
Bolton, S.R.
Chemla, D.S.

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G. Sucha, S.R. Bolton, and D.S. Chemla

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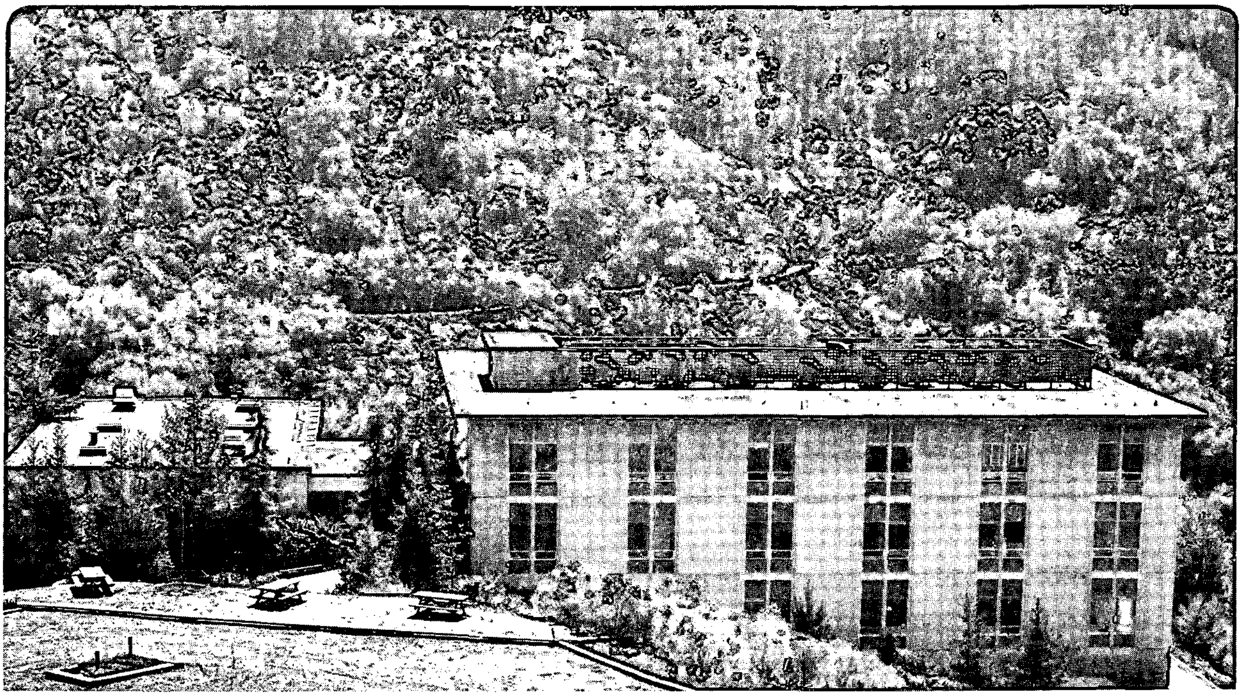

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THE EFFECTS OF CAVITY TOPOLOGY ON INSTABILITIES IN ADDITIVE-PULSE MODELOCKED LASERS

G. Sucha

IMRA America
1044 Woodbridge Avenue
Ann Arbor, MI 48105

S. R. Bolton and D. S. Chemla

Department of Physics
University of California
Berkeley, CA 94720

Materials Sciences Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

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G. Sucha*, S. R. Bolton, and D. S. Chemla

Department of Physics, University of California at Berkeley, and
Materials Sciences Division, Lawrence Berkeley Laboratory, University of California
Berkeley, California 94720

Ph: (510) 486-5265 *FAX: (510) 486-5530*

Abstract:

We compare the stability properties of the Michelson and Fabry-Perot APM lasers. With excessive Kerr nonlinearity, the Fabry-Perot APM exhibits period-doubling while maintaining an autocorrelation of deceptively high quality. The Michelson APM never exhibits period-doubling, but is prone to multiple-pulsing.

*Permanent address: *IMRA America, 1044 Woodridge Ave., Ann Arbor, MI 48105*
Ph: (313) 930-2560, *FAX: (313) 930-9957*

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G. Sucha*, S. R. Bolton, and D. S. Chemla

Department of Physics, University of California at Berkeley, and
Materials Sciences Division, Lawrence Berkeley Laboratory, University of California
Berkeley, California 94720

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The two most widely used APM laser configurations are the Fabry-Perot and the Michelson. The Michelson APM is reputed to be more stable[1,2] due, presumably, to mechanical considerations; *i.e.*, the Michelson APM is less sensitive to vibration because the gain crystal is in the *shared* branch of the cavity. In addition, the two cavity arms whose lengths must be matched (to better than $\lambda/10$) are shorter than the whole cavity length, thus minimizing the effects of air currents. However, we find that the enhanced stability is not due solely to mechanical considerations. In this talk we demonstrate, both theoretically and experimentally, that these two cavity topologies exhibit different nonlinear dynamics and are therefore subject to different types of instabilities, regardless of vibrations and air currents.

Experiments were performed in an NaCl F-center APM laser which was first configured in the Fabry-Perot geometry. While stable modelocking is easily obtainable at the proper power and fiber length, period-doubling and quasiperiodicity are observed when high levels optical power were coupled into the fiber in the control cavity. The period-doubling is manifested by the generation of pulses with alternating pulse energies (fig. 1). Numerical simulations of the FP-APM exibit this period-doubling when the nonlinear Kerr coefficient is increased beyond a certain threshold. The simulations also show that there is pulse distortion during period-doubled operation [fig. 2(a)] although the simulated autocorrelation [fig. 2(b)] (which is the average of the autocorrelations of the large and small pulses) still appears to be of high quality. This is observed experimentally also [fig. 2(c)].

When the APM is reconfigured into the Michelson geometry, period-doubling is never observed, even when the fiber power is set at very high values. At these high powers though, the autocorrelations can show 3, 5, and even 7 peaks [figure 3(c)]. Pulse train instabilities do occur in the form of modulation and relaxation oscillations, but never period-doubling. Similarly, in simulations of the Michelson APM, increasing the Kerr nonlinearity does not cause period-doubling. In fact, the simulations do not produce *any* kind of pulse train instability (relaxation oscillations require gain dynamics which are absent in our model). But as the nonlinearity is increased, the simulated laser generates distorted pulses with up to three peaks [fig. 3(a)], with correspondingly distorted autocorrelations [fig. 3(b)].

In conclusion, we find that the Michelson APM is less susceptible to pulse train instabilities than the Fabry-Perot APM due to the different nonlinear dynamics of the two cavity topologies. In addition, the effects of excessive nonlinearity are clearly shown in the pulse autocorrelations.

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References:

1. G. Kennedy, *priv. comm.*
2. M. Piche, *priv. comm.*

Figure captions:

1. Period-doubled pulse-train from a Fabry-Perot APM laser.

2. For the Fabry-Perot APM: (a) simulated intensity profiles of large and small pulses, (b) autocorrelation of simulated pulses (averaged), and (c) experimental autocorrelation produced during period-doubled operation.

3. For the Michelson APM: (a) simulated intensity profile for large values of nonlinearity, (b) the corresponding simulated autocorrelation, and (c) experimental autocorrelation generated at high powers.

Figure 1

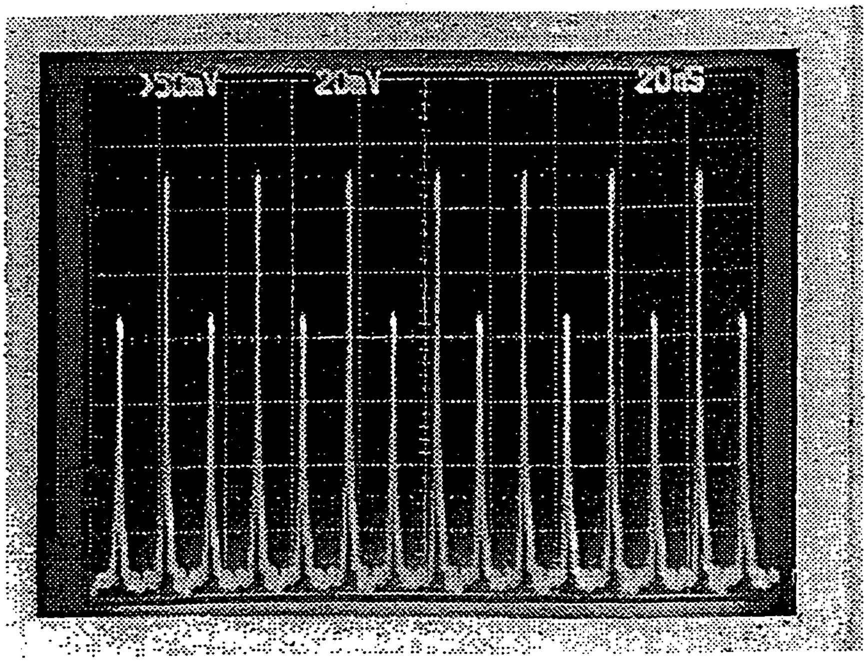


Figure 2

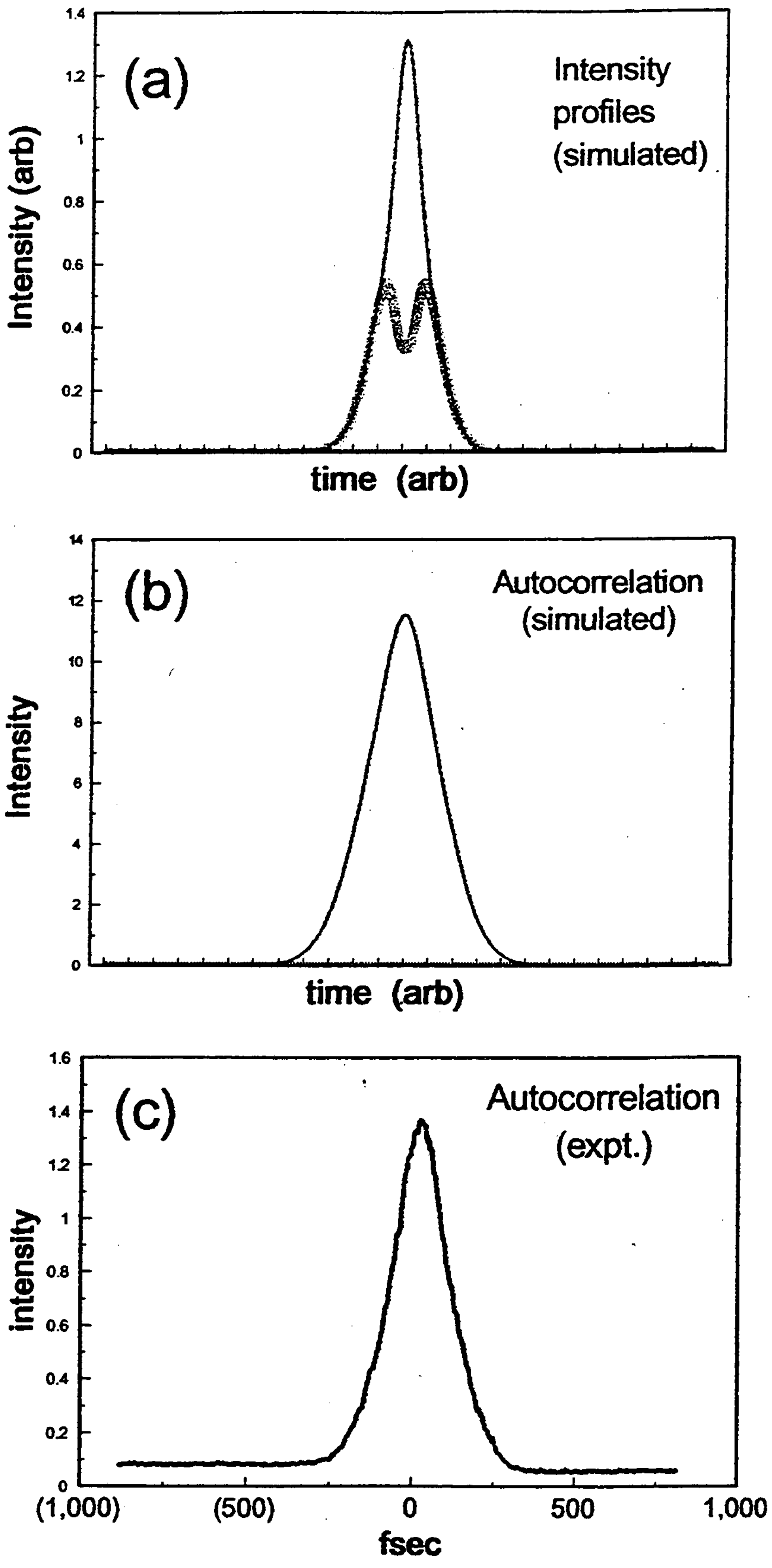
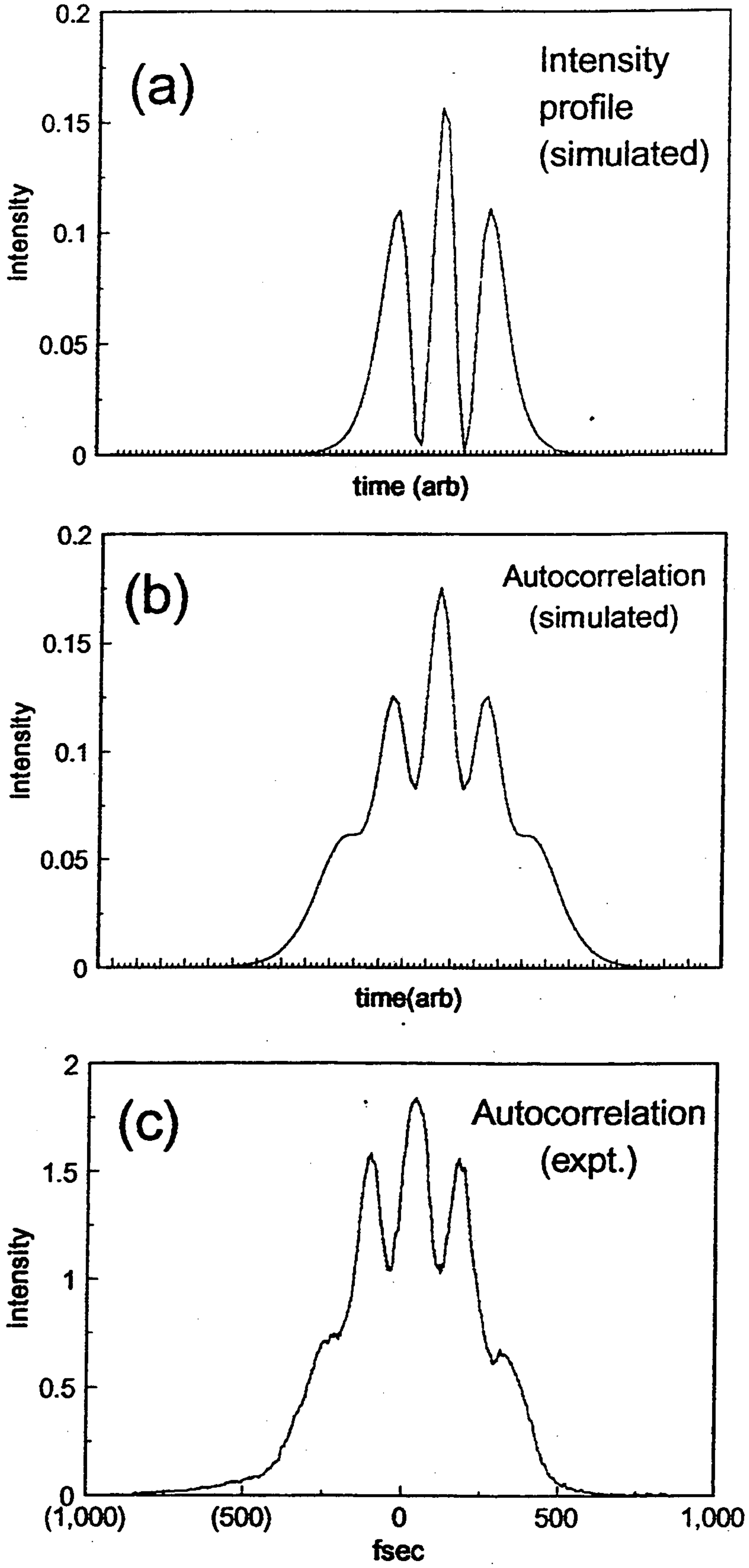

(a)
Intensity profiles (simulated)
Intensity (arb)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
time (arb)
(b)
Autocorrelation (simulated)
Intensity
14
12
10
8
6
4
2
0
time (arb)
(c)
Autocorrelation (expt.)
intensity
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
(1,000)
(500)
0
500
1,000
fsec

Figure 3



(a)
Intensity profile (simulated)
Intensity
0.2
0.15
0.1
0.05
0
time (arb)
(b)
Autocorrelation (simulated)
Intensity
0.2
0.15
0.1
0.05
0
time(arb)
(c)
Autocorrelation (expt.)
Intensity
2
1.5
1
0.5
0
(1,000)
(500)
0
500
1,000
fsec

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UNIVERSITY OF CALIFORNIA
TECHNICAL INFORMATION DEPARTMENT
BERKELEY, CALIFORNIA 94720