Synchronization of SMBS components in a laser cavity

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We report the experimental observation of synchronization of the SMBS components excited in an active substance in a laser cavity whose natural frequencies are close to those of the SMBS components corresponding to the initially excited cavity mode.

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The generation of supershort laser pulses as a result of synchronizing the SMBS components when the active substance in the SMBS is in the laser cavity has been examined theoretically in a number of papers.[1-3]

The important factor in this case is that the natural frequencies of the cavity are close to the frequencies of the Stokes components of the SMBS spectrum of the active substance in the cavity. An introduction of a nonlinear absorber causes a strong parametric interaction between the SMBS components. In fact, this produces coupling between the cavity modes and hence synchronization and generation of short pulses. Theoretical estimates for ethyl ether in the laser cavity give the expected pulse duration of the order of 2 psec when 100 components are synchronized. The cited estimate shows the synchronization of the SMBS components may be the principle of a new method of generation of short laser pulses.

In this paper we report the results of an experiment based on the discussed considerations. The experimental setup was comprised of a ruby laser and a cavity (1 meter long) formed by a mirror and a selector of the Fabry-Perot type interferometer. A cell with the active material and a saturable filter were placed inside the cavity. In the experiment we took advantage of the very small misalignment of the working surfaces of the selector, which enabled us to tune it by moving it at right angles to the laser axis. As a result, we were able to fine-tune the free interval of the selector, so that it would be equal to the frequency shift of the SMBS components in the investigated material. Moreover, the selector could be moved along the axis of the laser, which allowed us to fine-tune the interval between the normal modes of the laser cavity to the mentioned frequency shift of the SMBS.

A very stable frequency of the generated pulses of the laser was provided primarily by thermostabilization. The selector and the cell with the active material in the SMBS were thermostabilized with an accuracy of better than 10^{-2} K and the laser crystal was thermostabilized to 10^{-2} K. The output laser radiation was focused on the Fabry-Perot interferometer with a 150-mm spacing for recording the spectrum of the excited radiation and with a 3-mm spacing for recording the spectrum of the SMBS components.

The time-dependent parameters of the output pulse were measured by using a

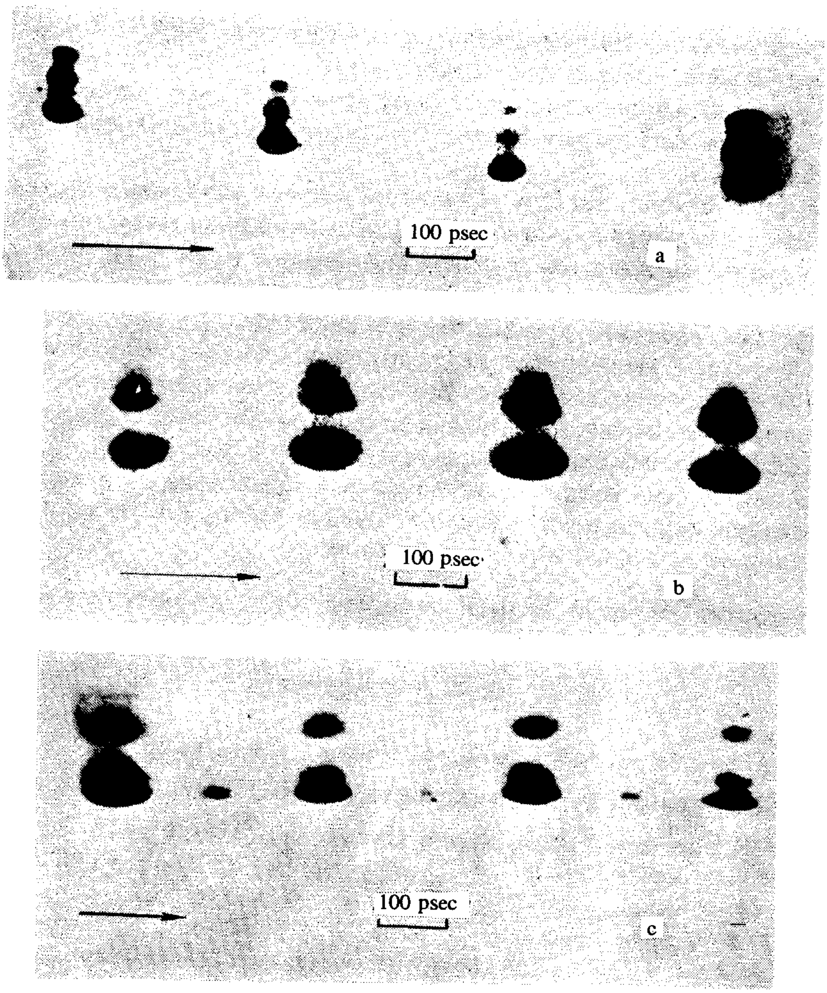

FIG. 1. "EOC patterns" of the output radiation; the duration of scanning is 1.2 nsec: a, 10 SMBS components. The duration of a single pulse is 20 psec; b, 4 SMBS components. The duration of a single pulse is 50 psec; c, 4 SMBS components. The cavity's modes are slightly detuned relative to the frequencies of the SMBS components. An incomplete synchronization is observed.

FÉK-14 coaxial photocell, an electron-optical chamber (EOC) operating in the linear scanning mode with a scanning rate of 10^{10} cm/sec and a time resolution of 2 psec, and a I2-7 time-interval meter.

In the modulated *Q*-factor mode the laser gave a 25-nsec, 0.07-J single-mode radiation pulse.

Figure 1 shows photographs of the scanned output pulses obtained from the EOC screen. An analysis of the "EOC-pattern," along with interference patterns of the output radiation, showed that as a result of generating several SMBS components the laser tuned to their frequencies produces supershort light pulses whose duration is inversely proportional to the number of generated SMBS components. For 10 SMBS components the duration of single pulse is ~20 psec [Fig. 1(a)] and for 4 components the duration is ~50 psec [Fig. 1(b)]. When the laser was only roughly tuned to frequencies of the SMBS components, we observed an incomplete synchronization [Fig. 1(c)].

In this case, when the laser's cavity contained a cell without active material, the laser generated either one mode or, at high pump level, two similar axial modes. Thus, the EOC screen displayed either a smooth scanning or a sharp periodic structure corresponding to a beating of two modes.

The described experiment confirms the mechanism for generation of supershort pulses as a result of synchronization of the SMBS components and justifies further development of the new method of obtaining such pulses.

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