Synchronization of Chaotic Unidirectionally Coupled Multisection Lasers

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Chaos based communication is an alternative technique to encode and transmit information at high bit rate in conventional optical communication systems. A promising new encryption method termed on/off phase shift keying (OOPSK) has been proposed recently [1]. It bases on unidirectionally coupled external cavity lasers whose synchronization switches on and off when changing the masters feedback phase by a portion of 2π. Since it is known that fast encryption rates require short cavity lengths, we investigate the ultrashort cavity regime. This regime can be achieved by integrating the feedback path into a multisection semiconductor laser. The result is a compact and robust device which, in addition to the short time scales, is an important requirement for possible applications [2].

We numerically study integrated devices by using a comprehensive travelling-wave model [2]. This model is used to search and characterize regimes of chaotic operation. The transmitter chaos involves multiple time scales: slow irregular pulse packages, few-GHz relaxation oscillations as well as beating pulsations of some ten GHz. The slow packages synchronize well but not the fast oscillations, see Fig. 1 (a). To check the potentiality of this configuration for the OOPSK encryption we first analyse the dependence of the synchronization degree on the feedback phases difference $\Delta\phi_P$ between transmitter and receiver lasers Fig. 1 (b). To study the encoding performance we proceed as follows: we first select the value for $\Delta\phi_P$ for which emitter and receiver operate in a chaotic and synchronized regime. We then, change the phase from a unsynchronized state to the synchronized one to estimated the resynchronization time. This time is related to the maxima encoding rate. We finally modulated $\Delta\phi_P$ and calculate eye diagrams and Q-factors to evaluate the performance of the proposed scheme. Multisection lasers are indeed expected to be essential sources for high bit rate OOPSK encryption.

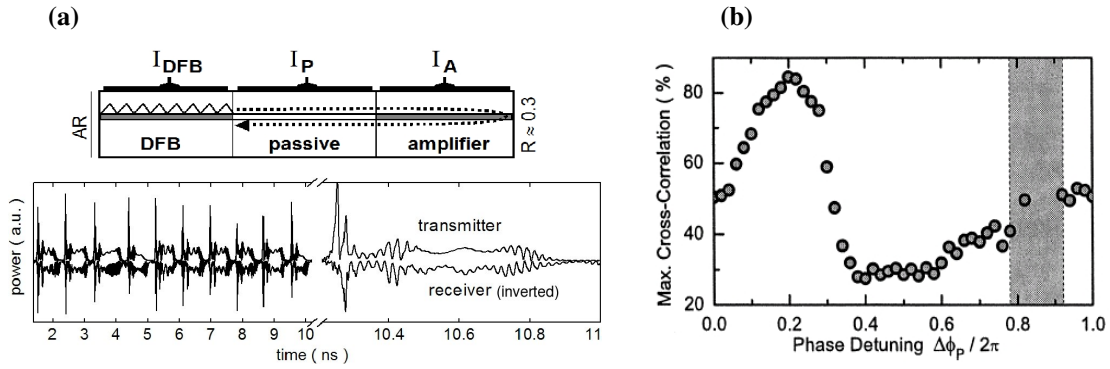

Fig. 1 (a) Upper panel: schema of a laser with integrated optical feedback. Lower panel: representative time traces of transmitter and receiver multisection lasers in a master-slave configuration. (b) Maximum of the cross-correlation function versus the detuning between the passive shift of transmitter and receiver laser.

References

1. M. Peil et al., Phys. Rev. Lett. 88 (2002), 174101.
2. T. Pérez et al, Phot. Tech. Lett. 18 (2006), 2135.