Application of chaos synchronization in injected mid-infrared quantum cascade lasers for private free-space communication

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Free Space Optics (FSO) is a growing technology offering fast and cost-effective deployment compared to fiber technology. Chaos-based transmissions [1] in FSO are fundamentally restricted by atmospheric phenomena. Thus, the operating wavelength is a key parameter that has to be chosen wisely to reduce the impact of the environment. In this context, QCLs are relevant semiconductor lasers because their optical wavelength lies within the mid-infrared domain where the atmosphere is highly transparent [2]. The simplest way to generate a chaotic optical carrier from a QCL is to reinject part of its emitted light back into the laser's cavity after reflection on a distant mirror [3]. The QCL that is driven chaotic is called the master QCL and the small-amplitude message to be transmitted is added to the chaotic waveform, thus hindering simple extraction for an eavesdropper. The master's signal is transmitted free-space toward a second QCL, called slave laser, which resembles the properties (wavelength, carrier lifetime, linewidth enhancement factor) of the master laser. Because of chaos synchronization, the slave QCL reproduces the chaotic waveform of the master QCL but not the hidden message. Subtraction of the master's signal by the slave's signal allows recovering the private message. Figure 1 (a) illustrates the quality of the synchronization between the master QCL and the slave QCL. Figure 1 (b) shows that the difference signal, in purple, reproduces the bit pattern of the initial encoded message, in green, while the master and the slave signals, in red and blue respectively, do not give any indication about the transmitted sequence hidden in the red signal.

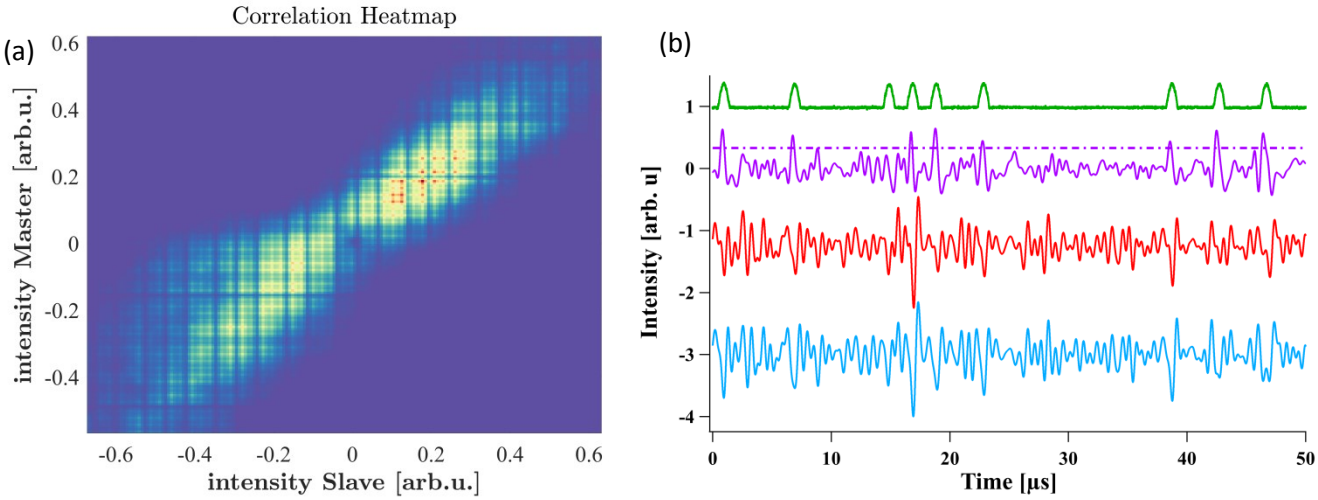

Figure 1. (a) Intensity correlation between the master QCL and the slave QCL, showing high-quality synchronization; (b) Recovery process after blue signal is synchronized with red signal, containing message and chaos. The difference signal in purple reproduces with acceptable fidelity the bits of the green sequence (strongly magnified in this example) that was initially concealed in the red signal.

References

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