Paper 12141-18

The linewidth enhancement factor of a semiconductor frequency comb: a spectrally-resolved measurement technique

In person: 6 April 2022 • 11:10 - 11:30 CEST | Etoile A, Niveau/Level 1

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Abstract **Authors**

Semiconductor lasers are compact, electrically pumped sources of coherent light. If designed properly they emit frequency combs, which nowadays find application in various areas such as telecommunications, metrology and high-precision spectroscopy for chemical sensing and medical diagnostics. Laser design and optimization require profound knowledge of the working principles at play and powerful techniques to infer their characteristics. One of these characteristic quantities is the linewidth enhancement factor (LEF). It originates from a theoretical description of the linewidth broadening beyond the Shawlow-Townes-limit, but is recently moving in the spotlight of frequency comb research to understand dynamic processes like modulation response, comb formation and even soliton generation. However, as of yet the experimental investigation of the LEF was limited to single-mode laser operation or measurements below to the lasing threshold. This is insufficient, since the LEF changes drastically with the laser bias and is dependent on the wavelength. In this work we present a novel technique which enables the spectrally-resolved measurement of the LEF of an arbitrary laser source regardless of the operation state or bias. It relies on the RF modulation of the driving bias and “Shifted Wave Interference Fourier Transform Spectroscopy” (SWIFTS) – a phase-sensitive measurement scheme. When investigating a laser frequency comb, a single-shot measurement reveals the spectral dependence of the LEF over the whole comb spectrum. Extensive simulations utilizing a numerical spatiotemporal model based on the Maxwell–Bloch formalism were performed to explore the success of this approach. The technique was vastly tested by simulating both, single-mode lasers and laser frequency combs. A comparison to the theoretical model shows good agreement. The experimental demonstration of the technique is performed on a quantum cascade laser (QCL) frequency comb. The resulting LEF values are comparable to recent publications and follow the spectral shape predicted by the theoretical model.

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