Strong Anti-correlation in a Quantum Cascade Laser Frequency Comb

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Frequency combs (FC) have found tremendous utility as precision instruments in domains ranging from frequency metrology [1], optical clocks [2], broadband spectroscopy [3] and ranging [4]. While in literature FC are mostly linked to ultra-fast lasers that emit short pulses, Quantum Cascade Lasers (QCLs) were shown to rather generate a frequency modulated combs whose intensity was thought to remain constant [5]. In contrast to ultra-fast lasers, the generated FM comb in QCLs is appealing for fundamental laser science and molecular spectroscopy. While the QCL's comb nature has been rigorously proven through the Shifted Wave Interference Fourier Transform Spectroscopy (SWIFTS) [6], the correlations among spectral lines and noise have yet to be explored.

Here we demonstrate the presence of strong anti-correlations among two spectral portions of a standard monolithic Fabry-Perot QCL that operates in the FC regime. The laser under study is a standard ridge 6mm QCL, operating at 290K in continuous wave at a wavelength of ~ 8.5µm with maximum output power of 100mW. The recorded optical spectra (Fig.1 (a)) shows two spectral lobes separated in frequency by ~0.6 THz. Applying the SWIFTS technique to this FC we were able to reconstruct the temporal evolution of the intensity of each lobes over one round trip of the cavity. The result, in Fig. 1(b), shows a strong antiphase dynamics between the two spectral lobes. The laser action associated to Lobe 1 is perfectly anticorrelated with that of Lobe 2, when one is on the intensity of the other is off. This behavior is further confirmed by analyzing the intermodal beat note corresponding to each of the two lobes (Fig. 1(c)).

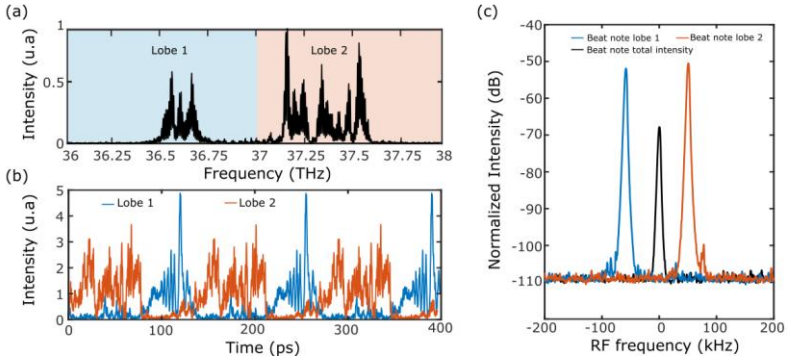

Fig. 1: (a) Optical spectrum of the bilobed QCL (b) SWIFTS reconstructed intensity of each spectral lobes (c) Intermodal beat note of each lobes (blue & red) and of the total intensity (black)

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