**Temporal Dynamics of THz Quantum Cascade Laser**

**Frequency Combs with Strong Injector Anticrossing**

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We investigate the temporal dynamics of terahertz (THz) quantum cascade laser (QCL) frequency combs with a strong injector anticrossing via numerical solution of the Maxwell-Bloch laser equations [1].

The presence of a strong anticrossing between the injector and upper laser levels of the device in [2] leads to a pronounced splitting of the emission spectra into high and low frequency lobe components around the central frequency of 3.5 THz. Moreover, such an effect also manifests itself in the time domain as a form of pulse switching between signals corresponding to the two lobes of the split gain, as experimentally observed in [3]. This process was explained as a form of temporal hole burning. Here we present a theoretical model, based on coupled density matrix/Maxwell equations, which can correctly account for that effect.

Fig. 1 compares experimental results (left column) with simulation data (right column) for the instantaneous intensity of a terahertz QCL frequency comb with a strong injector anticrossing [2, 3]. In both plots the mentioned pulse switching behaviour is clearly visible, and we also notice a more prolonged pulse duration for the signal corresponding to the high frequency spectral component. Density matrix calculations reveal that this dynamics could be due to alternating saturation of the symmetric and anti-symmetric dressed states [4], which are responsible for the low and high frequency radiative transitions, respectively. The dependence of this process on different model parameters such as bias, anticrossing strength, chromatic dispersion etc. will be thoroughly discussed and possible methods for its utilization for frequency comb characterization will be considered.

Intensity (a.u.)

0

5

10

0

0.5

1.0

1.5

2.0

2.5

Time (normalized to Trt )

3

0

0.5

1

0

0.5

1.0

1.5

2.0

2.5

Time (normalized to Trt )

3

Intensity (a.u.)

**Simulation**

**Experiment**

Fig. 1 (Left column) Experimental data for the smoothed instantaneous intensity of the THz QCL comb reported in [2], compared to simulation results (right column) of the same device, based on numerical solution of the Maxwell-Bloch equations. In both plots the x-axis represents time, normalized to the round trip time (Trt) in the cavity. The blue and red curves correspond to the high and low frequency lobe signals, respectively.

High freq. lobe

Low freq. lobe

**References**:

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