Tuning a distributed feedback THz quantum cascade laser with an external microcavity

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Distributed feedback resonator for THz QCL

- Double metal waveguide
- Periodic slits in the top metallization

→ Very big coupling constant
t = \frac{\text{n}\text{eff}}{(c \cdot \alpha_w)} \approx 6\text{ps} \text{ for } \alpha_w = 20\text{cm}^{-1}
With a reflecting top boundary

Tuning range of up to 10 % could be possible
Move the mirror with a piezo drive
Anti-crossing
Grating design

Strong vertical emission required

Force the laser to the radiative band-edge
Device design
Fabricated device
Experimental setup
Anti-crossing

- Strong intensity modulation
- Tuning only 1-2 GHz
- Increase vertical emission!
Quasi-periodic Structures

- Non-periodic
- Deterministic

Fibonacci sequence: \( S_{j+1} = \{S_{j-1}, S_j\} \) with \( S_0 = \{B\} \) and \( S_1 = \{A\} \)

\( S_7 = \{ABABAABABAABABA\} \).

- For metallic gratings: Replace the A,B interface with a slit in the metal
First devices

Quasi-period 5.45 µm, slit 1.8 µm
Slit-width dependence

Frequency (THz)
Grating-dependent emission

Emission scales with the quasi-period
Lasing on the lower band-edge
Light-current characteristics

Power (mW)

Current (A)

18K

60K

80K
Far-field
Bragg peaks

Grating wavevector ($k/k_0$)

Periodic

Quasi-periodic

$$k_{\text{Guided mode}} = nk_{\text{Grating}} - k_{\text{Guided mode}}$$
Far-field wavevectors

\[ \sin(\theta) k_{\text{Radiation}} = |k_{\text{Grating}} - k_{\text{Guided mode}}| \]
Tuning of a Fibonacci laser

Frequency (THz)

≈ 30 GHz

Mirror distance (um)
Experiment

\[ \approx 6 \text{ GHz} \]
Conclusions and Outlook

• It is very difficult to obtain laser oscillation on the radiative bandedge
• A Fibonacci laser has enough surface emission for a proof of concept
• Drastic improvements required to become useful

• What other geometries could be possible?
• Can we find a way to couple two lasers sufficiently?