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

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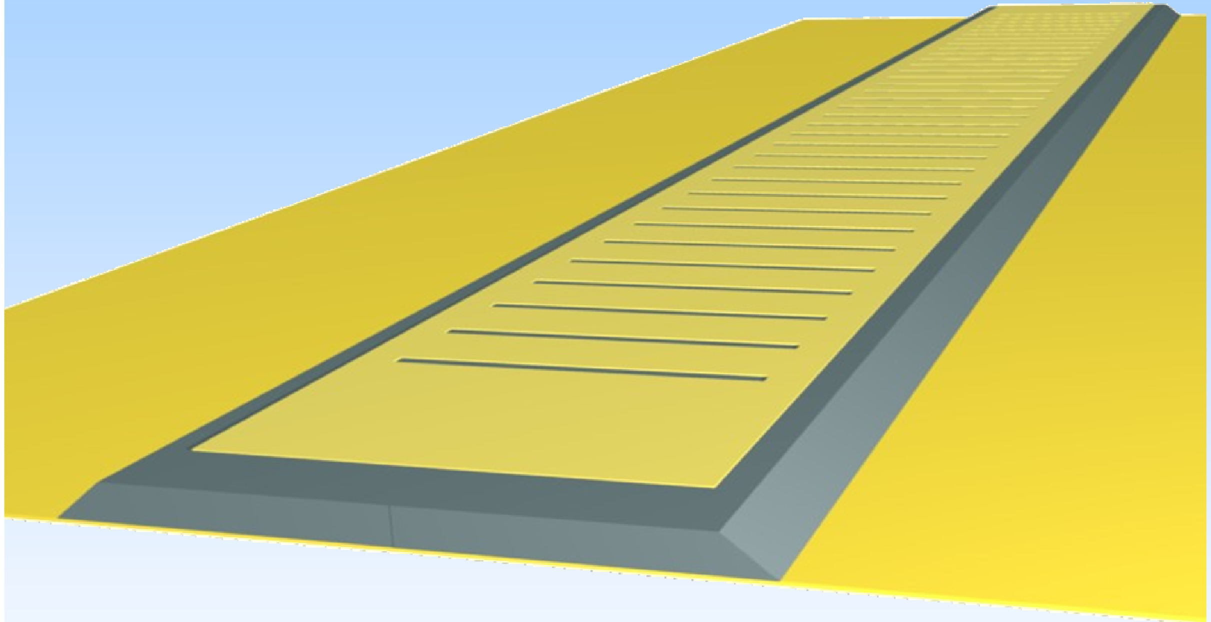
Distributed feedback resonator for THz QCL



- Double metal waveguide
- Periodic slits in the top metallization

→ Very big coupling constant

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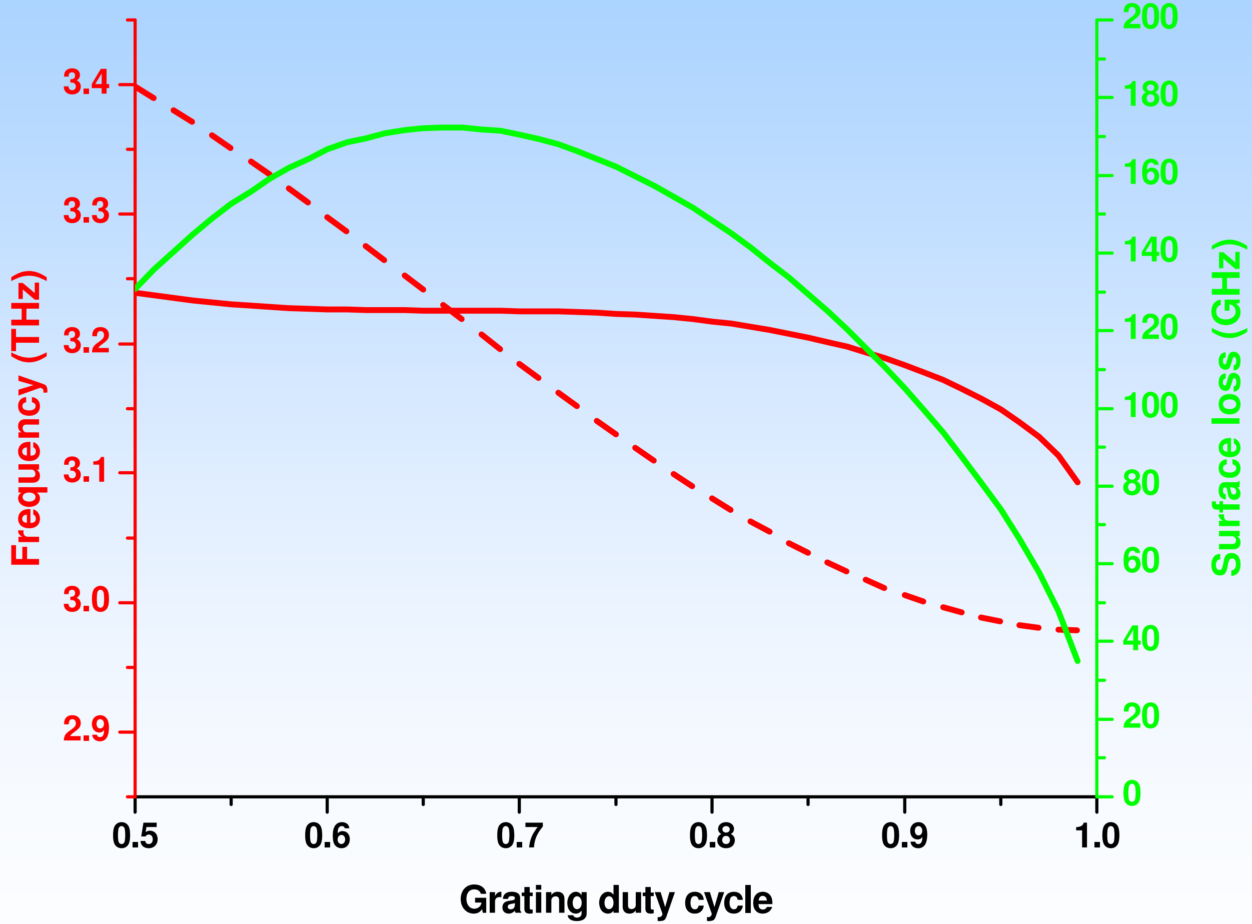
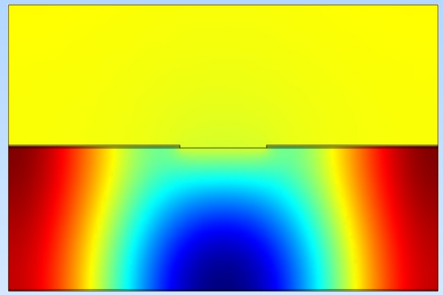
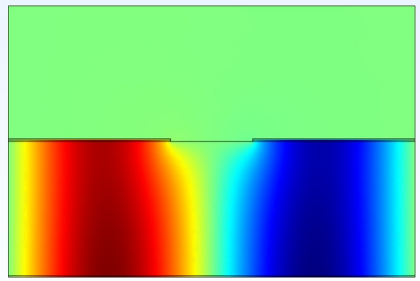
Bandedges of a grating



Radiating



Non-radiating



$t = neff/(c^*\alpha_w) \approx 6ps$ for $\alpha_w = 20cm^{-1}$

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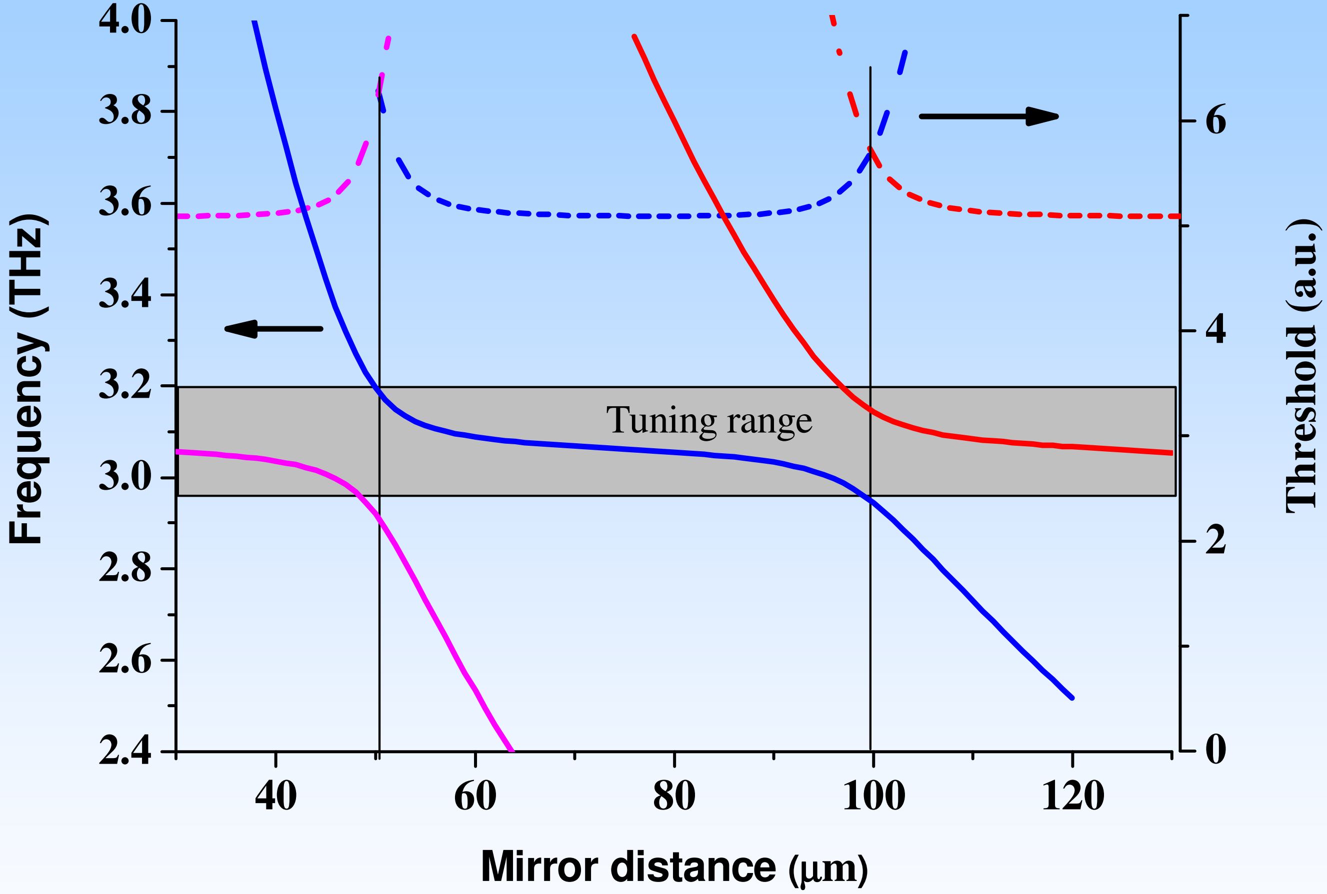
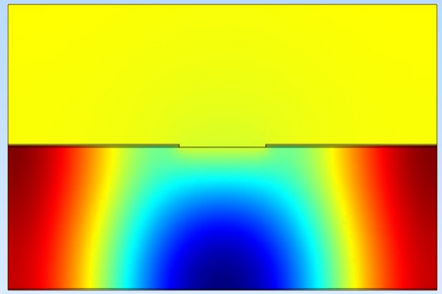
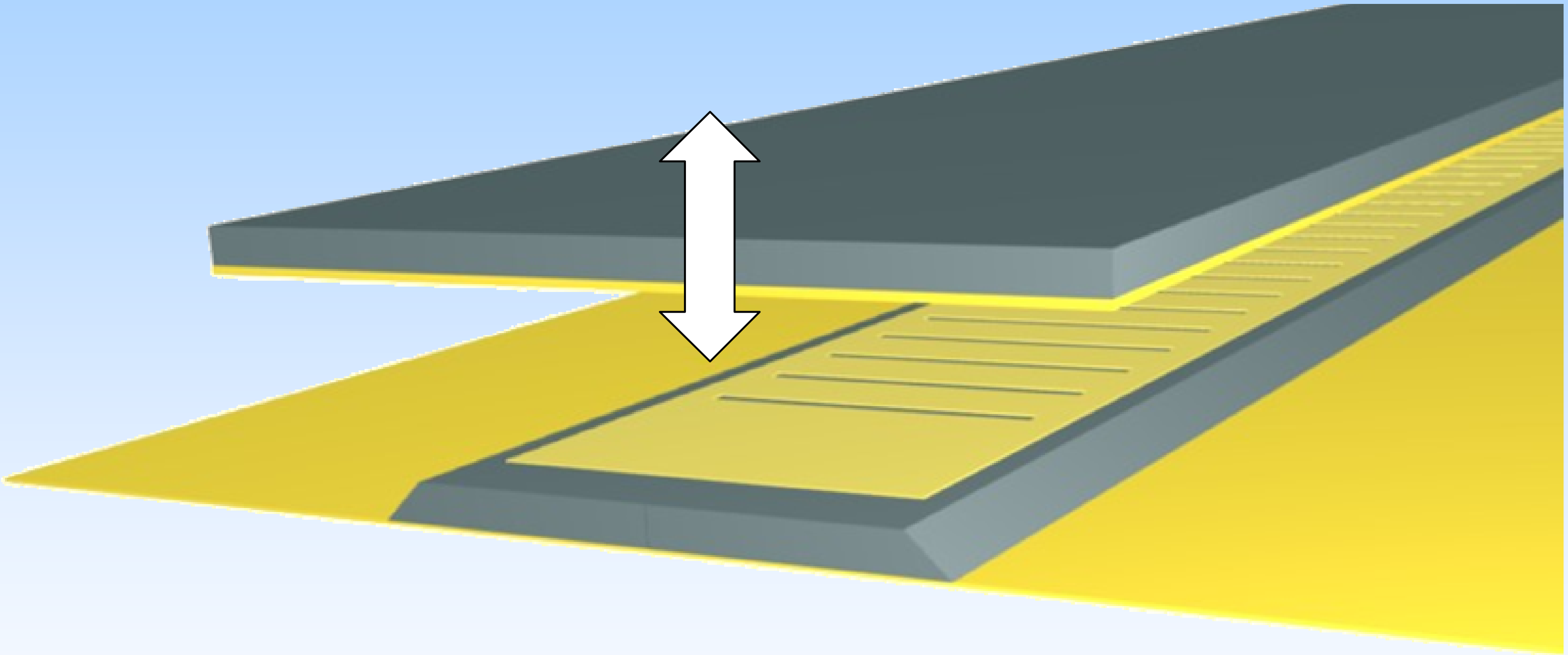
With a reflecting top boundary





Tuning range of up to 10 % could be possible

Implemetation



Move the mirror with a piezo drive

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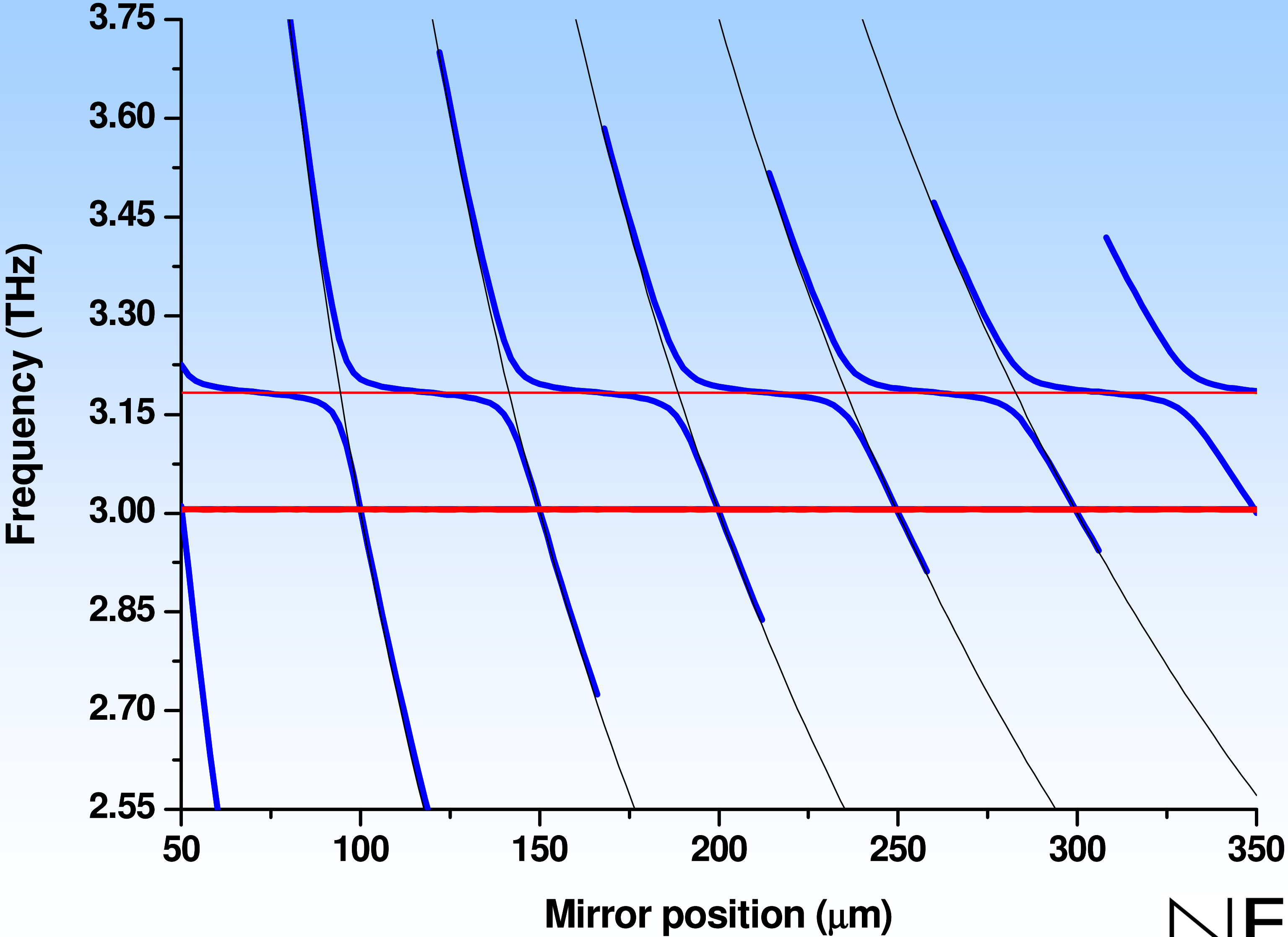
Anti-crossing



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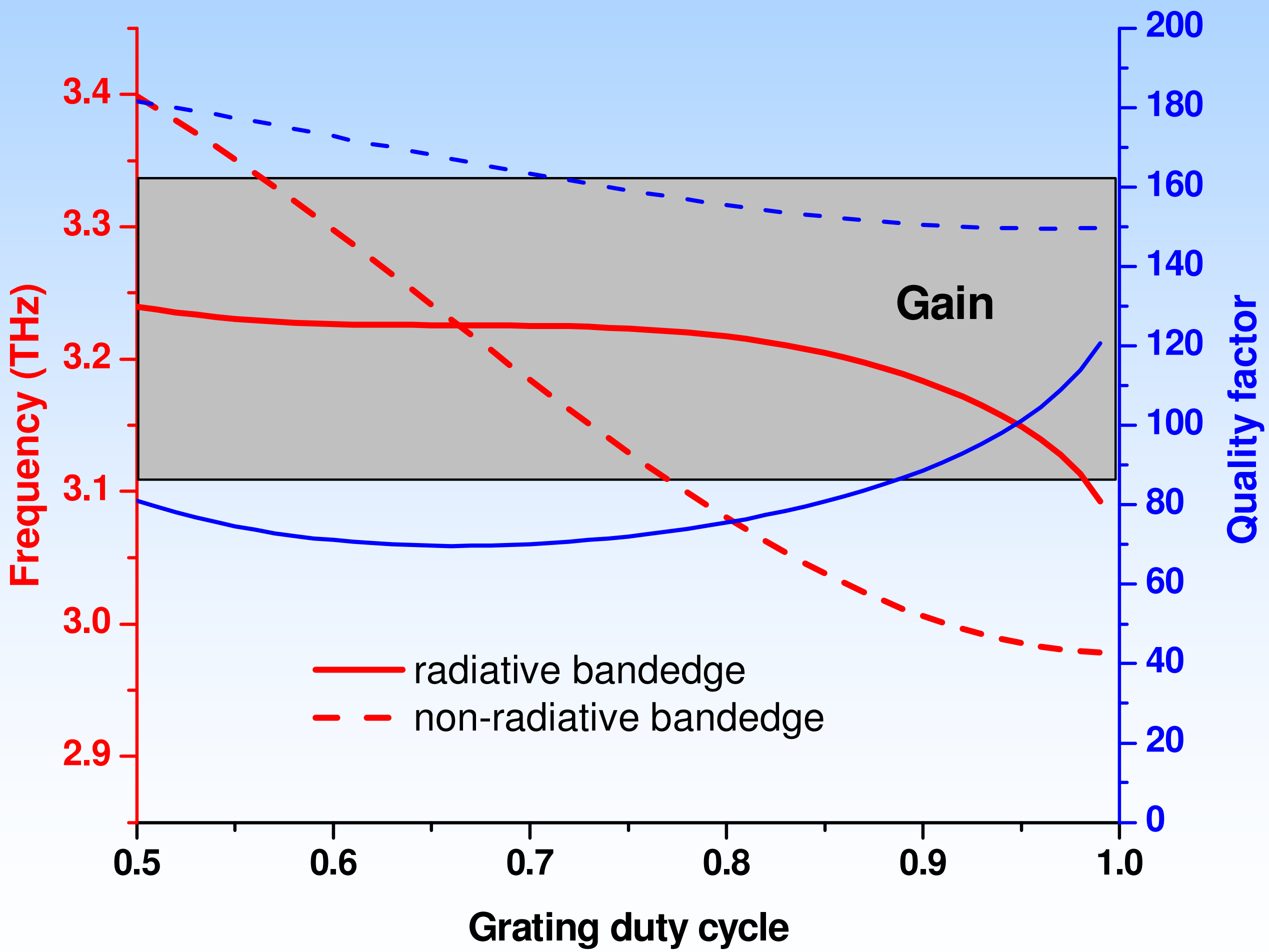
Grating design

Strong vertical emission required



Force the laser to the radiative band-edge

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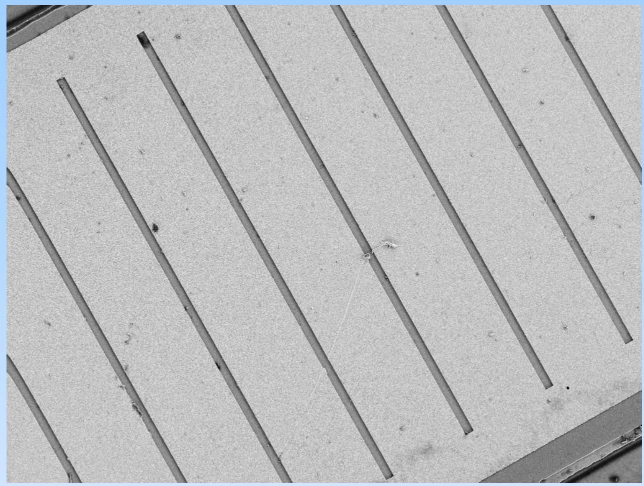
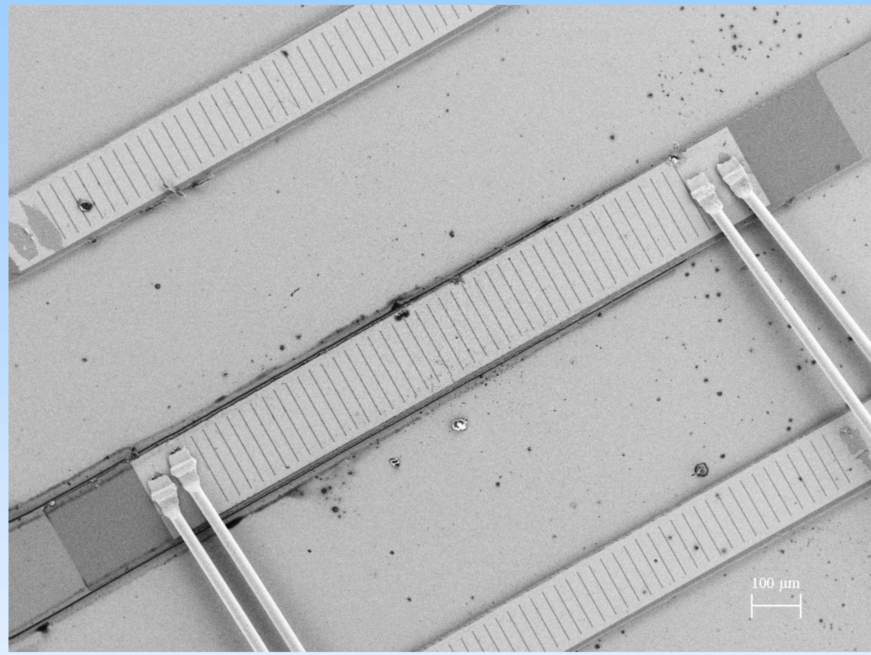
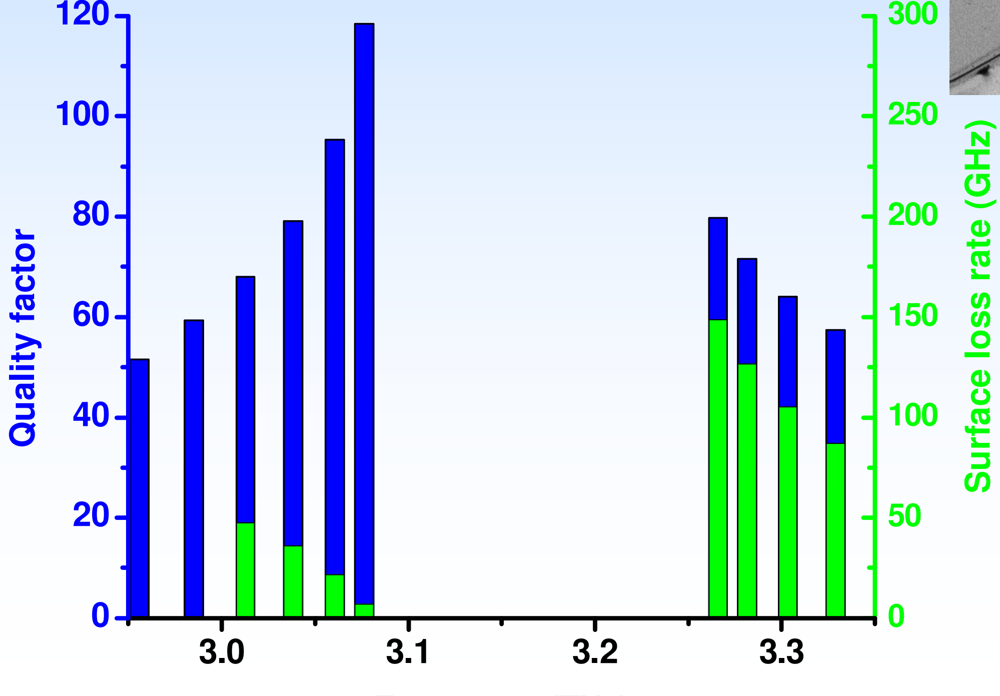
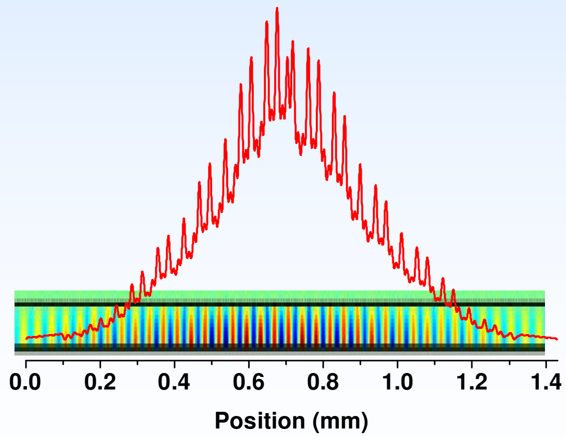
Device design









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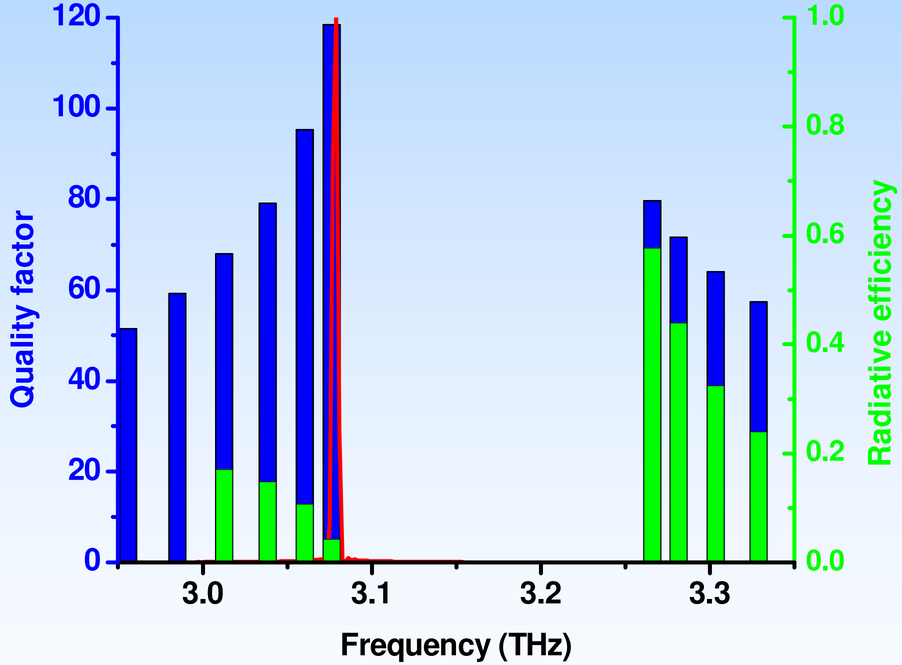
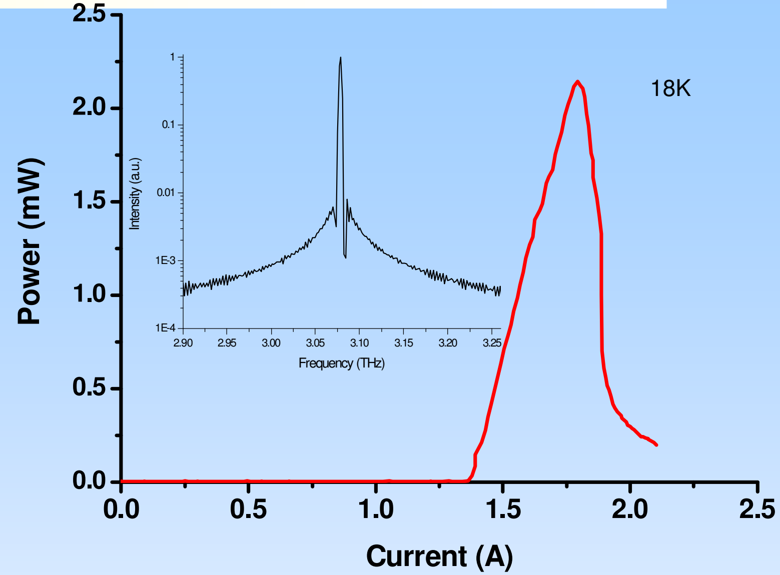
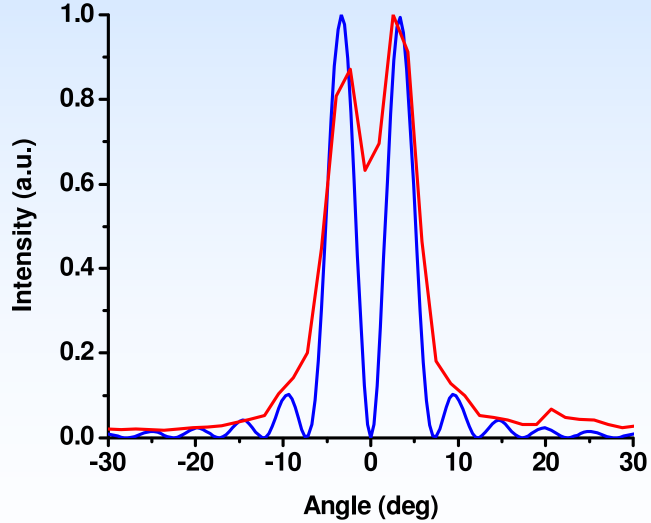
Fabricated device







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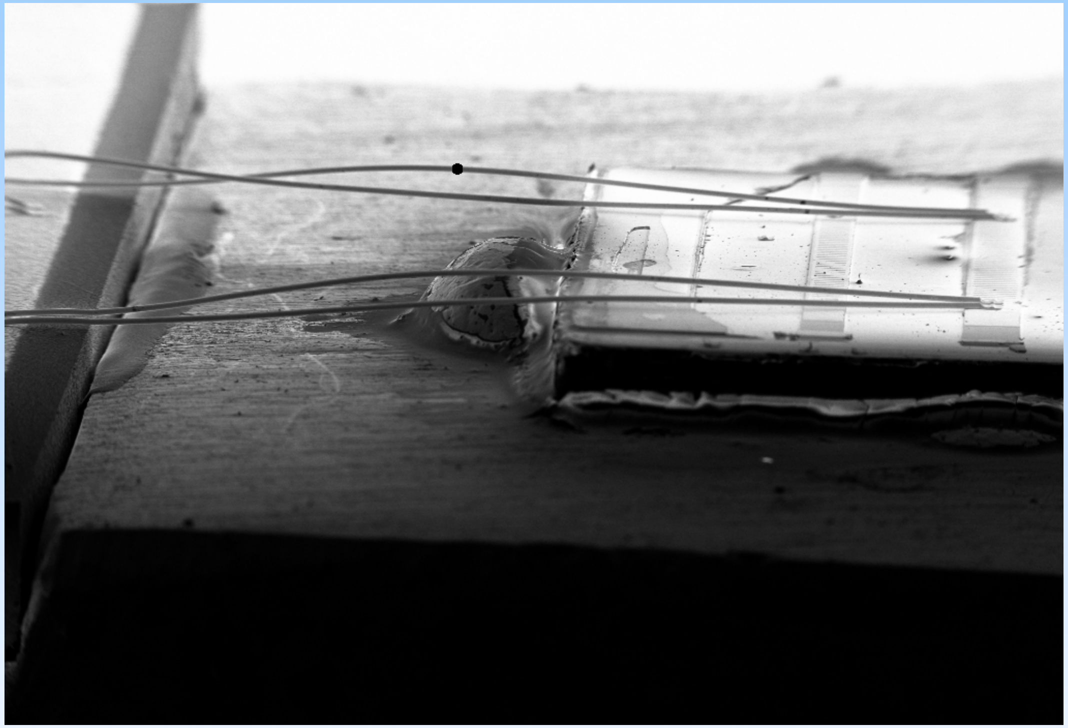
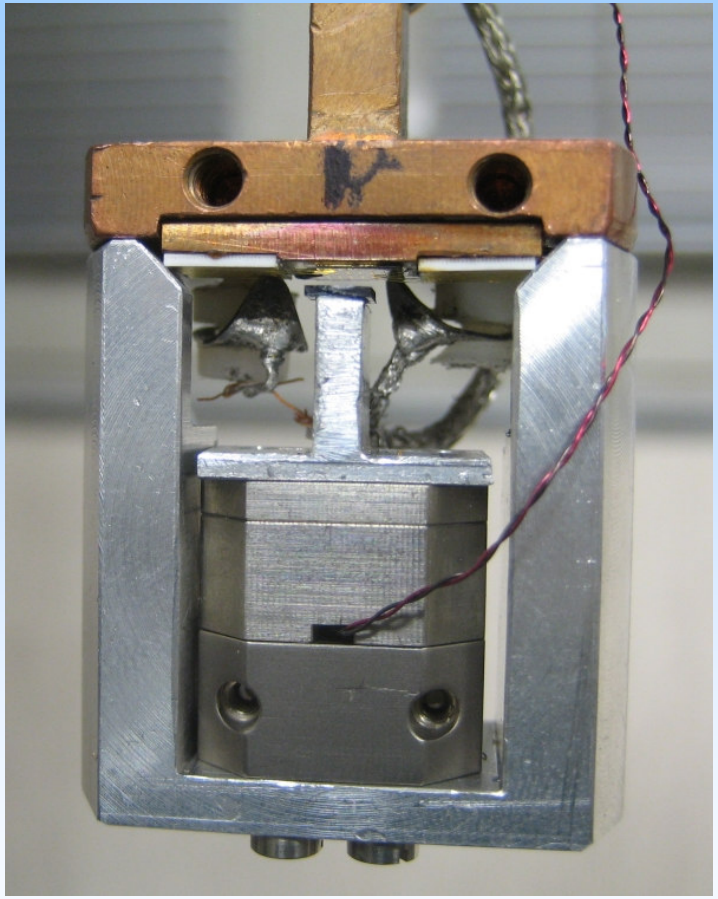
Experimental setup





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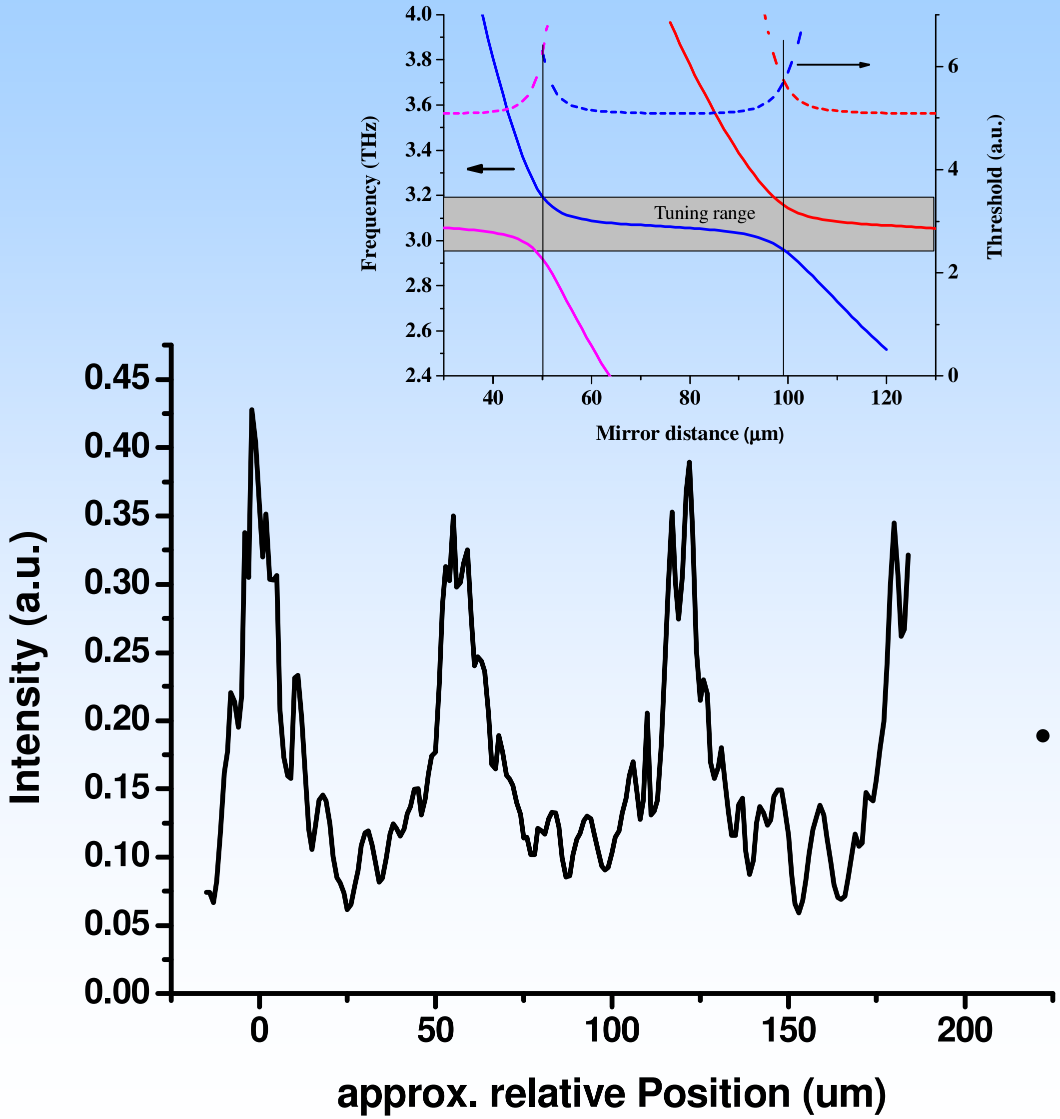
Anti-crossing



- Strong intensity modulation
- Tuning only 1-2 GHz

- Increase vertical emission!

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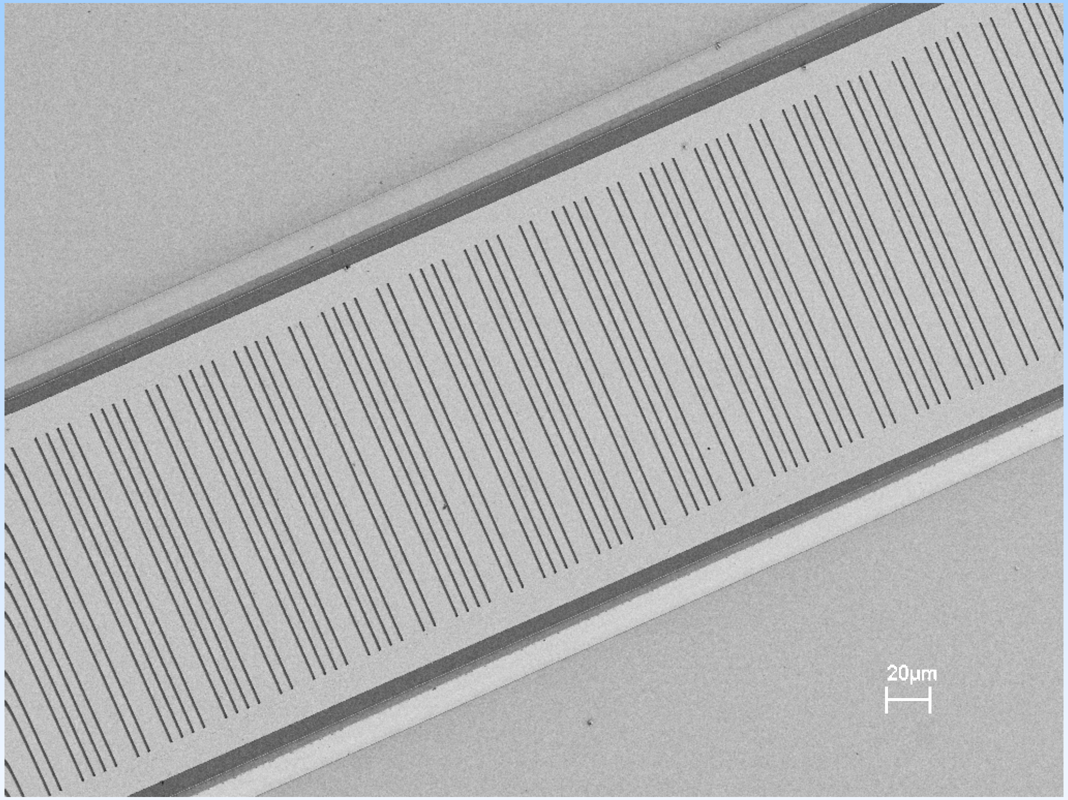
Quasi-periodic Structures



- Non-periodic
- Deterministic

- Fibonacci sequence: $S_{j+1}=\{S_{j-1}\ S_j\}$ with $S_0=\{B\}$ and $S_1=\{A\}$
- $S_7=\{ABABAABABAABAABABAABA\}$.

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

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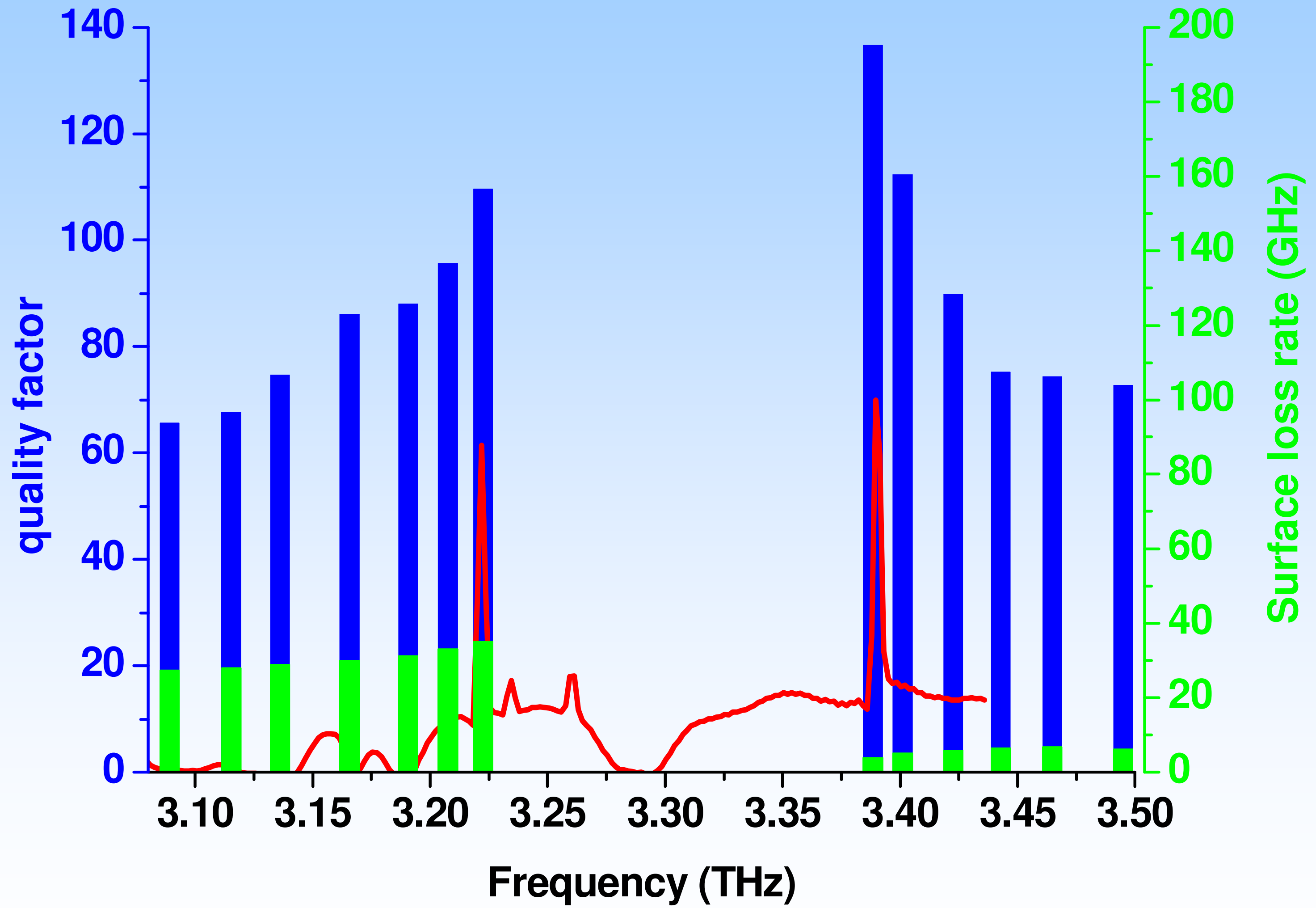
First devices



Quasi-period 5.45 μm, slit 1.8 μm

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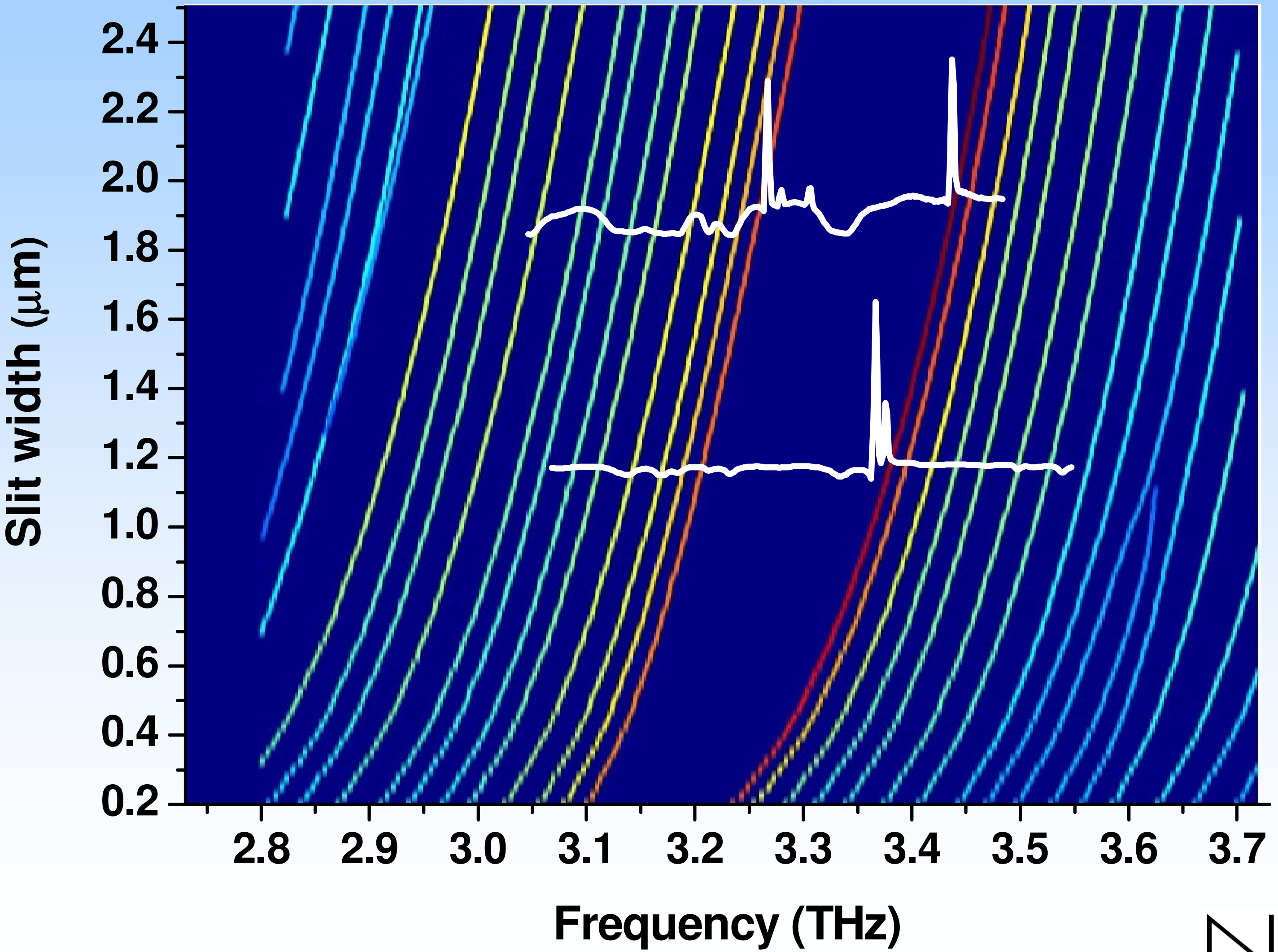
Slit-width dependence



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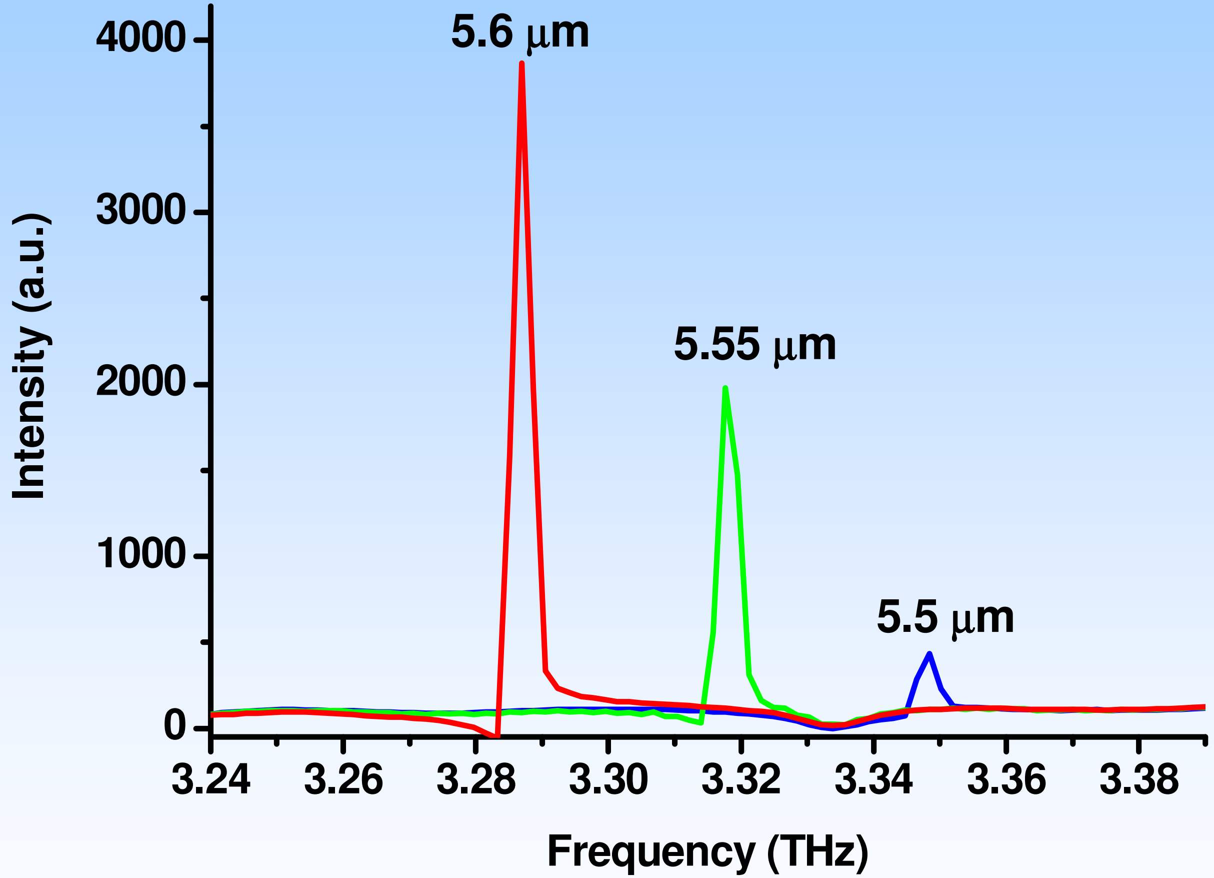
Grating-dependent emission



Emission scales with the quasi-period

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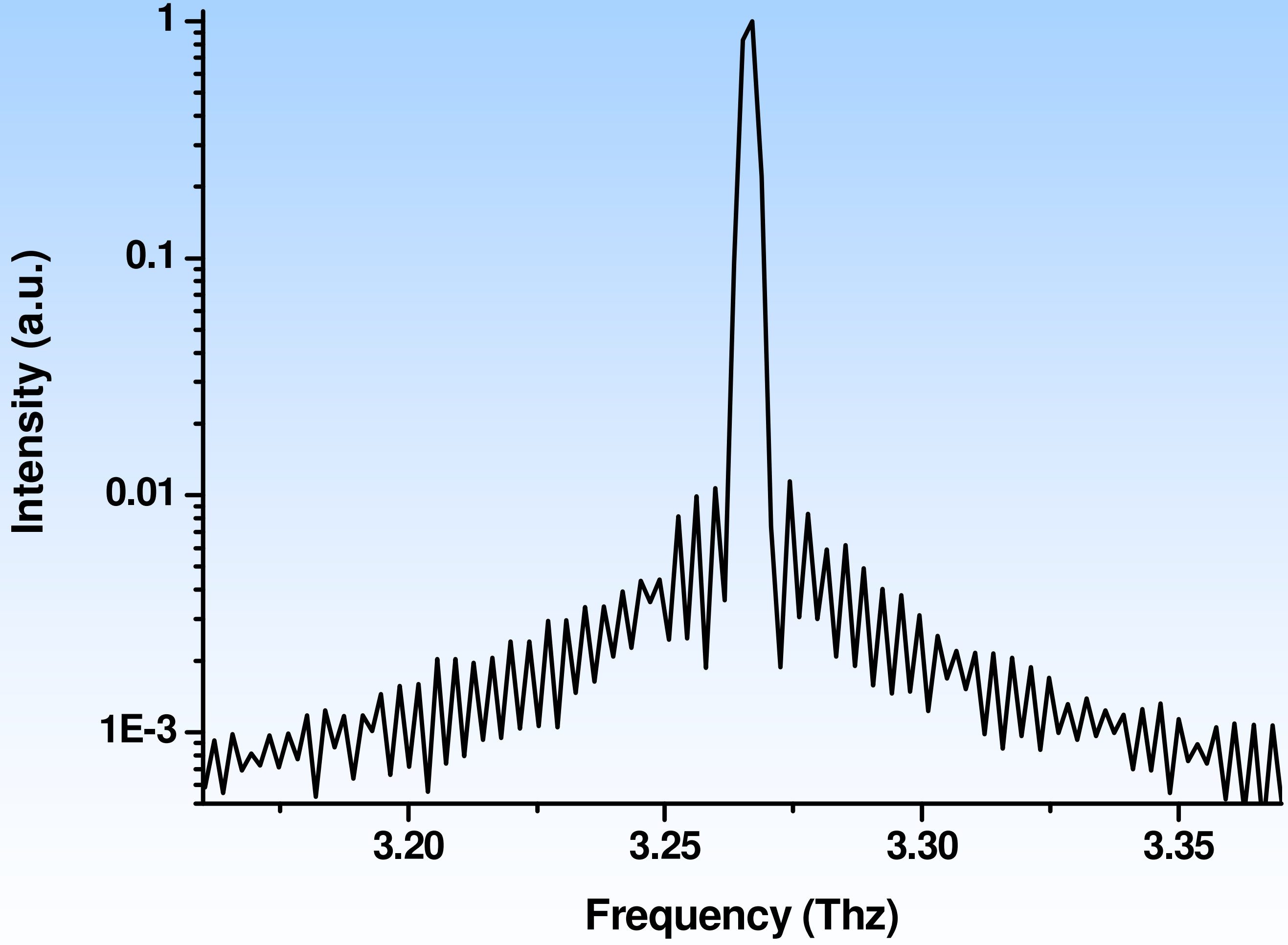
Lasing on the lower band-edge



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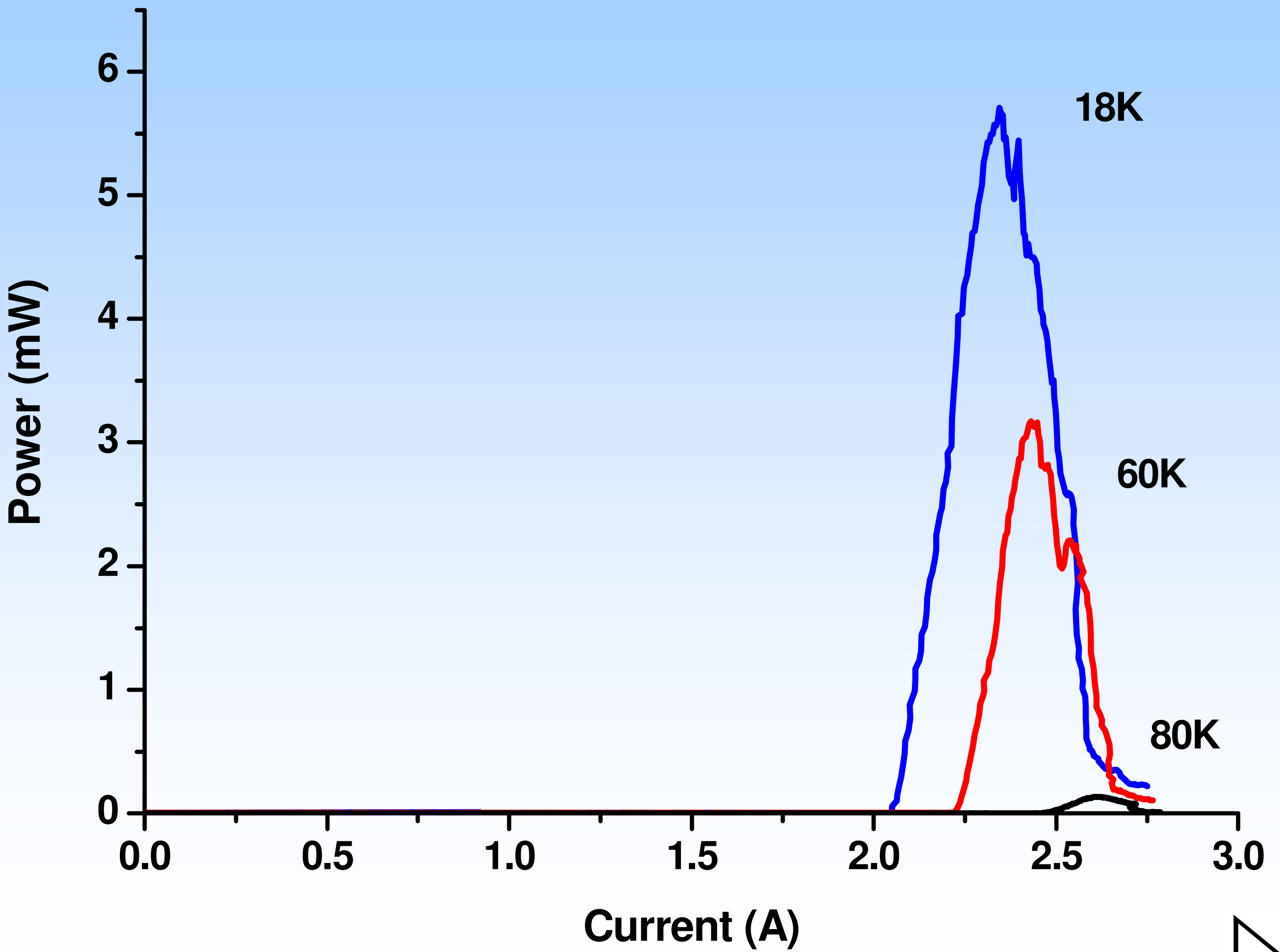
Light-current charactericstics



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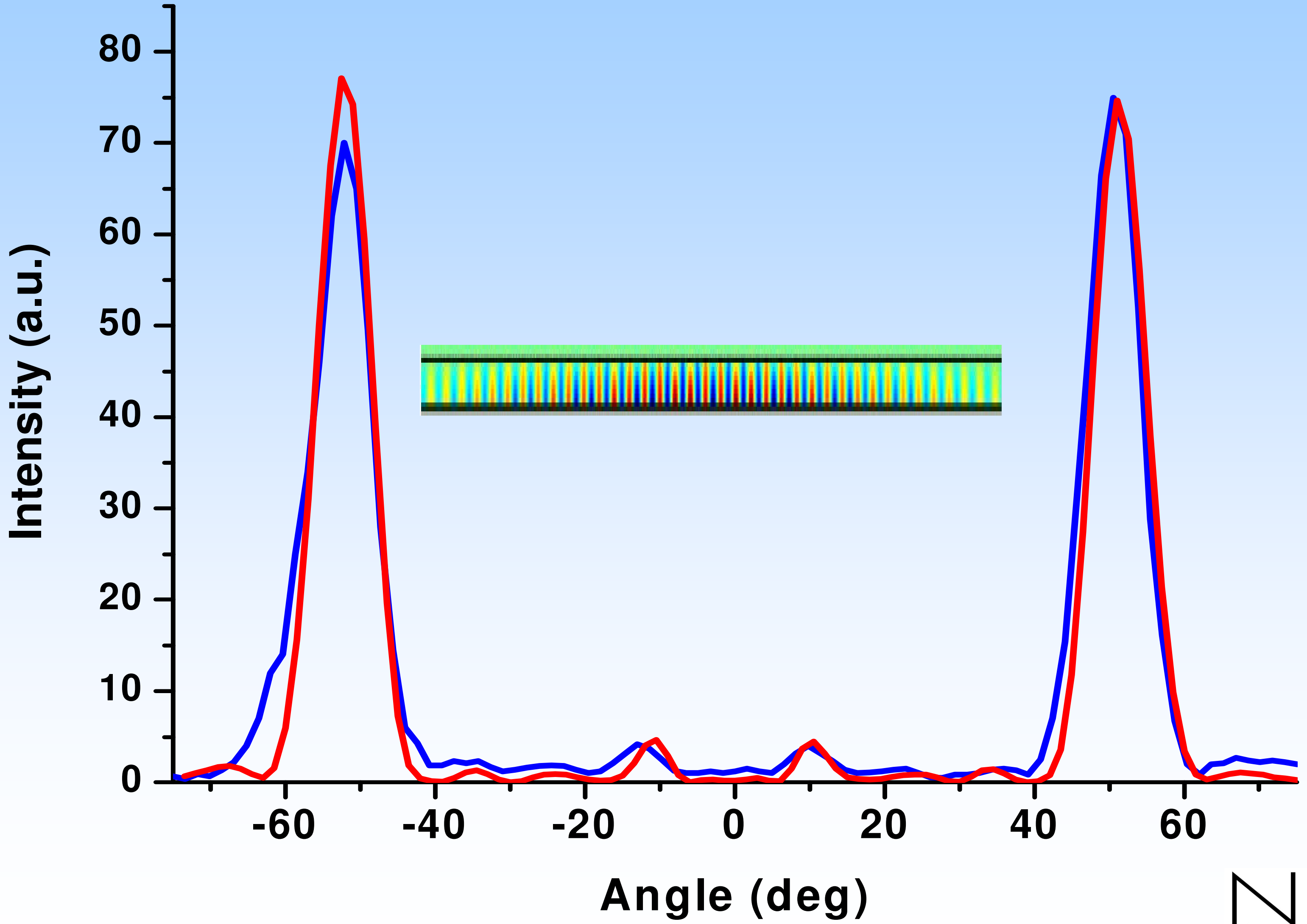
Far-field



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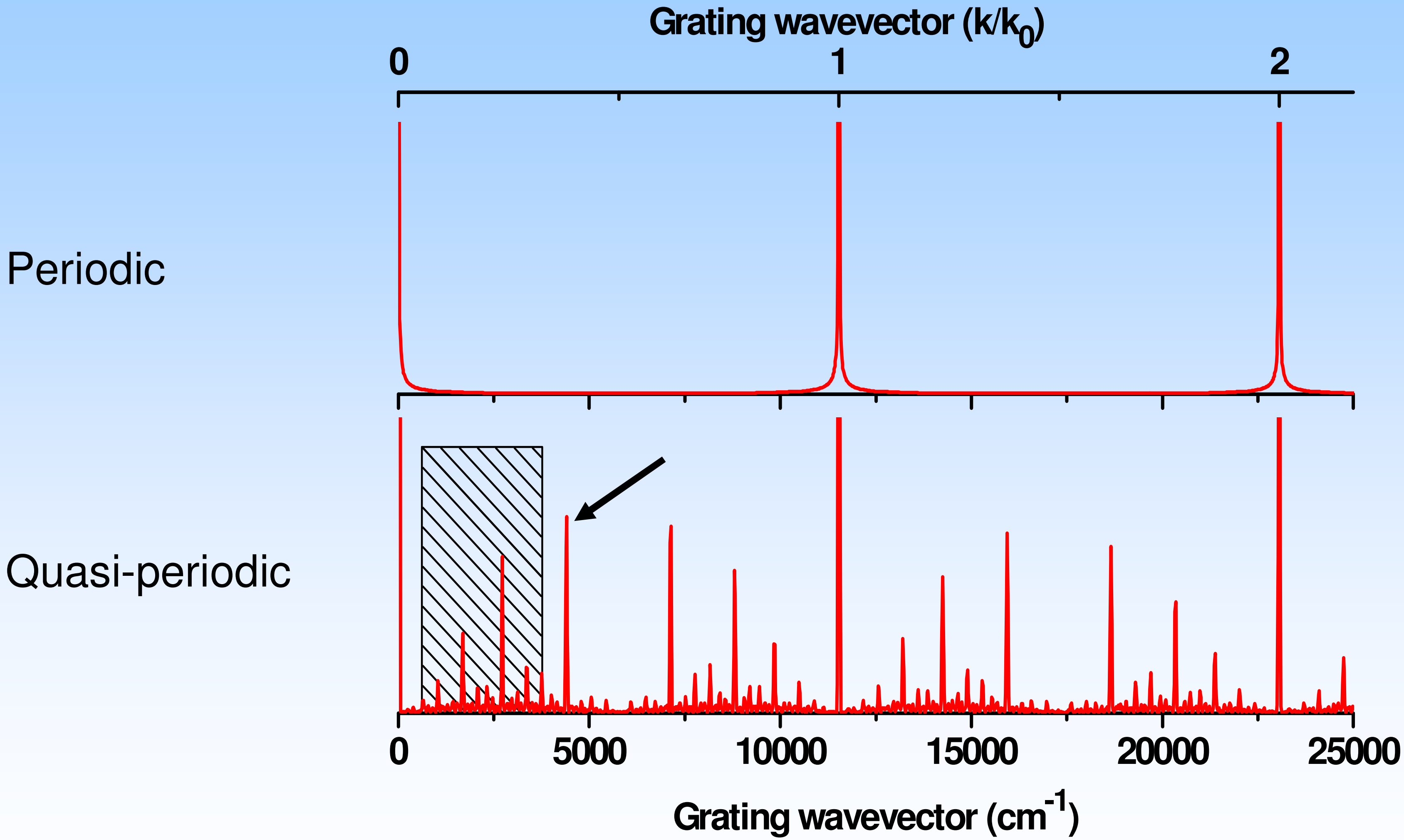
Bragg peaks



$$k_{Guided\ mode} = nk_{Grating} - k_{Guided\ mode}$$

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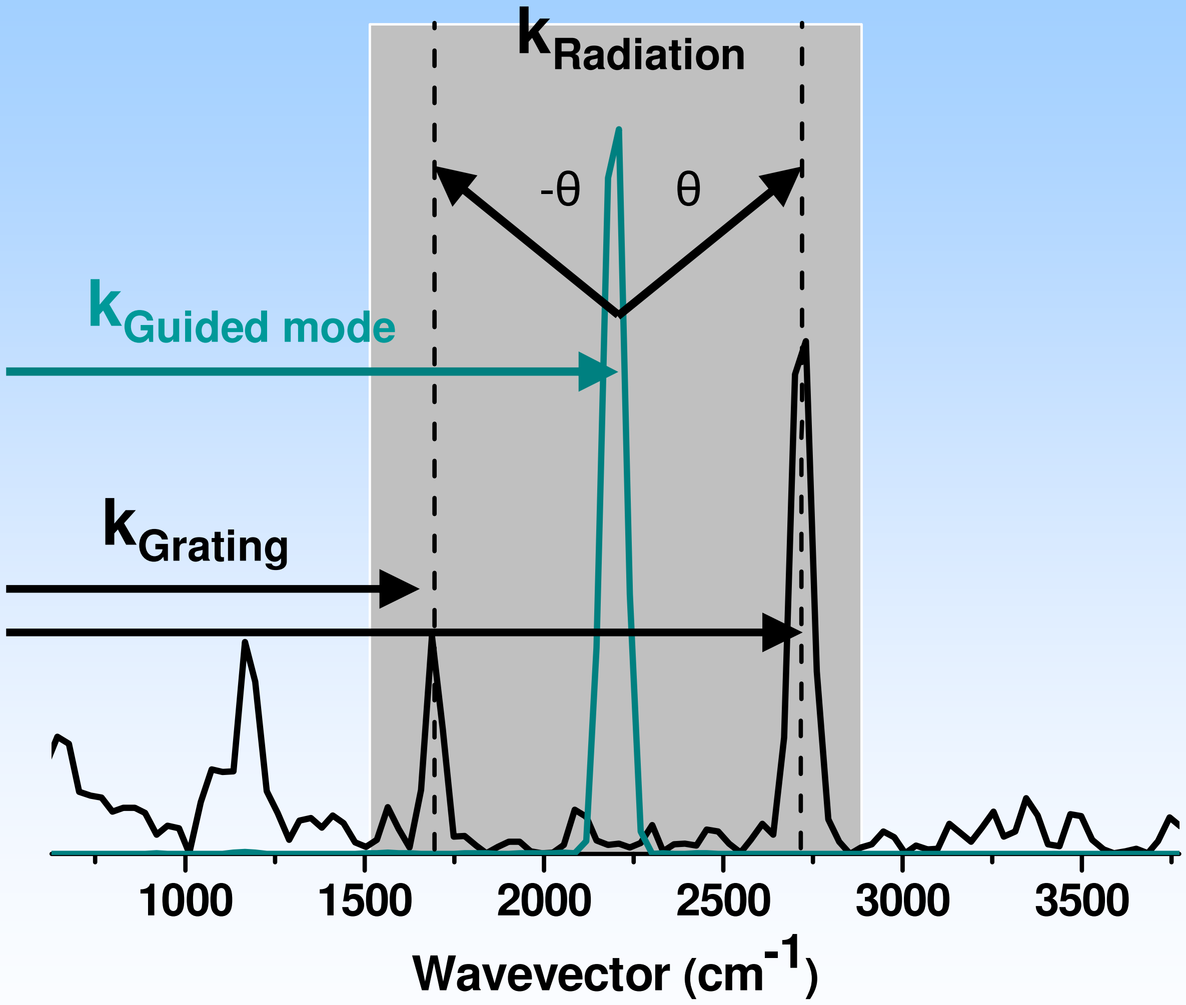
Far-field wavevectors



$\sin(\theta)k_{Radiation} = |k_{Grating} - k_{Guided\ mode}|$

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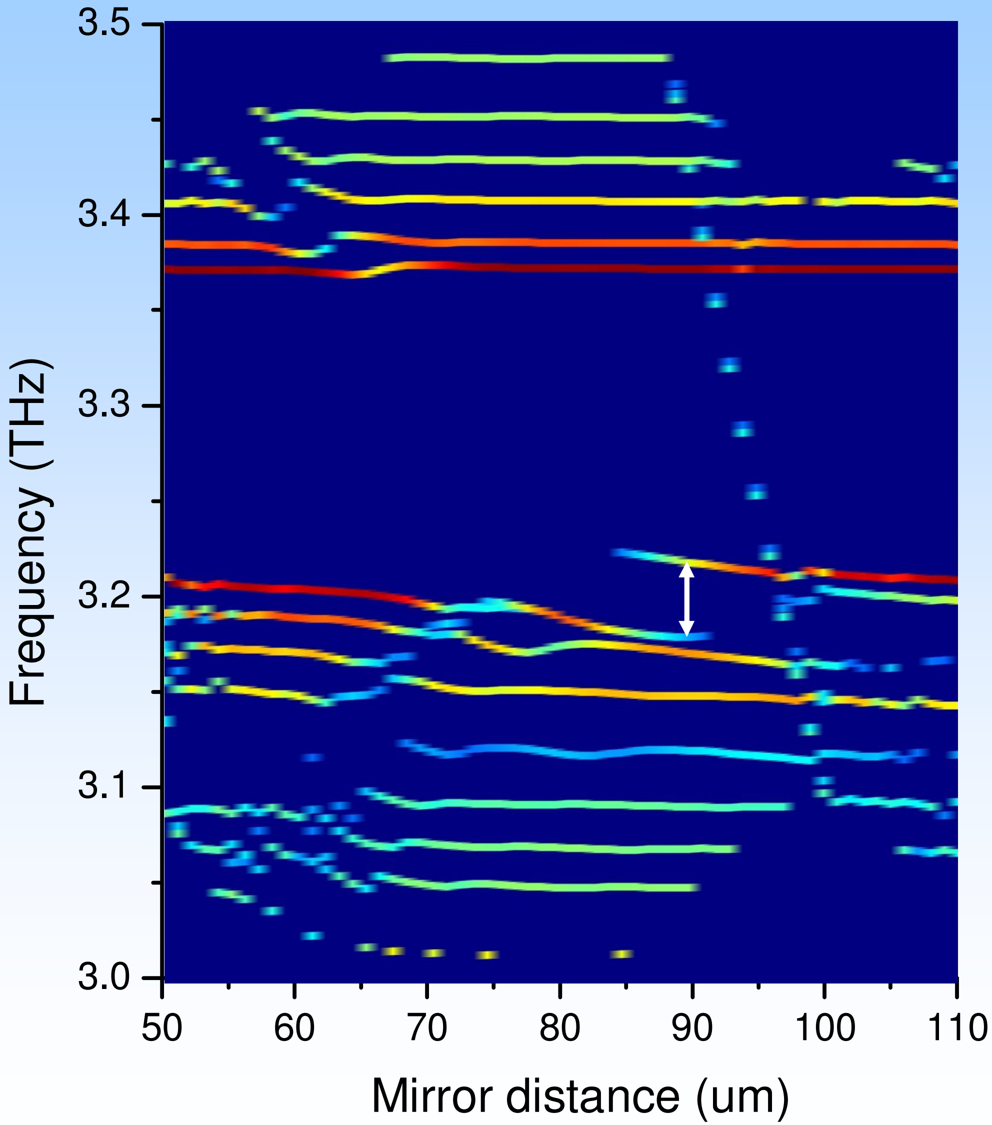
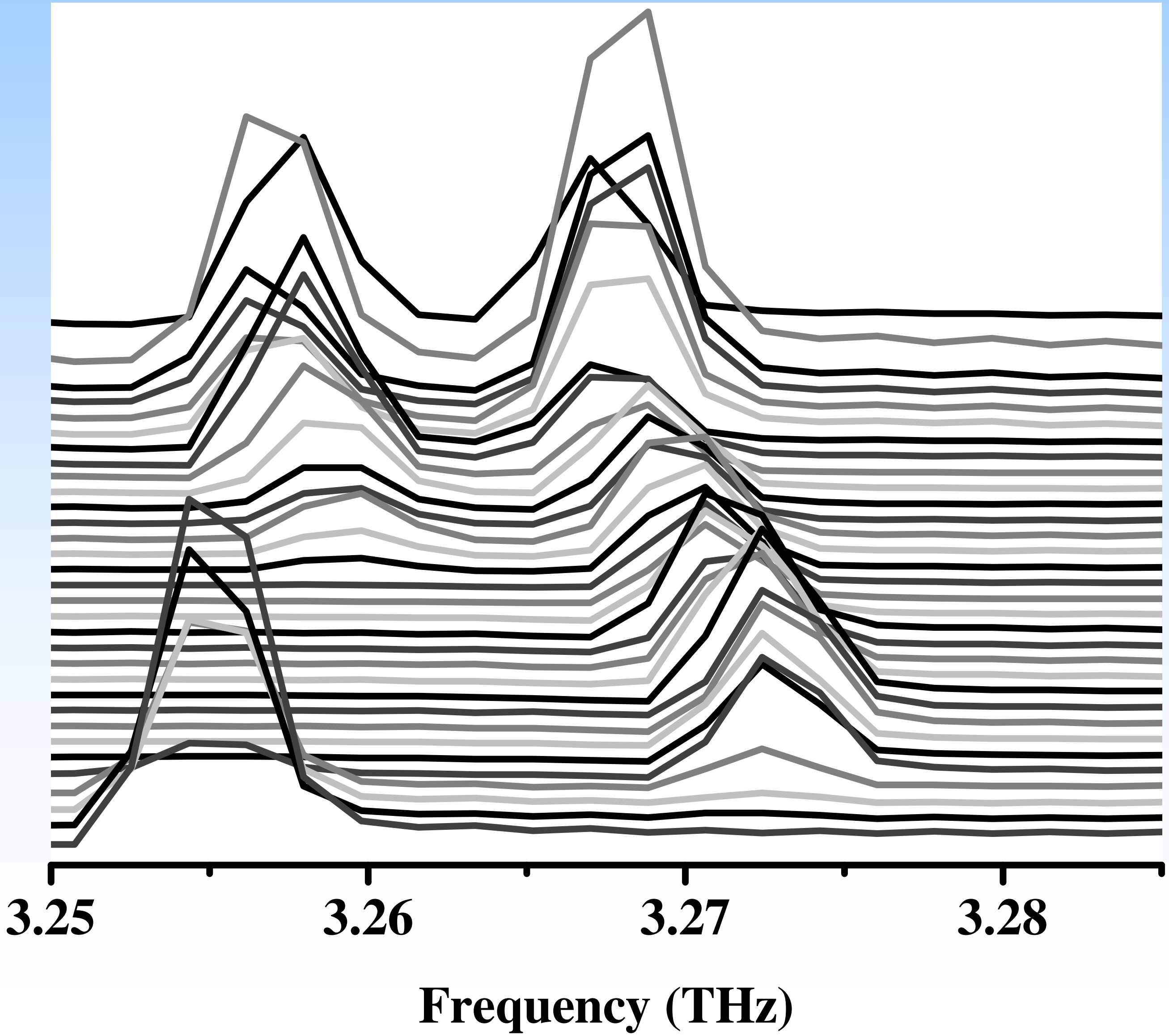
Tuning of a Fibonacci laser



≈ 30 GHz

Experiment



≈ 6 GHz

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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 improvments required to become useful

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