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Dual Tunability of Lithium Niobate Microresonators

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Outline

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- Lithium Niobate Microresonator Overview
- Dual tunability method
- Tuning SH frequency conversion
- Aligning multiple resonators

Lithium Niobate microresonators

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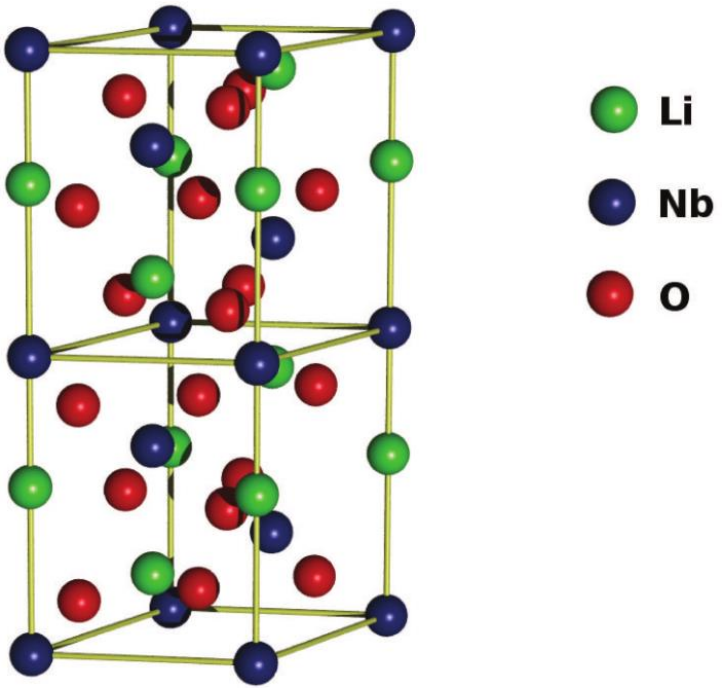
- Lithium Niobate: very large $\chi^{(2)}$ nonlinearity

$$\boldsymbol{P} = \epsilon_0\left[\chi^{(1)}\boldsymbol{E} + \chi^{(2)}\boldsymbol{EE} + \chi^{(3)}\boldsymbol{EEE} + \cdots\right]$$

- Non-centrosymmetric crystal
- $\chi^{(2)}$ material applications:
  - Optical modulation
  - Frequency conversion
  - Photon pair generation
  - Squeezed light generation



Lithium Niobate microresonators

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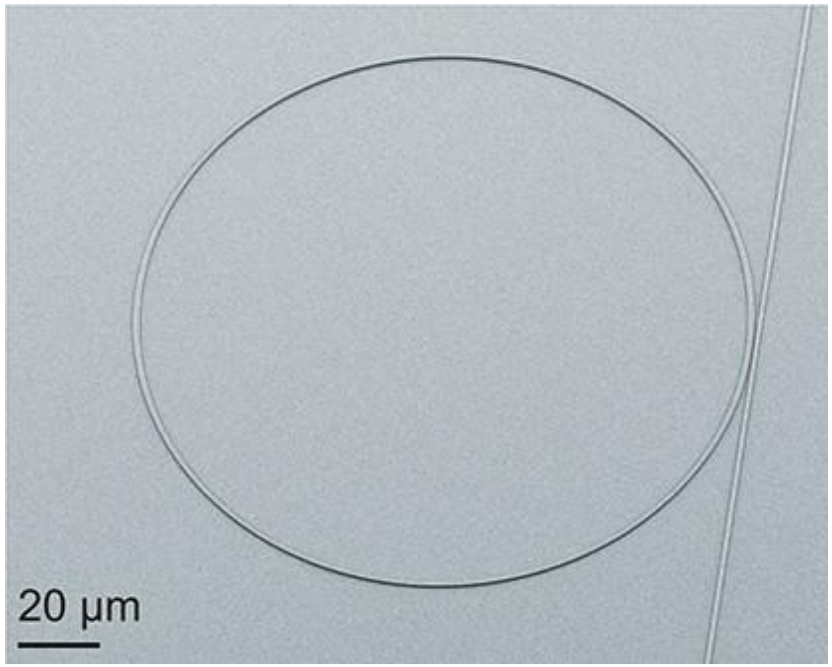
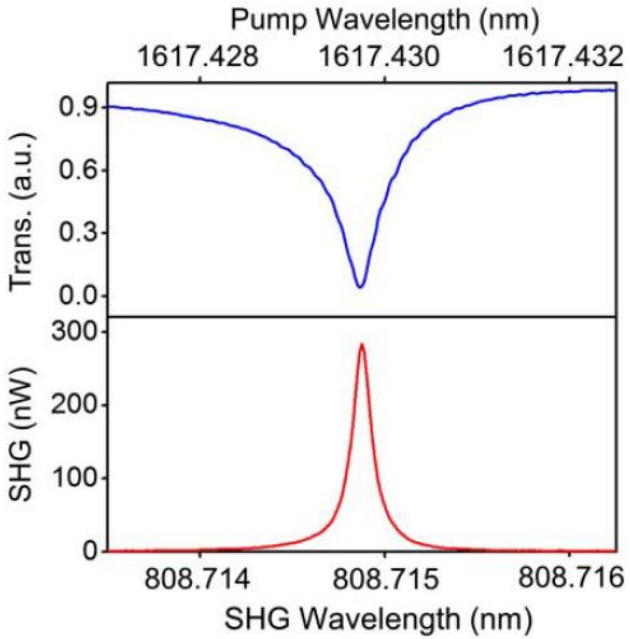
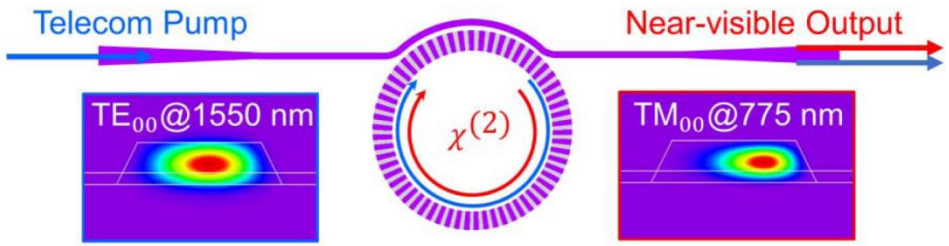
- Nanophotonics: decrease mode volume

$$g \propto 1/\sqrt{\mathcal{V}}$$

- Resonator: enhances interaction strength, decreases spectral linewidth







Optica **4**(12) 1536-1537 (2017)

Optica **6**(12) 1455-1560 (2019)

Importance of Tunability

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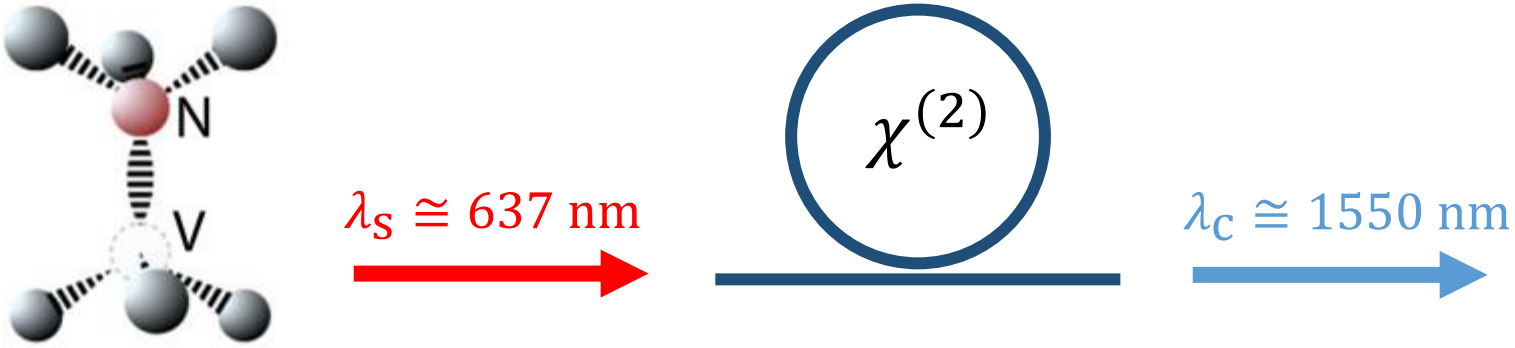
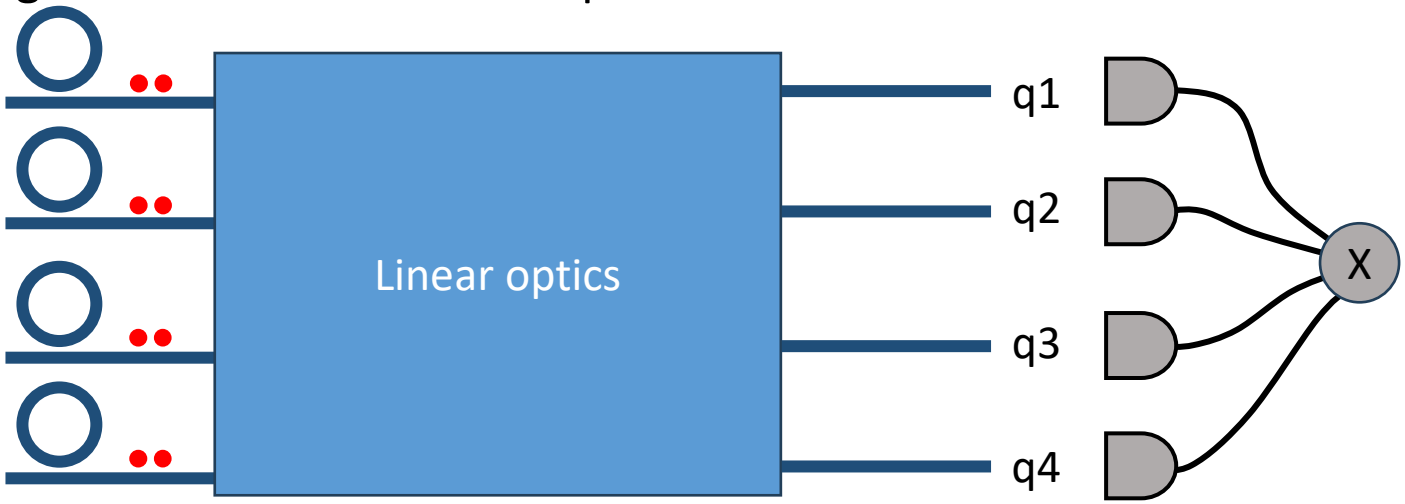
- Quantum frequency conversion: alignment of source wavelength with frequency conversion wavelengths



- Generating cluster states from multiple nonlinear sources



Resonator enhanced SHG comparison

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Article	λ
Optica **3**(10) 1126-1131 (2016)	1543.94 nm
Light: Sci & App **6** e16249 (2017)	1550.96 nm
Optica **6**(10) 1361-1366 (2019)	1559.635 nm
Optica **6**(12) 1455-1460 (2019)	1617.43 nm

Table S2. Calibrated SHG efficiency η from multiple devices

Dev.	λ_{pump} (nm)	$Q_{L,tele/nvis}$	$Q_{0,tele/nvis}$	$IL_{tele/nvis}$ (dB/facet)	η (%/W)
1	1617	800 k / 180 k	1.8 M / 1.0 M	9.0 / 12.6	250,000
2	1522	690 k / 290 k	1.0 M / 980 k	8.0 / 13.8	130,000
3	1520	1.1 M / 370 k	1.9 M / 590 k	8.8 / 12.5	170,000
4	1518	1.2 M / 480 k	1.5 M / 610 k	8.5 / 13.5	150,000

Resonator Alignment

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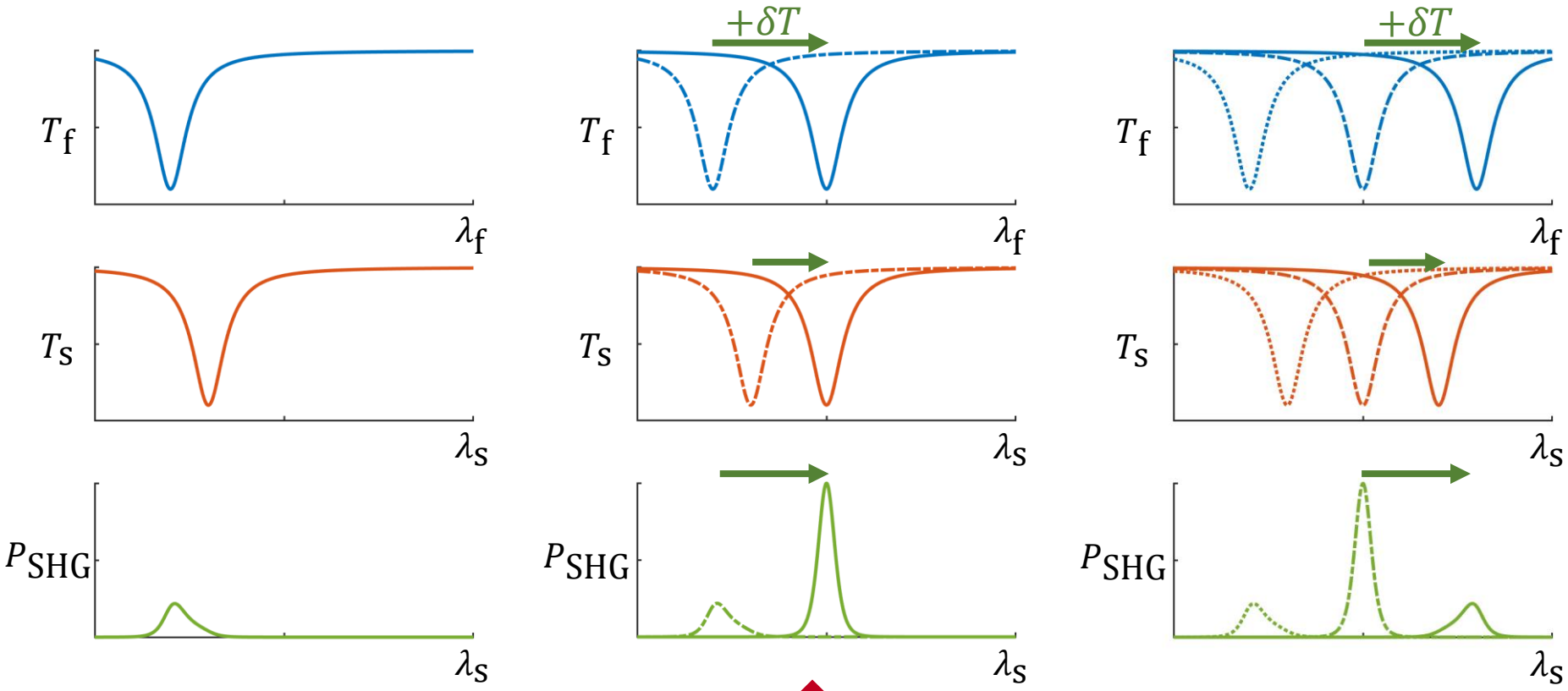
- Efficiency is maximized when all relevant frequencies are in-resonance

$$OPL = nC = m\lambda$$

- Alignment is NOT guaranteed due to dispersion
- Resonances typically aligned using temperature
- Resonance alignment can only be achieved at a limited set of wavelengths



Dual Tunability Method

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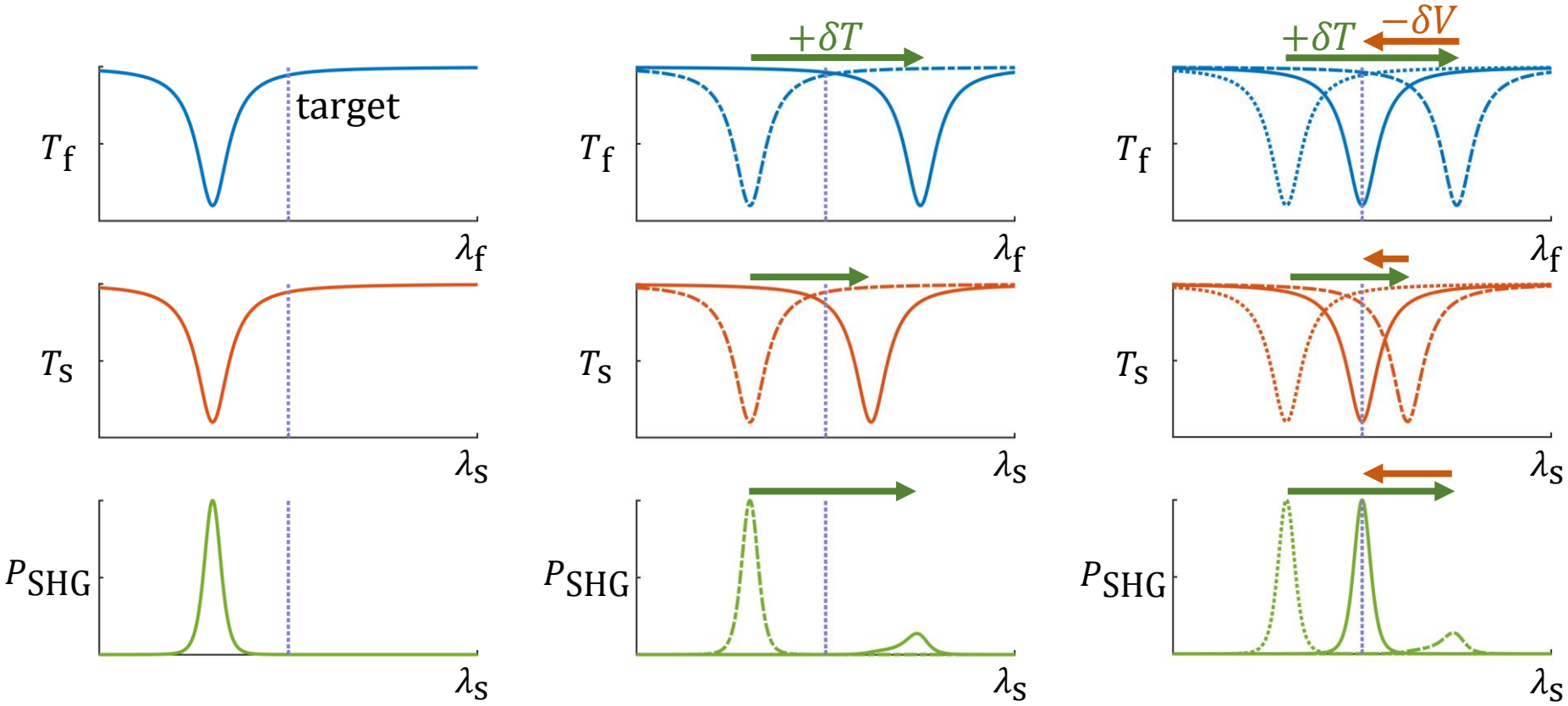
- Need another degree of freedom to achieve a range of aligned wavelengths
- Electro-optic tuning: apply DC electric field to lithium niobate



Resonator Architecture

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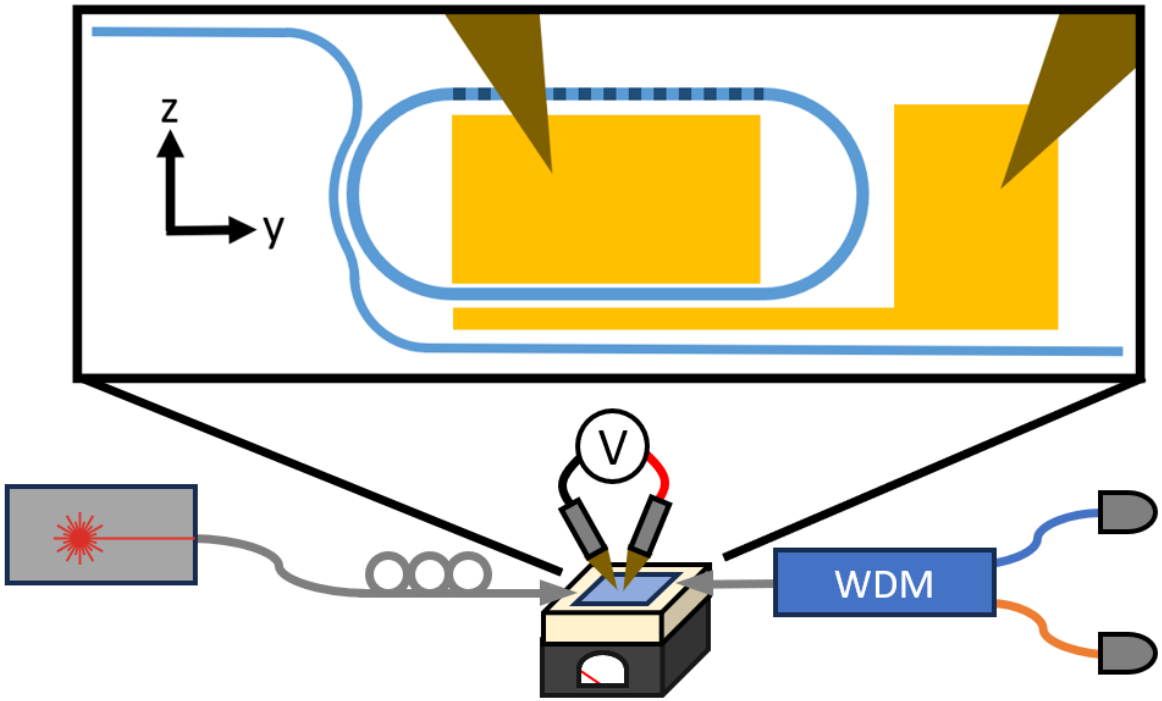

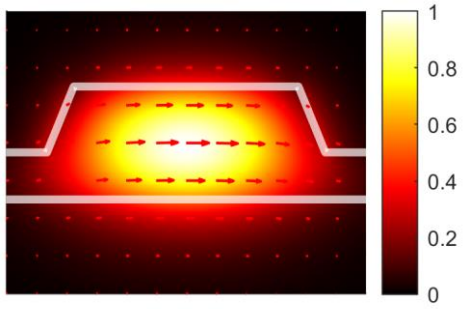

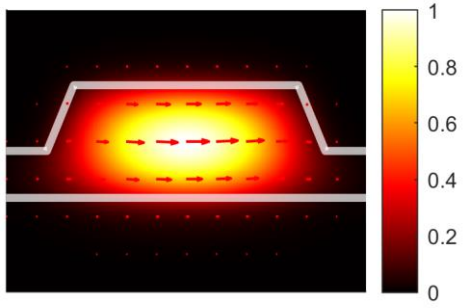

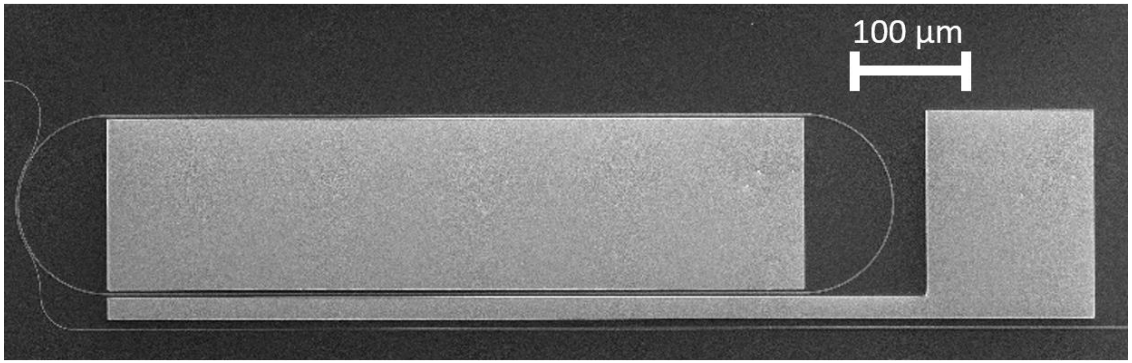

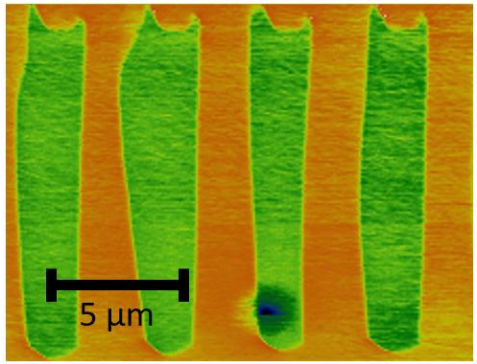

Tuning Characterization

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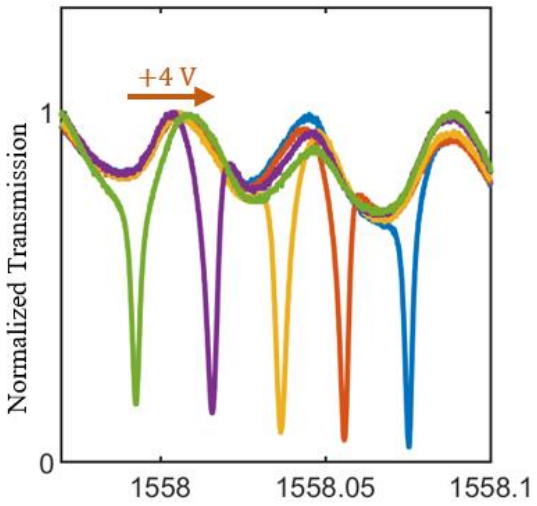

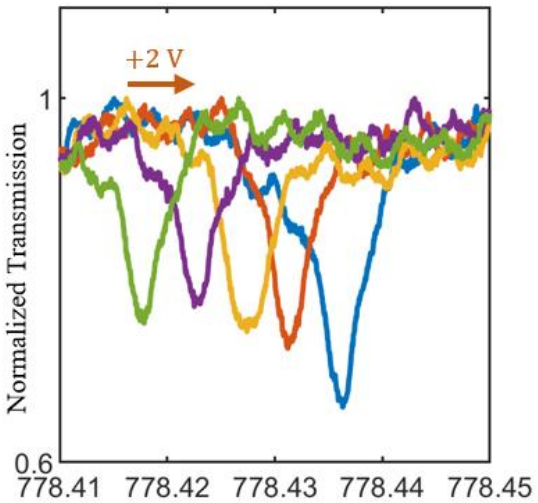

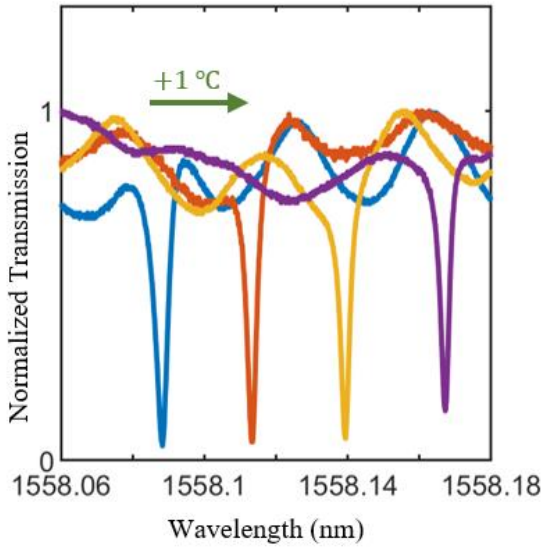

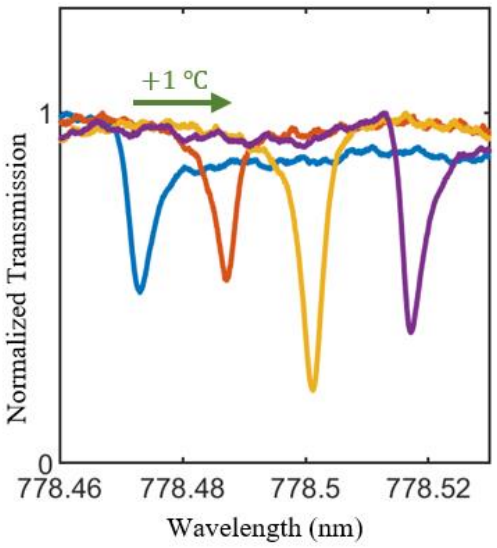

	TO	EO
IR	26 pm/°C	5.1 pm/V
visible	11 pm/°C	2.0 pm/V

Tuning Second Harmonic Generation

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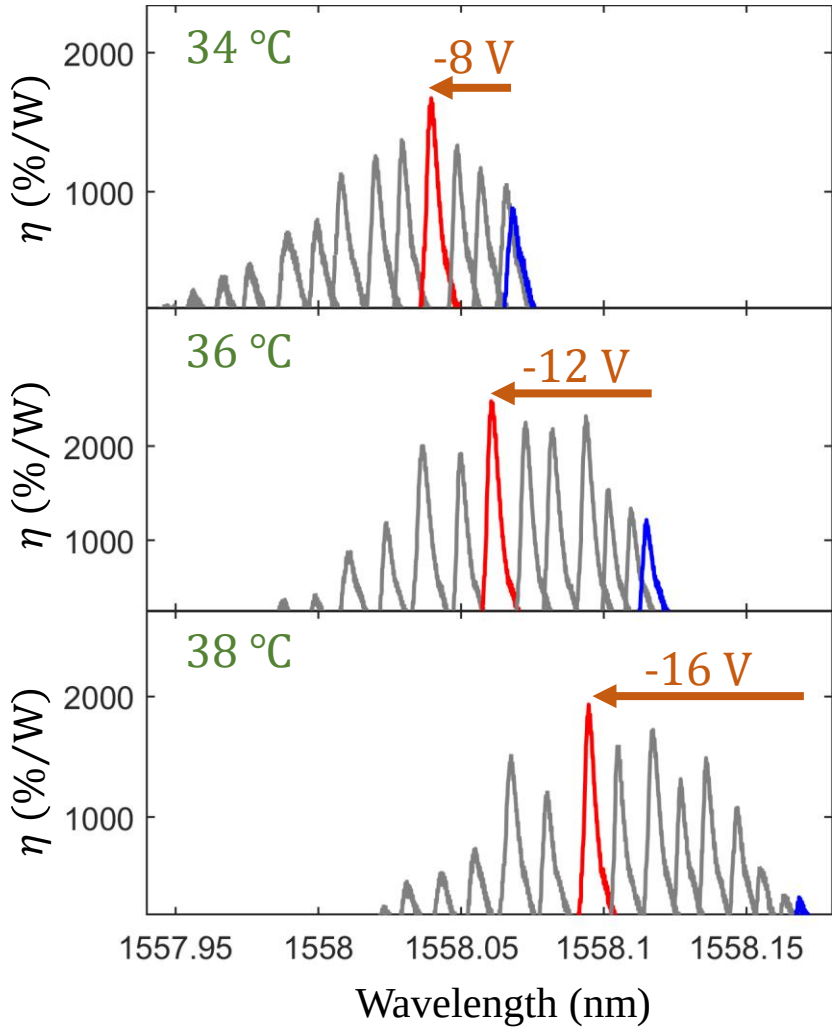

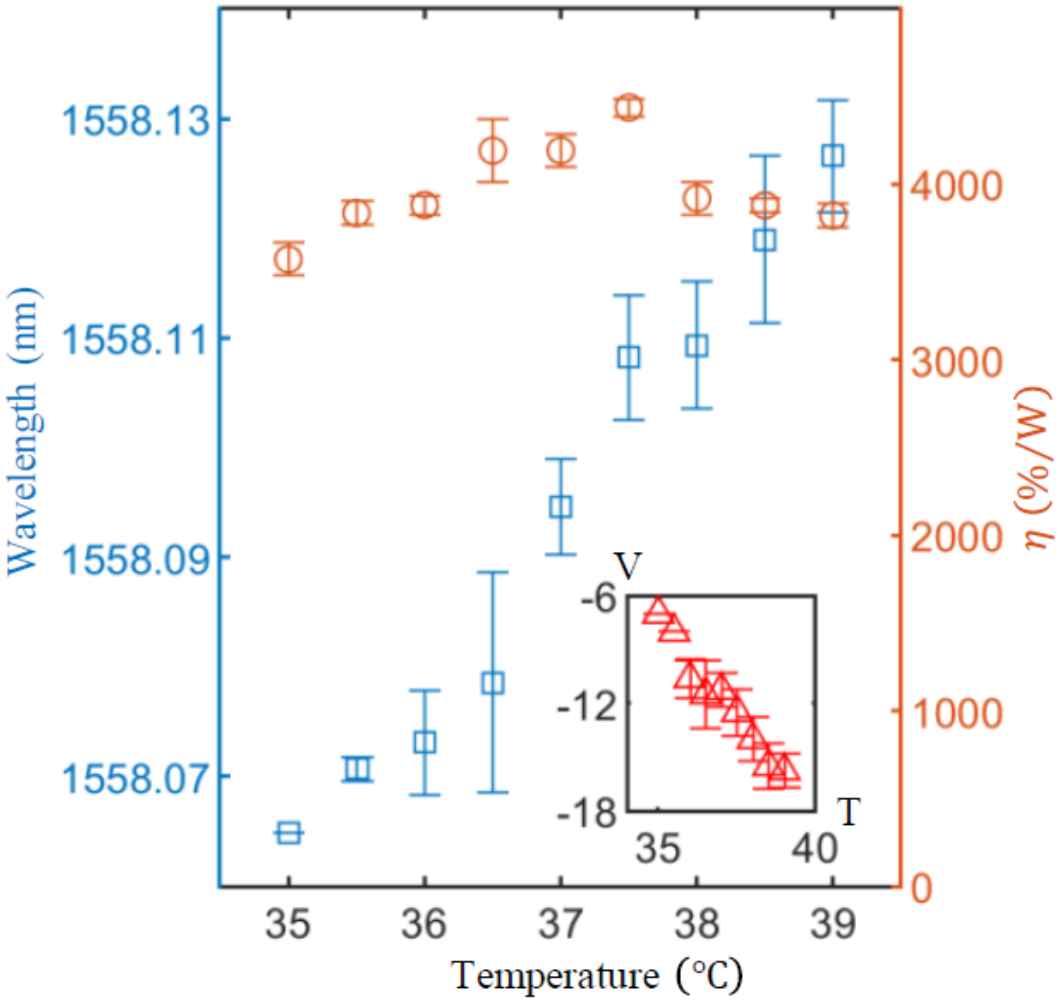

Multiple Resonator Alignment

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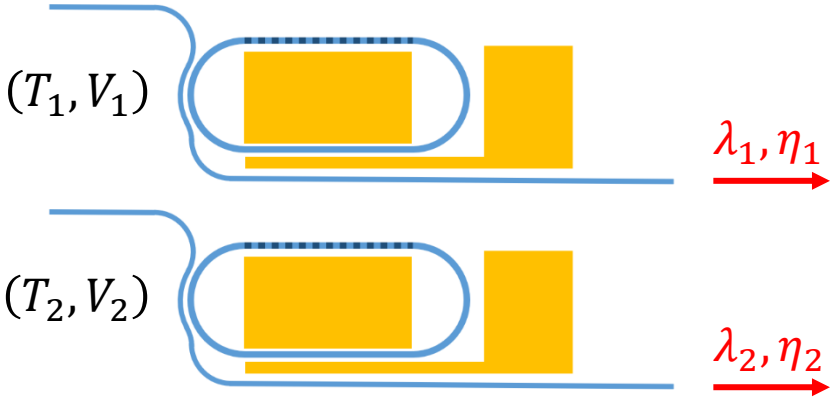
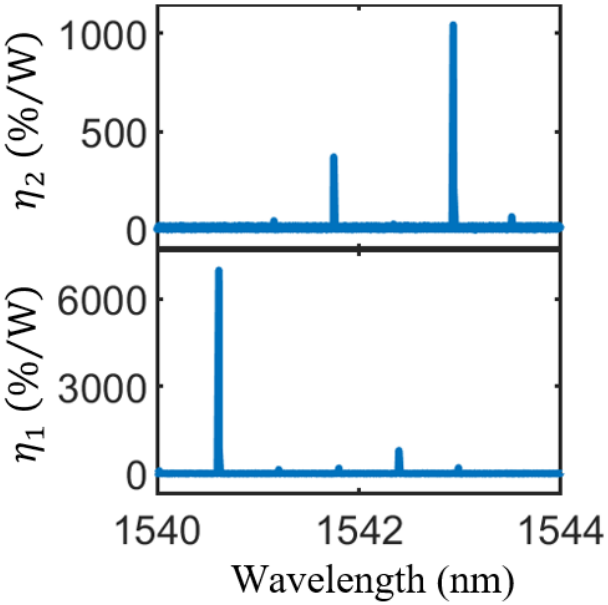


Alignment condition:

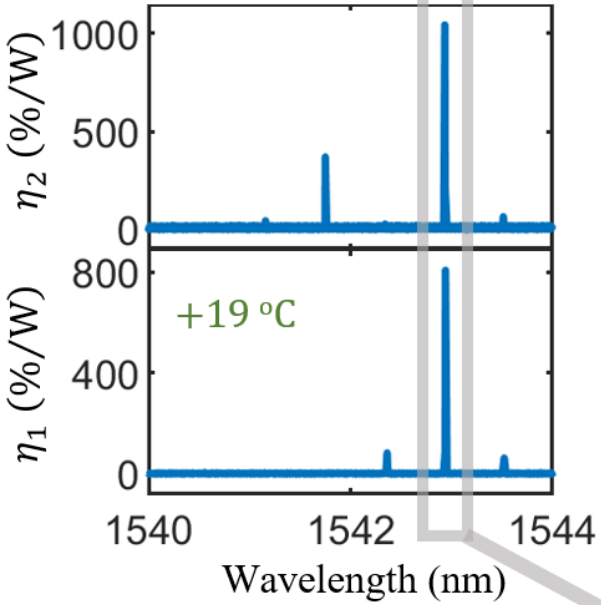
$\lambda_1 = \lambda_2$

$\max(\eta_1)$, $\max(\eta_2)$

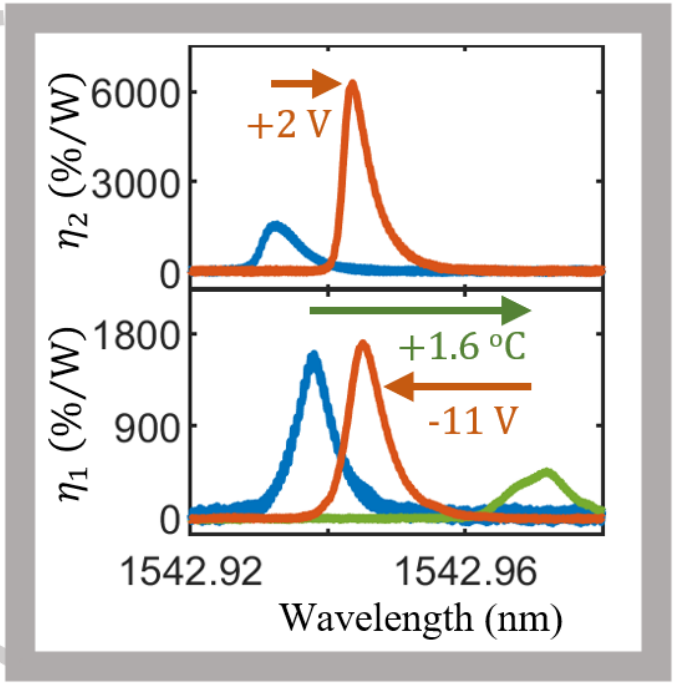
Initial Resonances



Broad Tuning



Fine Tuning




THANK YOU
hvala
danke
謝謝
どうも
ありがとう
gracias
merci
MERSI
takk
DANK U
köszi
danke schön
obrigado
OBRIGADO
ARIGATO
MOLTE GRAZIE
GO RAIBH MAITH AGAT
TEŞEKKÜR EDERIM
PALDIES
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