# Complications in Modeling Open Systems: The Case of Single-Photon Emission in Photonic Crystal Waveguides

Jakob Rosenkrantz de Lasson, Bruno Rigal, Eli Kapon, Jesper Mørk and Niels Gregersen

Technical University of Denmark

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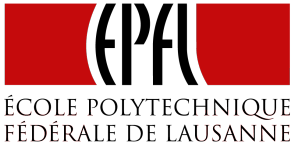
DTU Fotonik
Department of Photonics Engineering



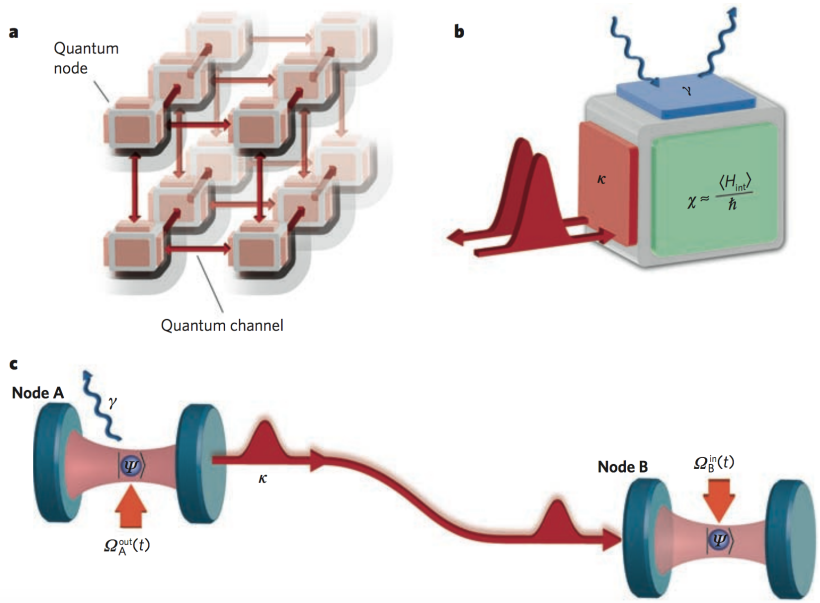
# The Quantum Internet

NATURE|Vol 453|19 June 2008|doi:10.1038/nature07127 INSIGHT REVIEW

## The quantum internet

H. J. Kimble[1]

**Quantum networks provide opportunities and challenges across a range of intellectual and technical frontiers, including quantum computation, communication and metrology. The realization of quantum networks composed of many nodes and channels requires new scientific capabilities for generating and characterizing quantum coherence and entanglement. Fundamental to this endeavour are quantum interconnects, which convert quantum states from one physical system to those of another in a reversible manner. Such quantum connectivity in networks can be achieved by the optical interactions of single photons and atoms, allowing the distribution of entanglement across the network and the teleportation of quantum states between nodes.**



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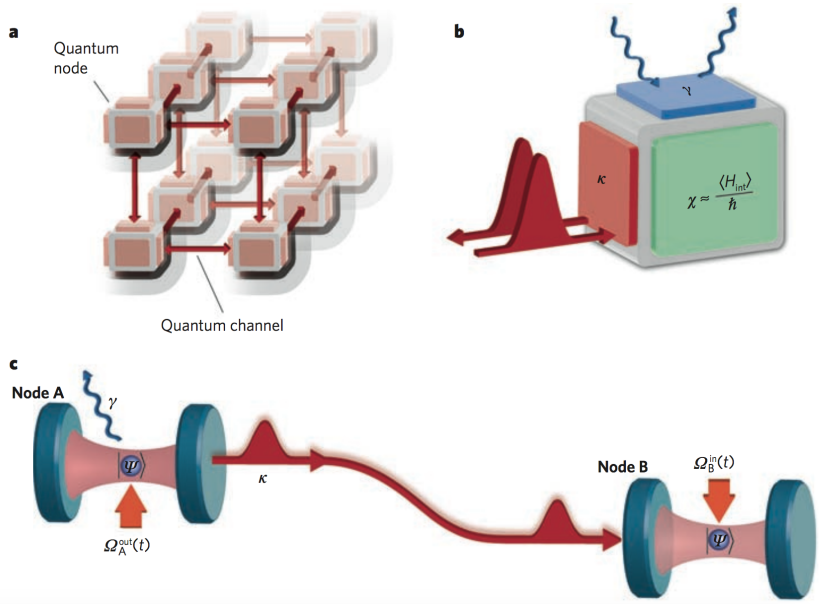
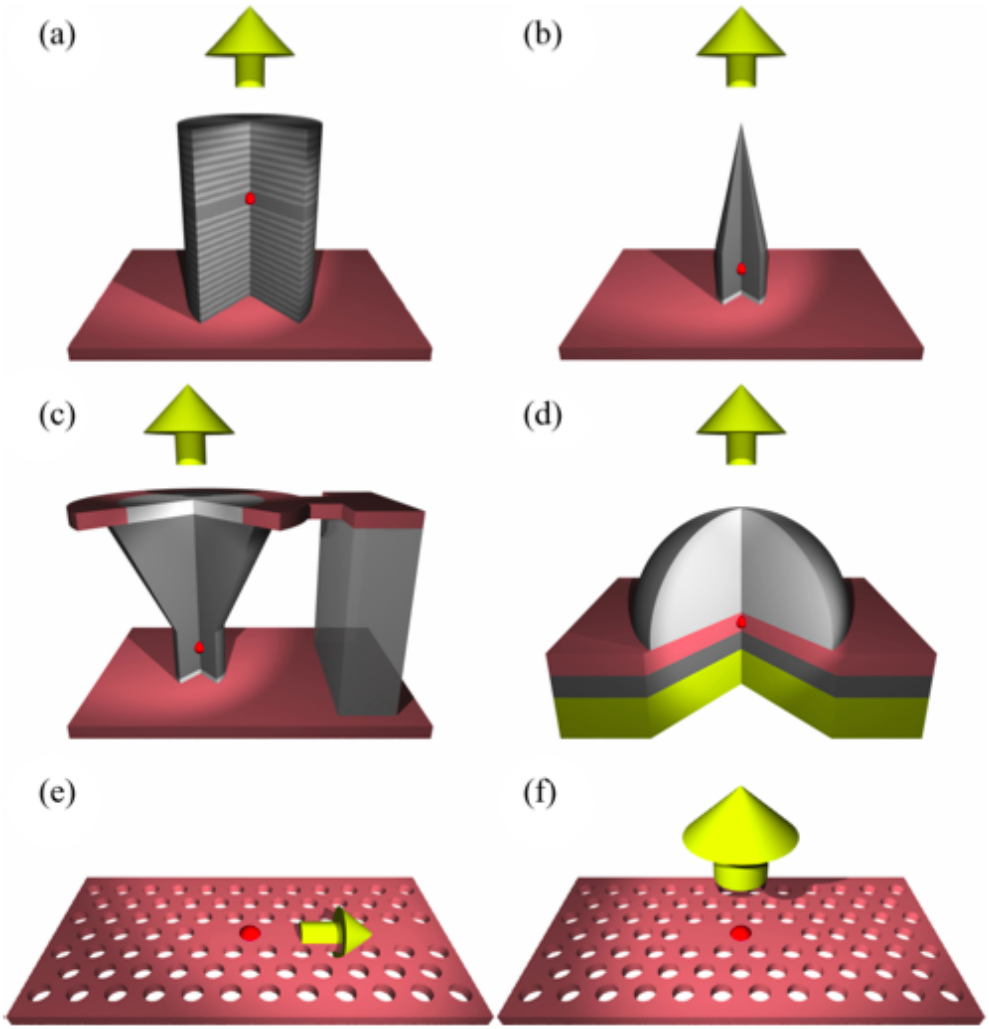


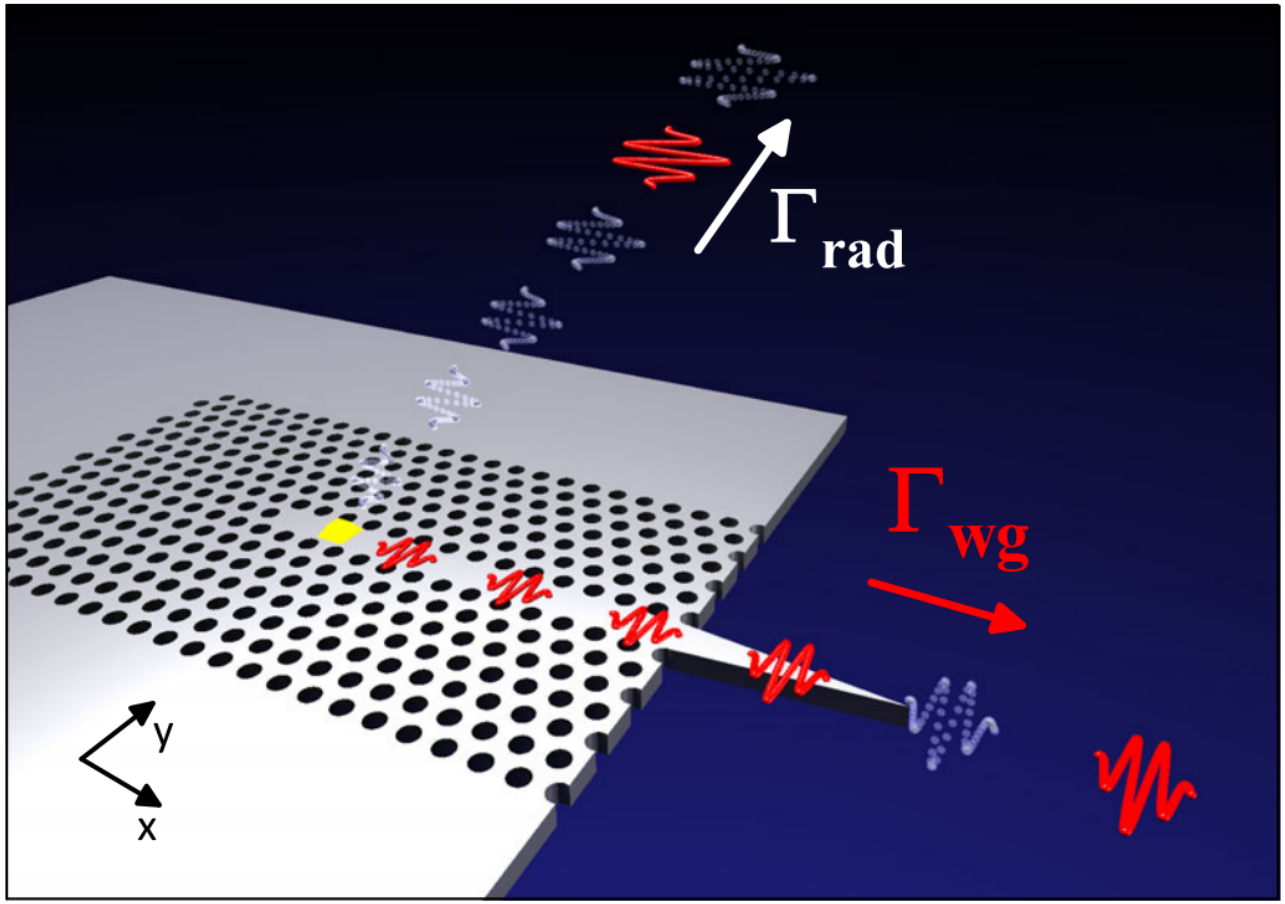

Need for deterministic single-photon sources

# Proposed Single-Photon Designs




[N. Gregersen *et al.*, IEEE J. Sel. Top. Quantum Electron. **19**, 9000516 (2013)]

# Guided vs. Radiation Modes – SE $\beta$ Factor




[M. Arcari *et al.*, PRL **113**, 093603 (2014)]

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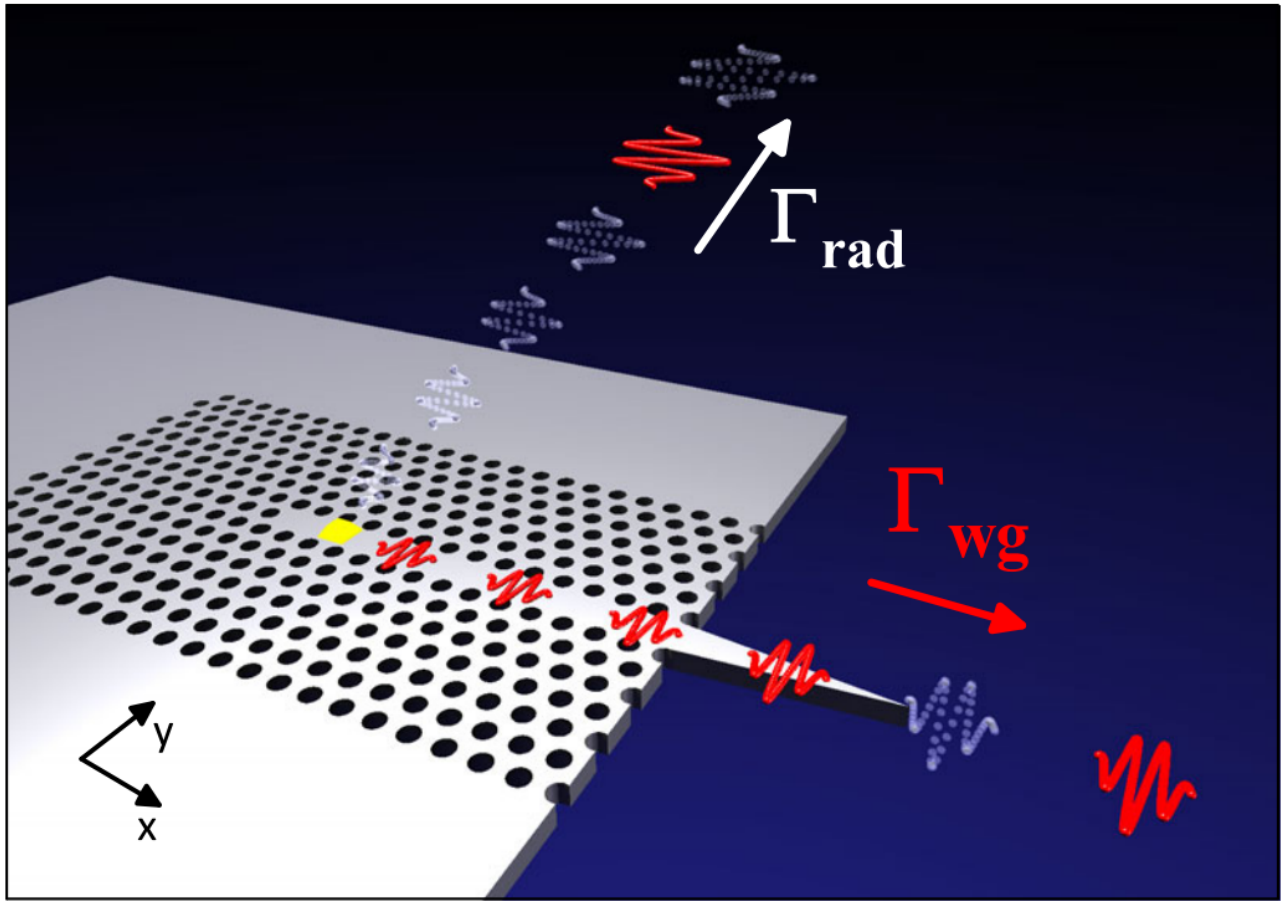


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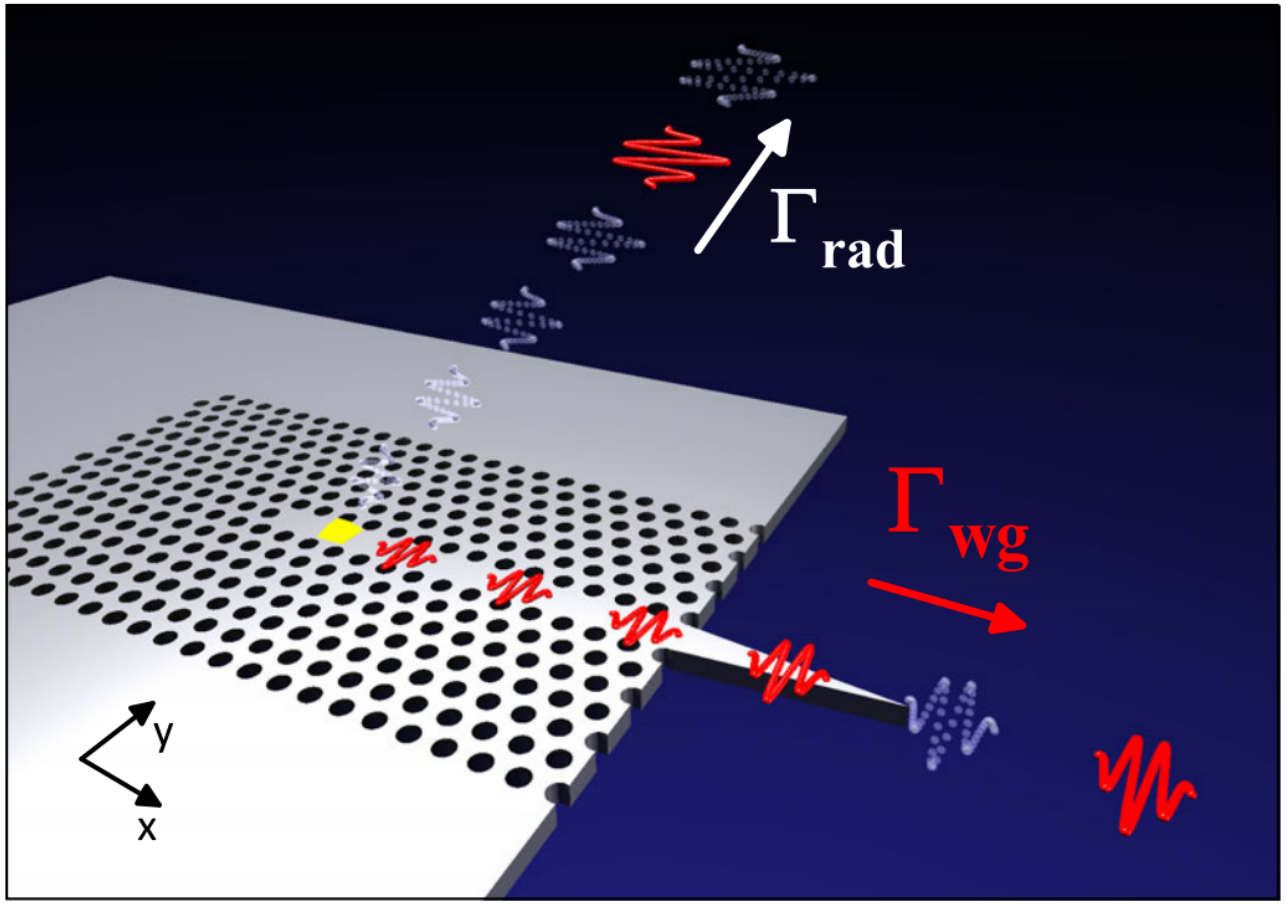


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$$F_{\mathrm{P}} \equiv \frac{\Gamma_{\mathrm{Guide}}}{\Gamma_{\mathrm{Bulk}}} = \frac{3}{4\pi^2}\left(\frac{\lambda_0}{n}\right)^3 \frac{Q}{V_{\mathrm{eff}}(\mathbf{r}_{\mathrm{QD}})}$$

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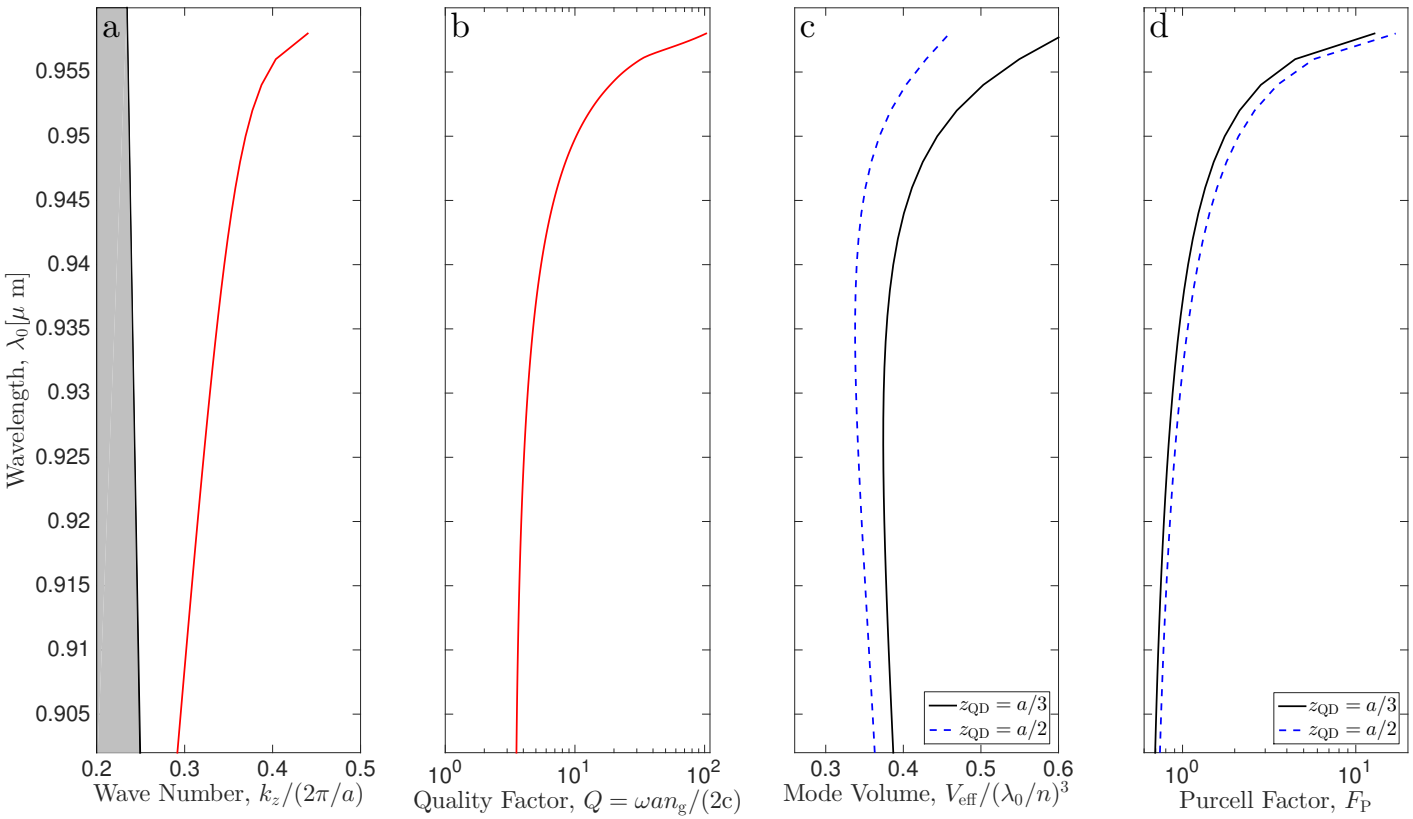


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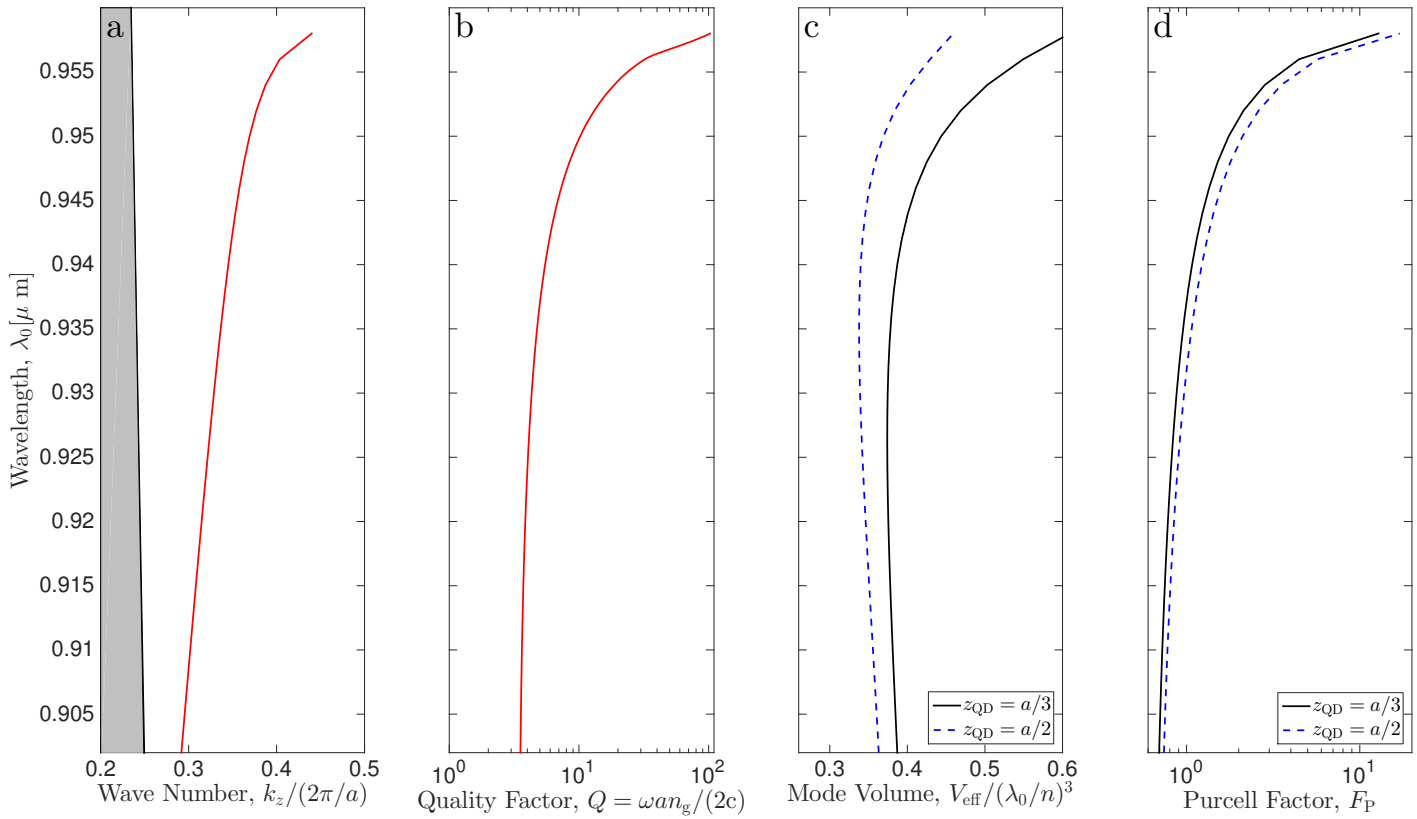


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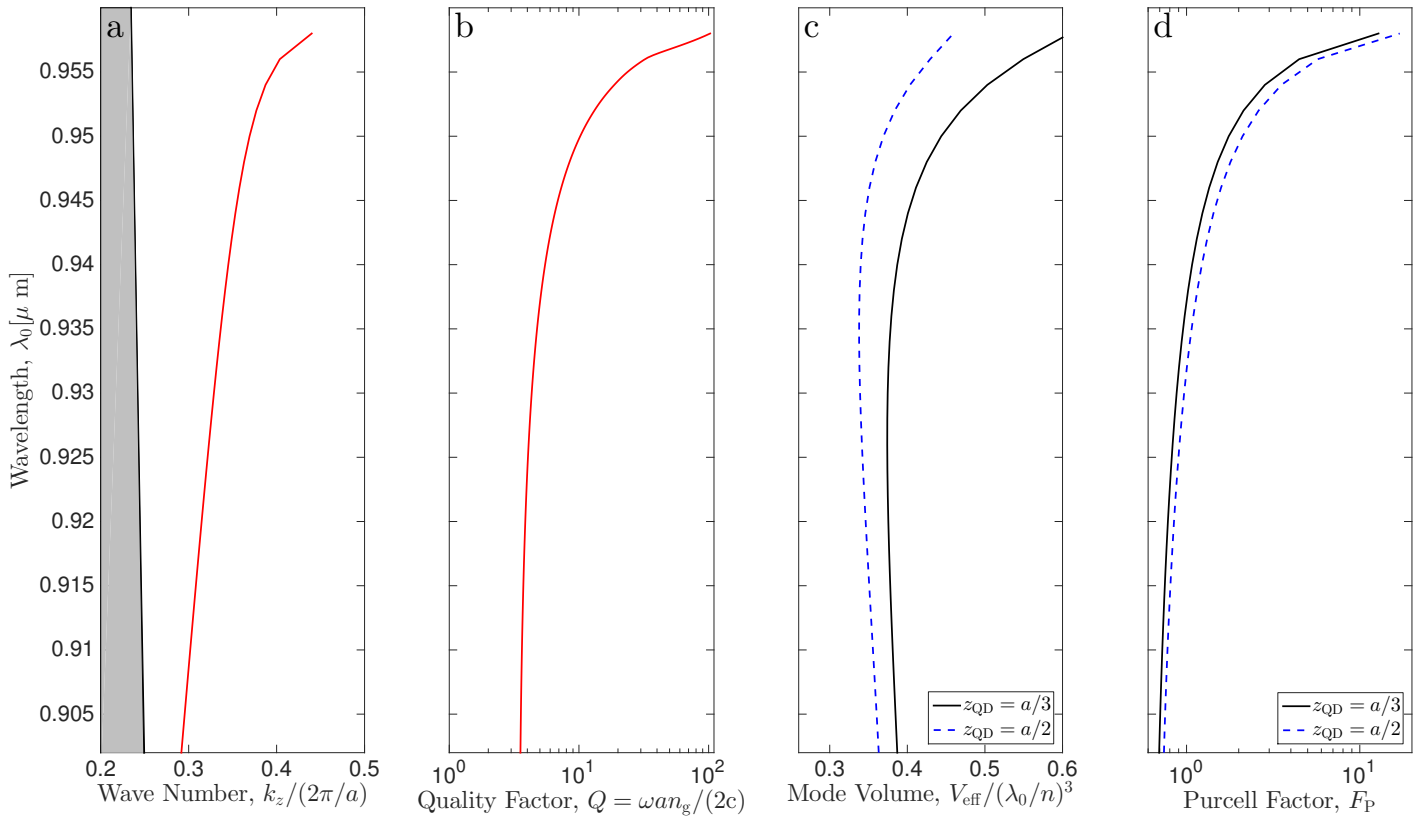


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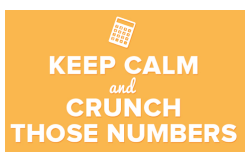

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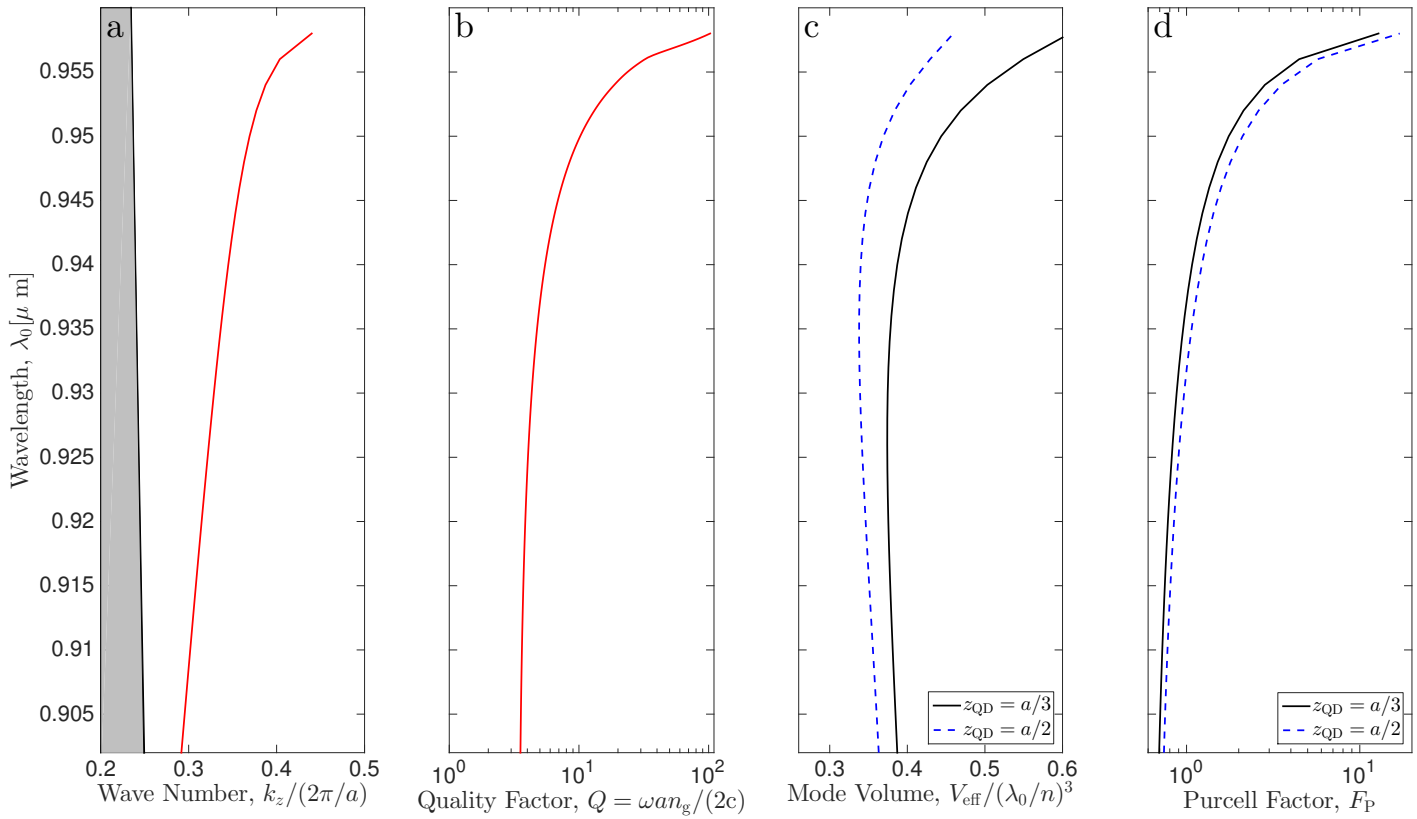


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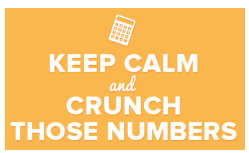


$= \text{Number}$

# Benchmark Against "State of the Art Methods"

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## Theoretical and computational concepts for periodic optical waveguides

**G. Lecamp, J. P. Hugonin and P. Lalanne***

*Laboratoire Charles Fabry de l'Institut d'Optique, CNRS, Univ Paris-Sud, Campus Polytechnique, RD 128 91127 Palaiseau Cedex, France.*

**Corresponding author :philippe.lalanne@institutoptique.fr*

#80752 - $15.00 USD Received 6 Mar 2007; revised 16 May 2007; accepted 16 May 2007; published 20 Aug 2007





PRL **99,** 023902 (2007) PHYSICAL REVIEW LETTERS week ending 13 JULY 2007

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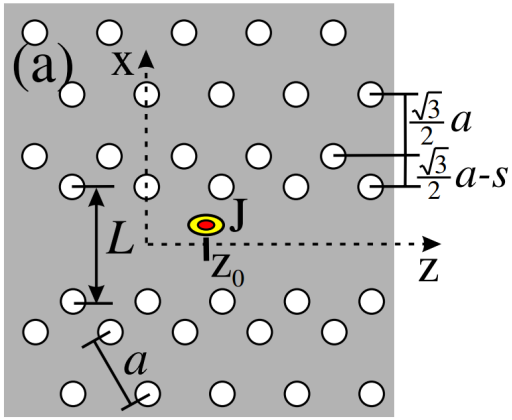


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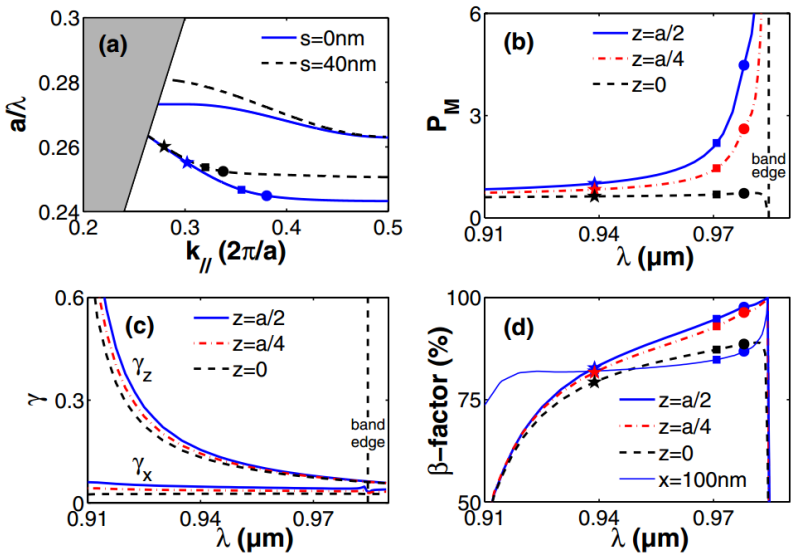

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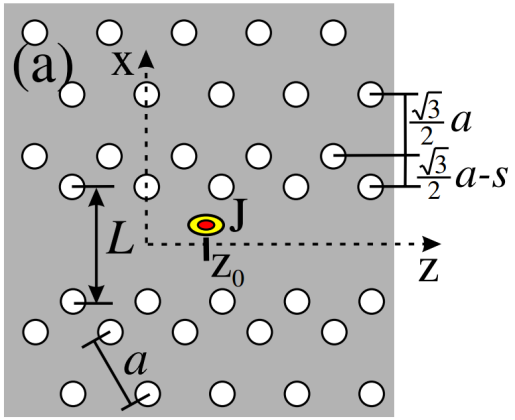


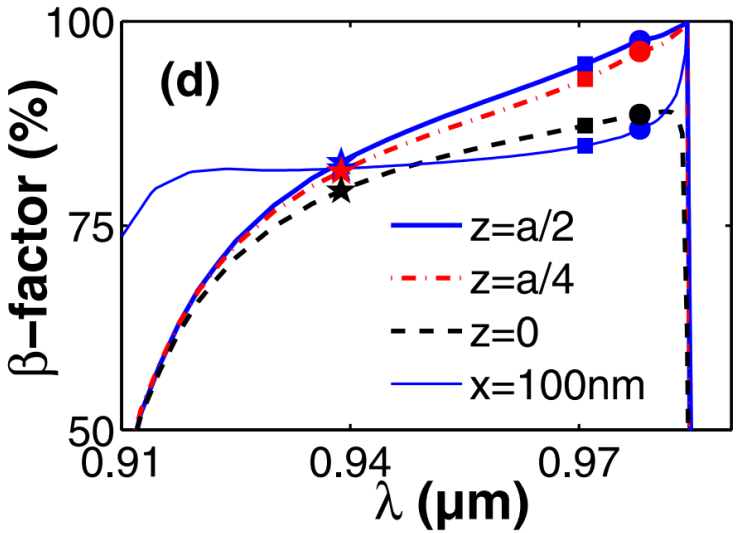

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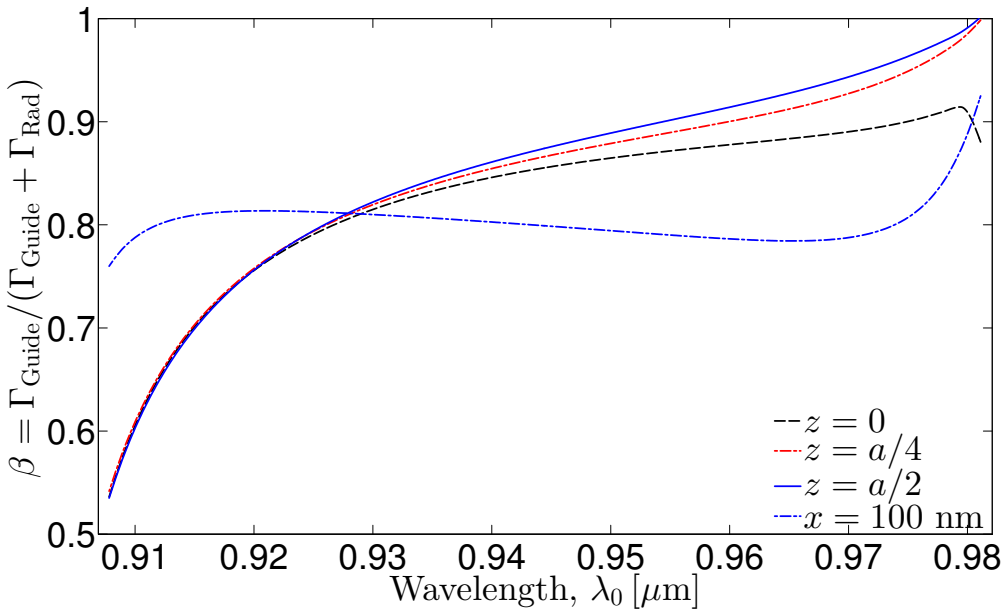
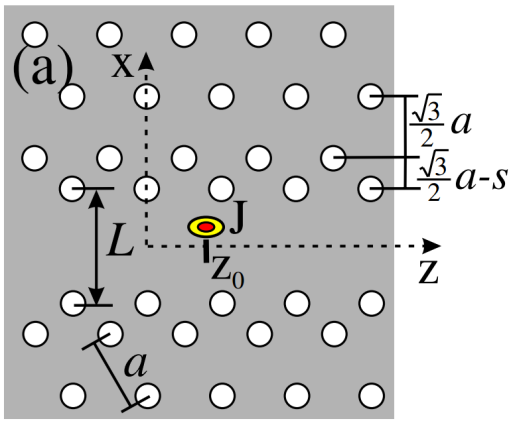
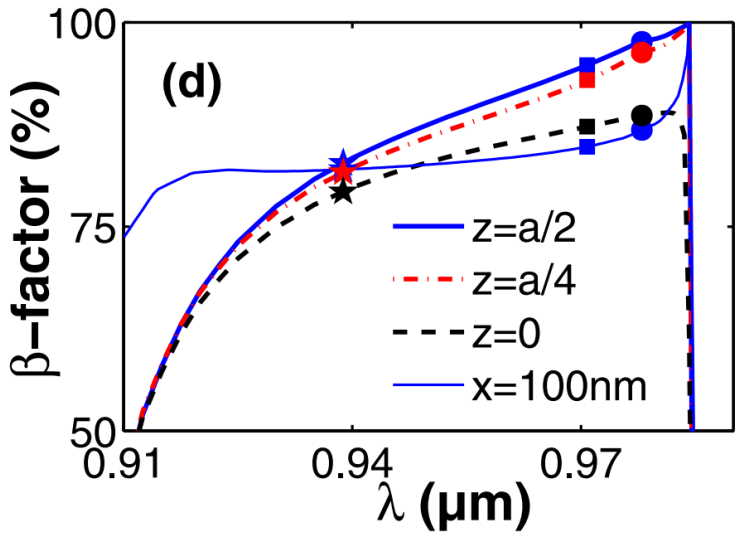
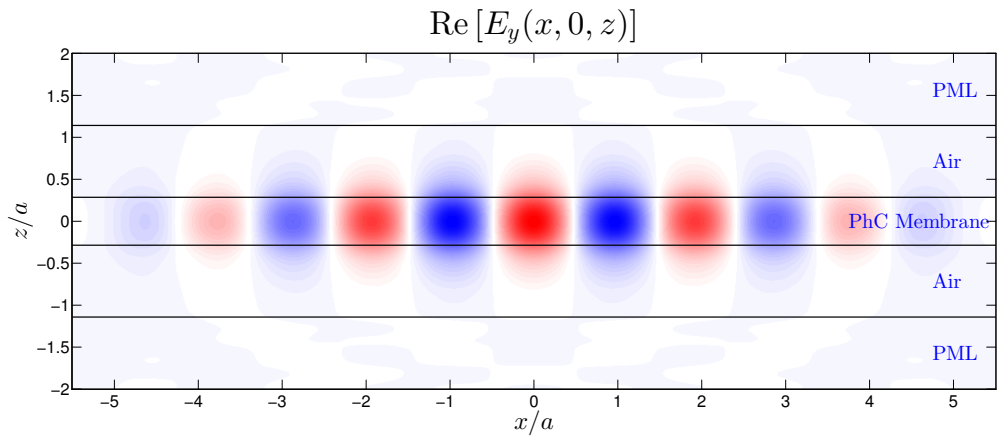


# SE $\beta$ Spectra: Dependence on Air Height and PML



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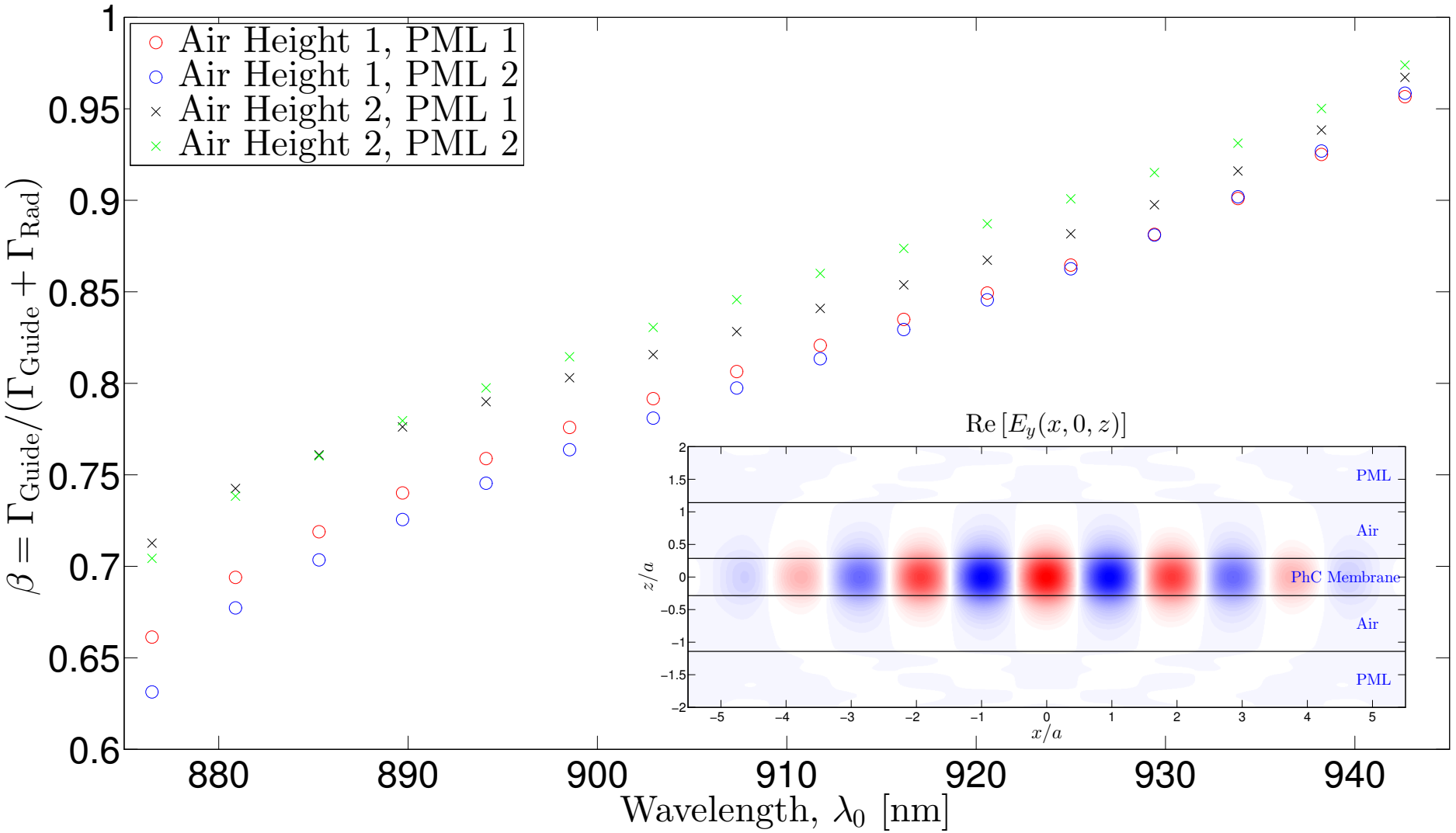

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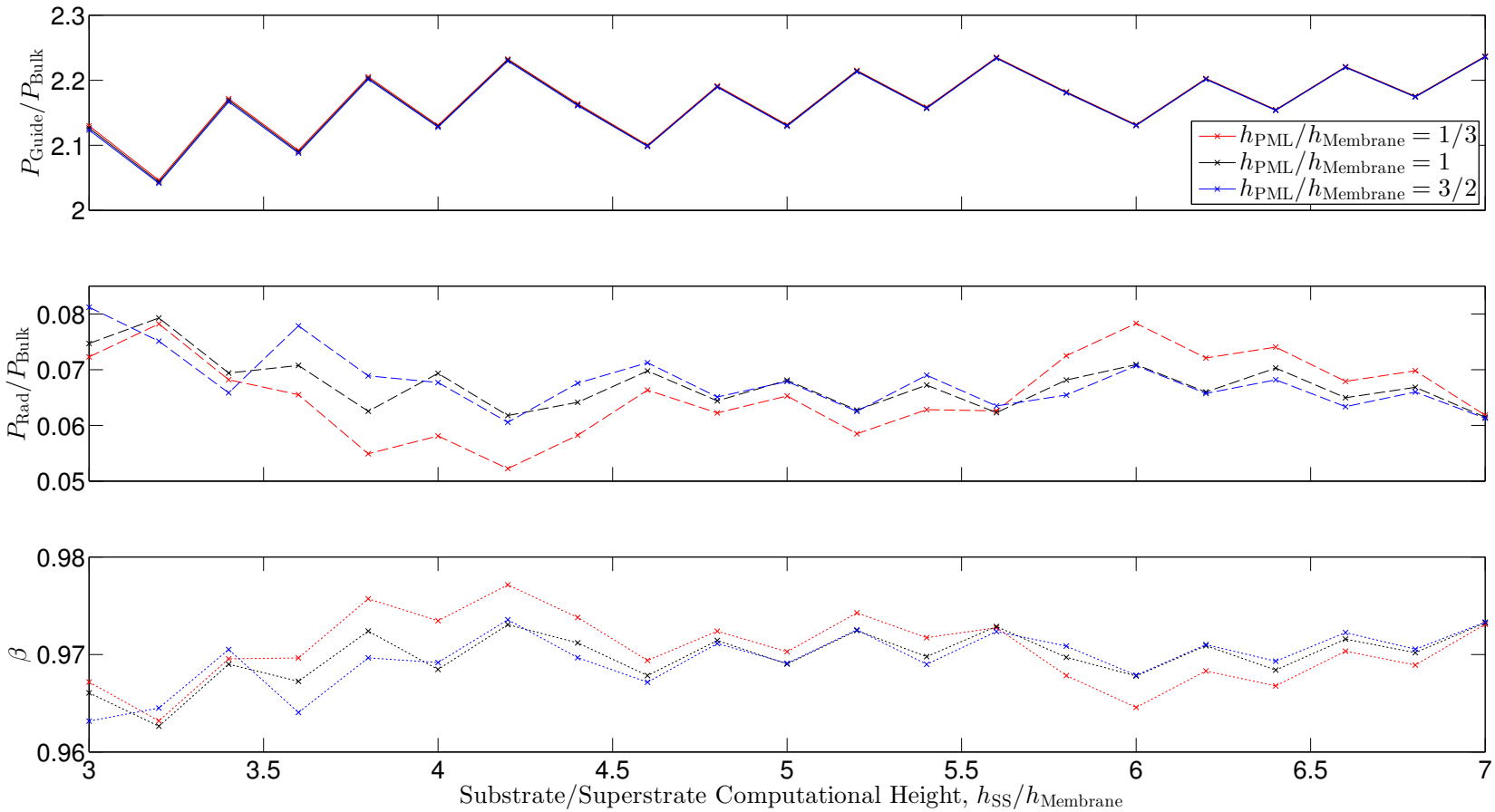

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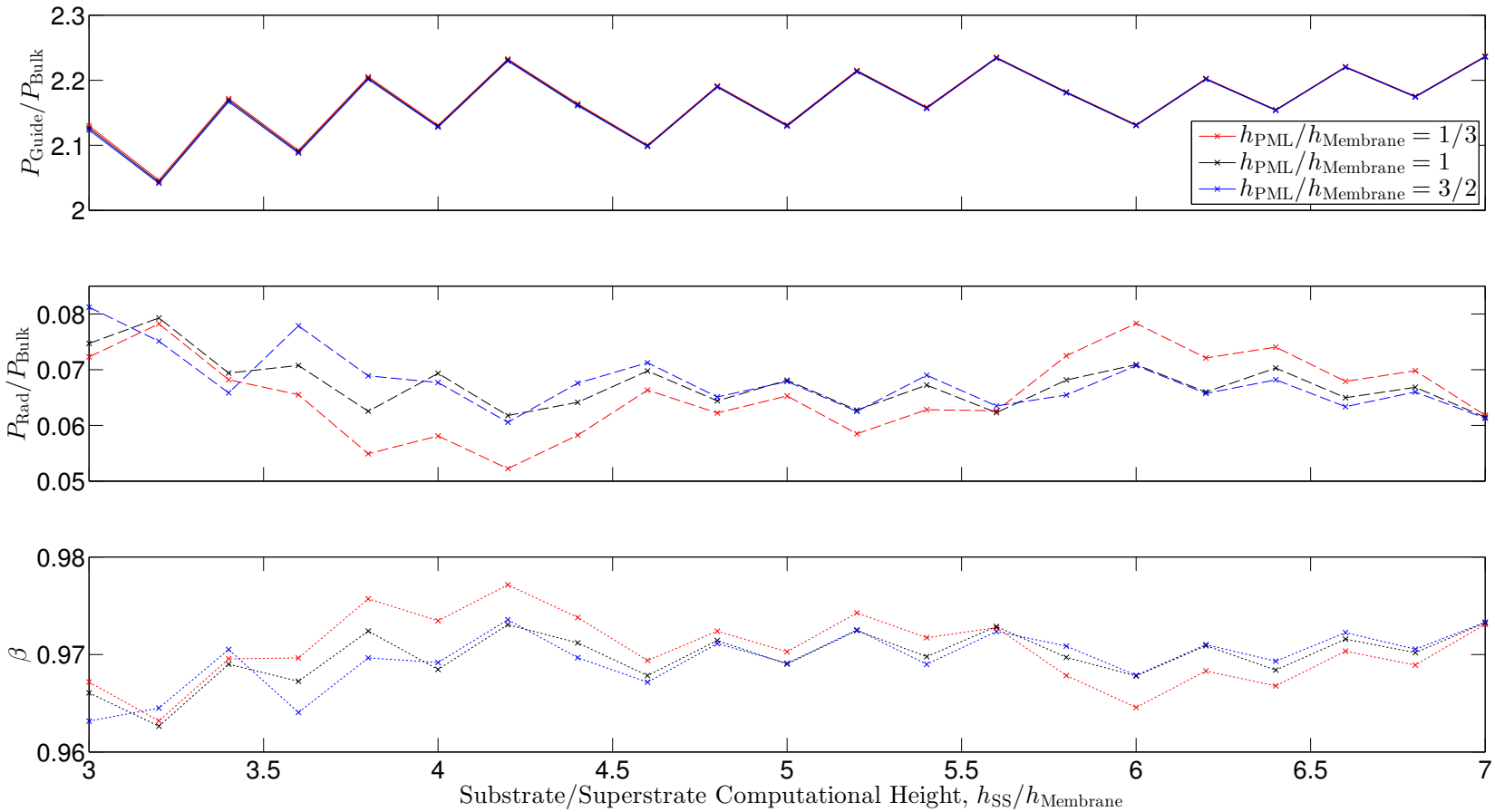
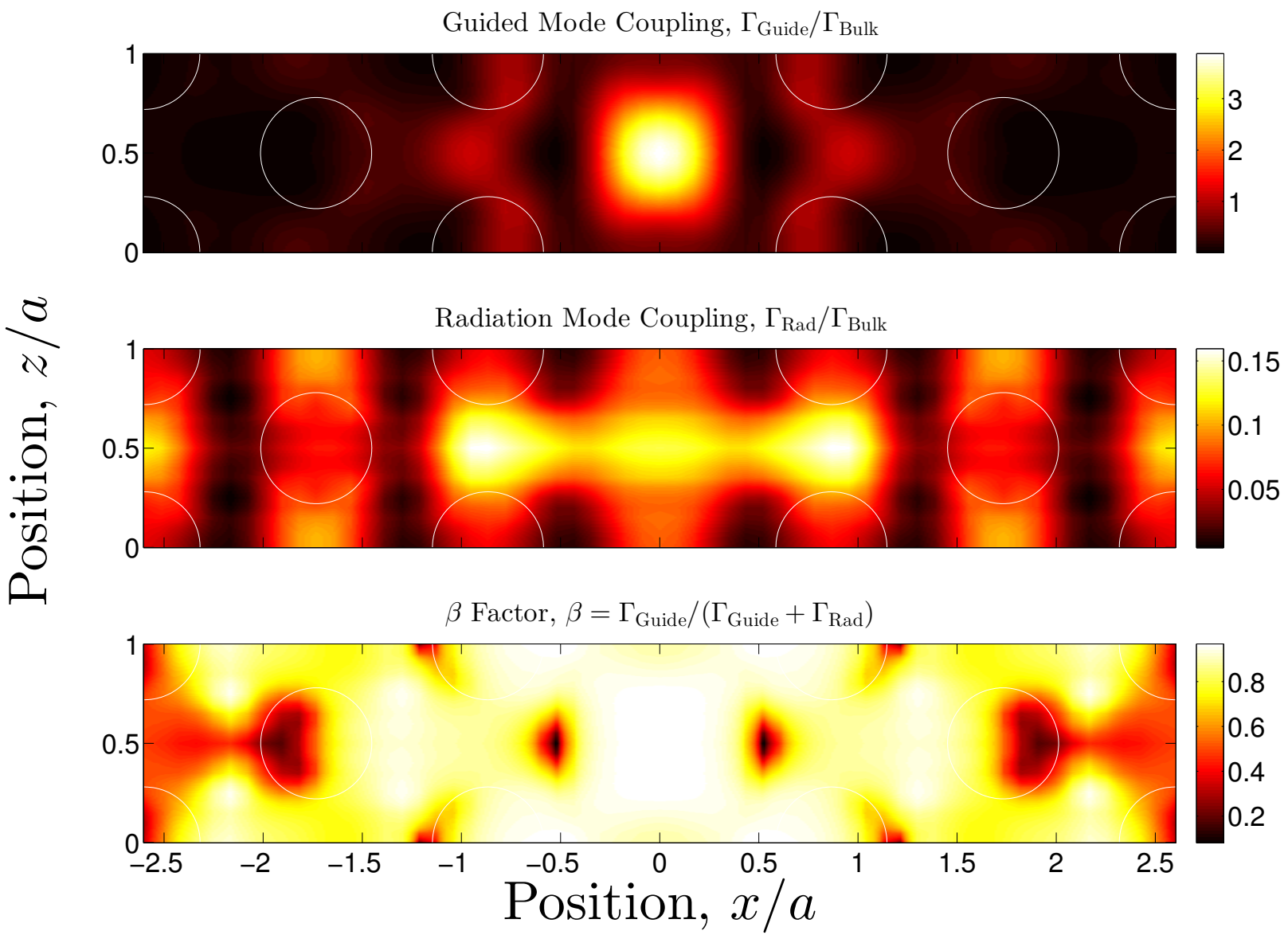



$$\delta P_{\mathrm{Guide}} \sim 5\% \qquad \delta P_{\mathrm{Rad}} \sim 20\% \qquad \delta\beta \sim 1\%$$

# Slow Light: Spatial Dipole Emission Maps




$$h_{\mathrm{SS}}/h_{\mathrm{Membrane}} = 4.2$$

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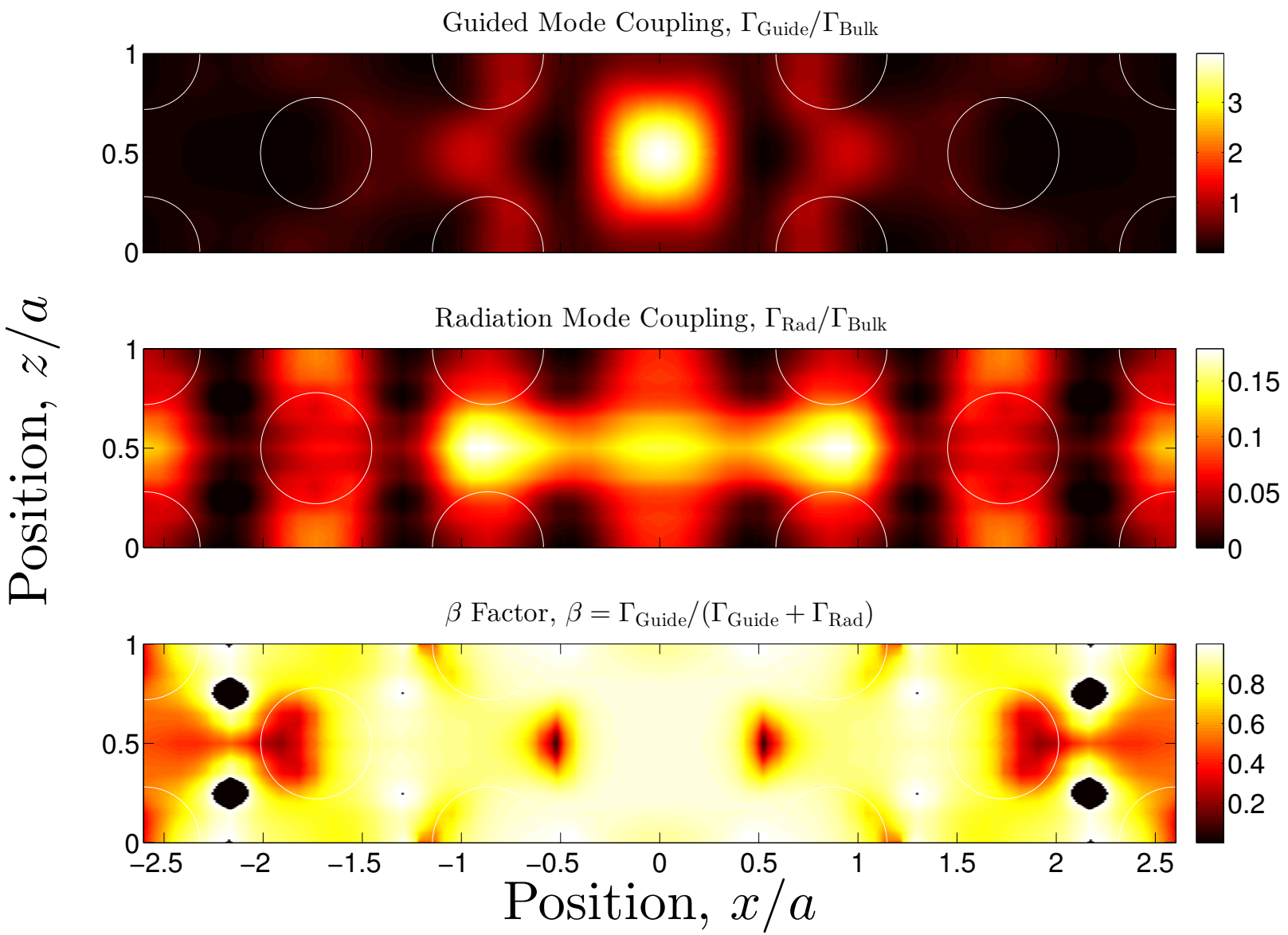


$$h_{\mathrm{SS}}/h_{\mathrm{Membrane}} = 3$$

# Different (Better?) Approach: Open Geometry



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Brahim Guizal



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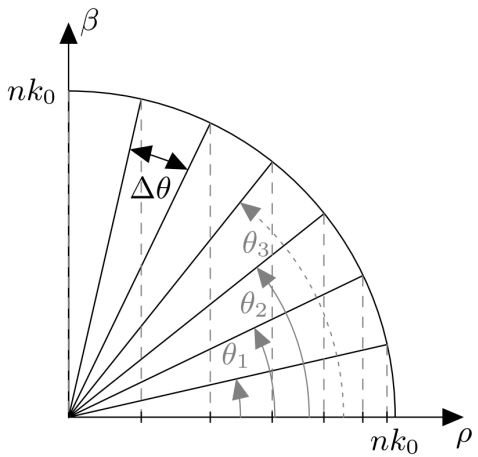


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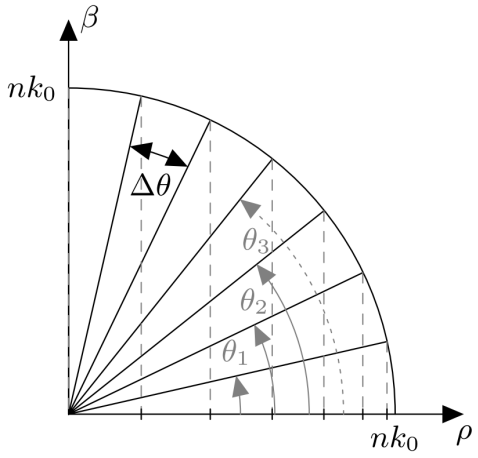


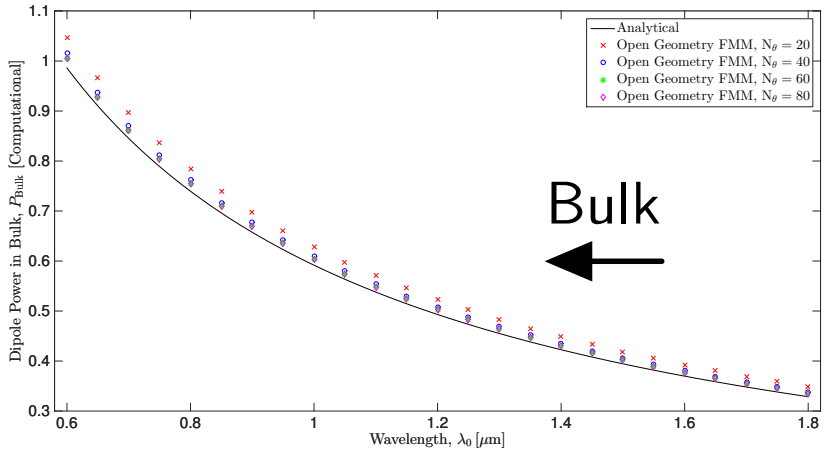


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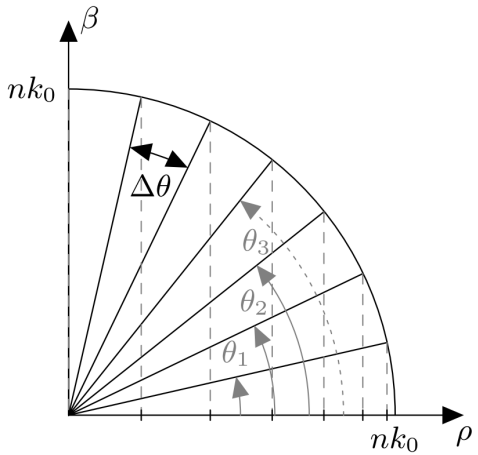


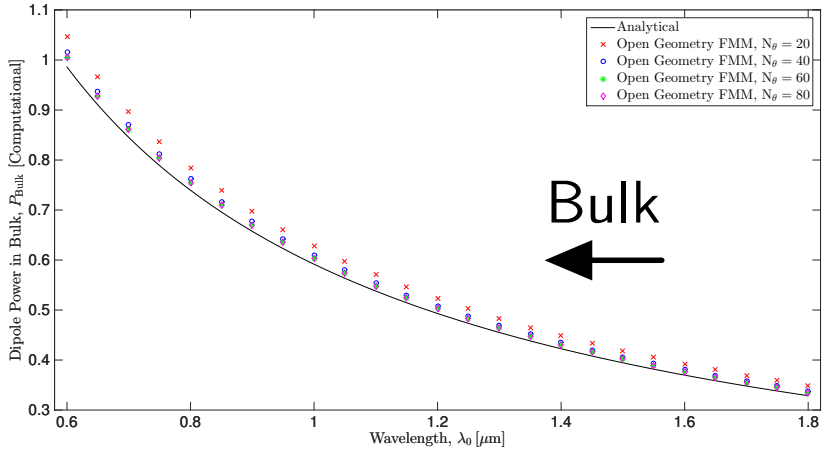


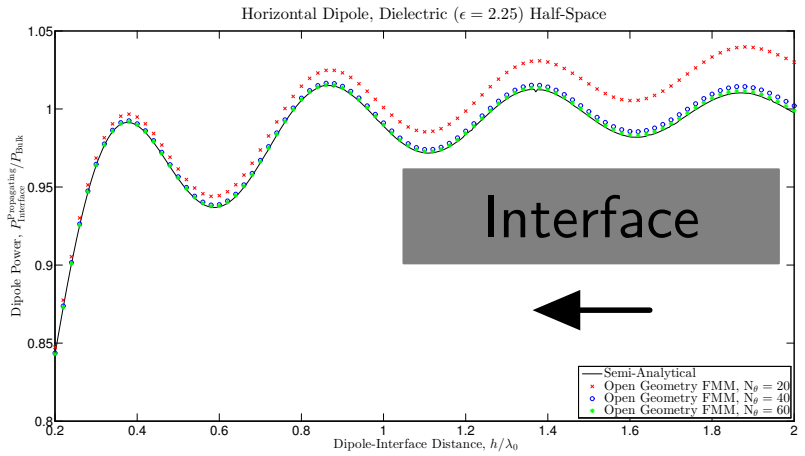


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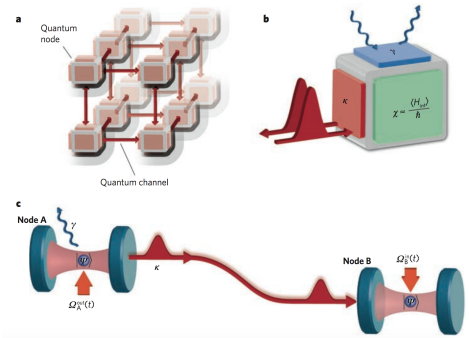
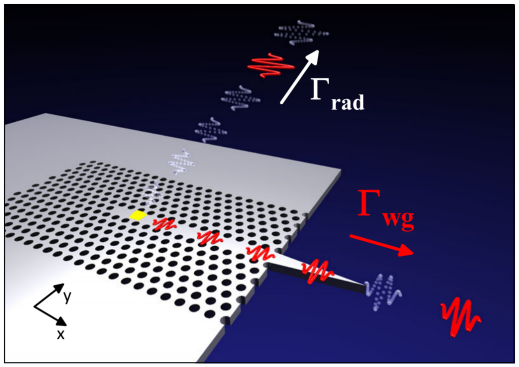
# Conclusions

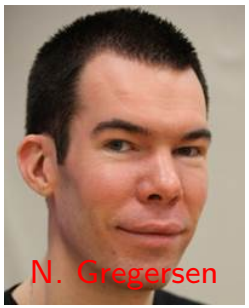
## (I) Single-Photon Sources with In-Plane Emission



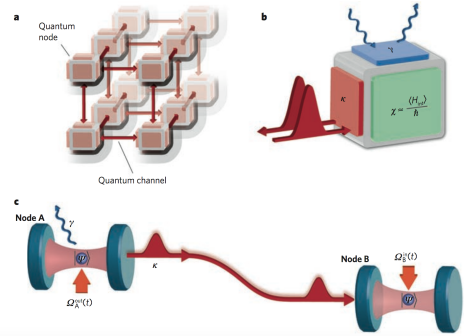


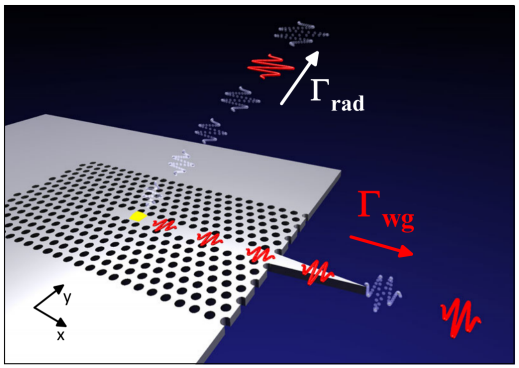




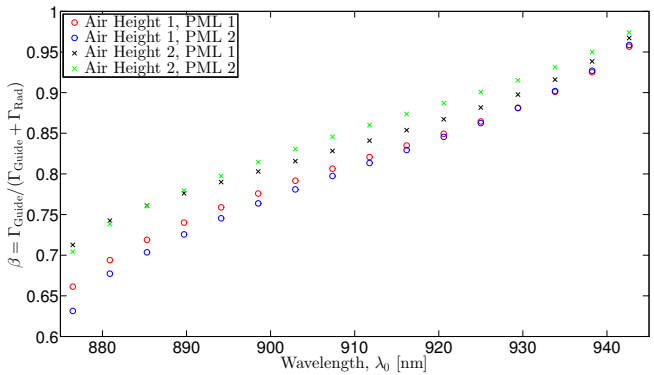
# Conclusions

## (I) Single-Photon Sources with In-Plane Emission



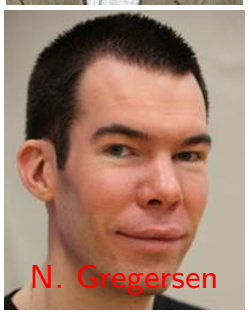




## (II) SE $\beta$ Factor Convergence Issues



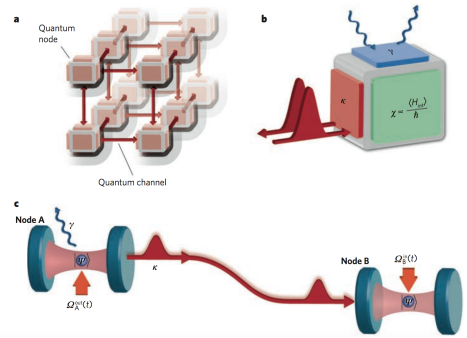


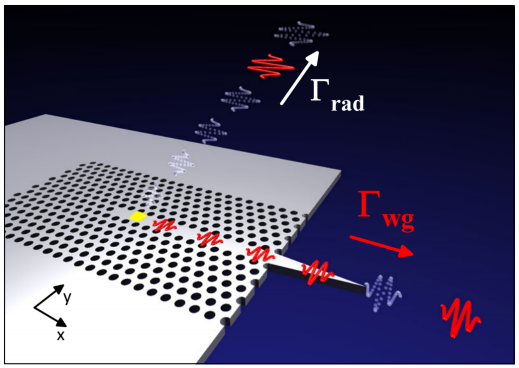




# Conclusions

## (I) Single-Photon Sources with In-Plane Emission

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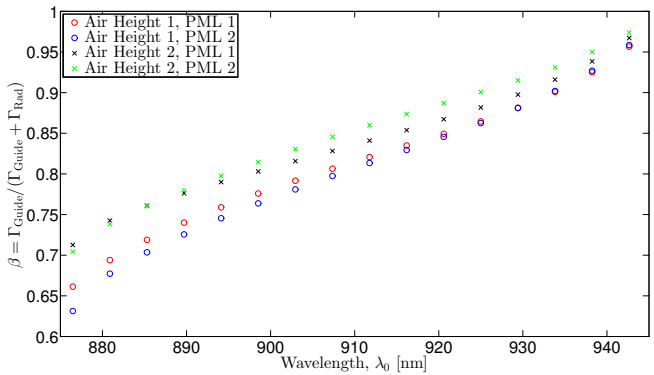


## (III) Open Geometry Approach