Colloquium

Microwave to optical quantum transduction and optical frequency combs: Nonlinear optics in ultra-high quality resonators

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Host: Johannes Fink

Legend has it that the ring of power was forged at Mount Doom Middle Earth (New Zealand). I will show how we strive to harness the power of light bound in crystalline ring resonators [1] realising optical frequency combs and connecting future quantum computers to quantum networks. The magic lies in the nonlinear interaction of matter with the light. Strong nonlinear interactions require high optical fields. One of the most successful platforms for harvesting strong nonlinear interactions with continuous wave pumping fields are optical resonators. Large optical fields require long confinement times and small mode volumes. A particular successful system for nonlinear interactions is that of a whispering gallery mode (WGM) resonator. In such a resonator type the light is confined within a dielectric by total internal reflection at its circular dielectric boundary. The confinement by total internal reflection allows modes to exist throughout the transparency region of the material. This broadband confinement combined with the tight guiding of the modes at the rim of the resonator is ideal for nonlinear interaction between different frequency domains or for resonantly enhanced lasing feedback. In this talk I will present our recent results of optical frequency combs [2] and dual frequency combs [3] and show how this geometry has been used for microwave to optical transduction [46] and propose a few new design ideas of how to achieve quantum transduction. 1. I. Breunig, "Three-wave mixing in whispering gallery resonators," Laser Photonics Rev. 10, 569---587 (2016).2. A. Rueda, F. Sedlmeir, M. Kumari, G. Leuchs, and H. G. L. Schwefel, "Resonant electro-optic frequency comb," Nature 568, 378--381 (2019).3. N. J. Lambert, L. S. Trainor, and H. G. L. Schwefel, "Microresonator-based electro-optic dual frequency comb," Commun. Phys. 6, 18 (2023).4. A. Rueda, F. Sedlmeir, M. C. Collodo, U. Vogl, B. Stiller, G. Schunk, D. V. Strekalov, C. Marquardt, J. M. Fink, O. Painter, G. Leuchs, and H. G. L. Schwefel, "Efficient microwave to optical photon conversion: an electro-optical realization," Optica 3, 597604 (2016).5. W. Hease, A. Rueda, R. Sahu, M. Wulf, G. Arnold, H. G. L. Schwefel, and J. M. Fink, "Bidirectional Electro-Optic Wavelength Conversion in the Quantum Ground State," PRX Quantum 1, 020315 (2020).6. N. J. Lambert, A. Rueda, F. Sedlmeir, and H. G. L. Schwefel, "Coherent Conversion Between Microwave and Optical PhotonsAn Overview of Physical Implementations," Adv. Quantum Technol. 3, 1900077 (2020).

Tuesday, June 17, 2025 11:00am - 12:00pm

Office Bldg West / Ground floor / Heinzel Seminar Room (I21.EG.101)

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