INRiM Seminar

From Optomechanical Sensing to Nonlinear Frequency Conversion: Engineering Light on Chip

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Abstract

Recent advances in integrated photonics and optomechanics are enabling unprecedented control over light-matter interactions, opening new pathways for sensing and nonlinear frequency conversion on chip-scale platforms. In this seminar, I will present an overview of two distinct lines of research that both make use of high-quality photonic and optomechanical resonators. First, I will discuss optomechanical resonators for ultra-sensitive mass detection, highlighting the real-time measurement of single nanoparticle and nanodroplet dynamics [1,2]. By exploiting multimode optomechanical coupling, these systems achieve millisecond time-resolution and enable the precise tracking of mass changes at the nanoscale, providing new insights into processes such as evaporation and particle adsorption. I will then focus on nonlinear integrated platforms for broadband and frequency-agile light generation. On one hand, aluminum nitride (AlN) waveguides provide a unique platform where both intrinsic second- and third-order nonlinearities ($\chi(2)$ and $\chi(3)$) coexist, enabling multi-octave supercontinuum generation with prospects for fully integrated f-to-2f interferometry [3]. On the other hand, silicon nitride (SiN), traditionally limited to $\chi(3)$, can exhibit an induced effective $\chi(2)$, allowing reconfigurable nonlinear interactions and access to otherwise challenging spectral regions [4]. Although these research directions address distinct physical systems and applications, they share a common underlying approach: the engineering of light-matter interactions at the micro- and nanoscale to enhance performance beyond conventional limits. By tailoring optical confinement, modal structure, and nonlinear coupling mechanisms, it becomes possible to boost sensitivity in optomechanical sensing and to extend the spectral reach and efficiency of nonlinear frequency conversion.

1. S. Sbarra, L. Waquier, S. Suffit, A. Lemaître, and I. Favero, "Optomechanical measurement of single nanodroplet evaporation with millisecond time-resolution," Nat. Commun. 13, 1-7 (2022).

2. S. Sbarra, L. Waquier, S. Suffit, A. Lemaître, and I. Favero, "Multimode Optomechanical Weighting of a Single Nanoparticle," Nano Lett. 22, 710-715 (2022).

3. S. Sbarra, S. Brunetta, P. A. Demongodin, J.-F. Carlin, N. Grandjean, R. Butté, and C.-S. Brès, "Three-octave supercontinuum generation in thick crystalline aluminum nitride waveguides," Opt. Lett. 50, 7147 (2025).

4. S. Sbarra, J. Zhou, B. Zabelich, M. Clementi, C. Lafforgue, O. Yakar, J. Liu, T. J. Kippenberg, and C.-S. Brès, "Reconfigurable Resonant Multimode Nonlinear Coupling for UV-to-infrared Frequency Generation," arXiv (2026)

Date: 25/05/2026 **At: 11:00 AM**

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