# THE PHYSICS COLLOQUIUM

Thursday 26 November 2026, 4:00 p.m.
Nijenborgh 4, Lecture Hall **5111.0080**

## Nanoengineered van der Waals nonlinear crystals for ultracompact classical and quantum photonics


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Nonlinear optics lies at the heart of classical and quantum light generation. Standard nonlinear crystals exhibit moderate second-order nonlinearities ($\chi(2)$ = 1-30 pm/V) but achieve high nonlinear conversion efficiencies due to their large thickness (millimeter/centimeter), limiting miniaturization.

Here we realize ultracompact nonlinear structures based on non-centrosymmetric van der Waals (i.e., layered) materials, e.g., 3R-MoS2, which exhibit high nonlinearity ($\chi(2)$~100-1000 pm/V) and easy system integration, making them highly promising for frequency conversion over ultrathin pathlengths [1], entangled photon pair generation [2], and efficiency scaling with thickness of nonlinear processes like second harmonic generation [3]. To achieve high efficiencies, we realize periodically-poled microscopic structures for quasi-phase matched up- and down-conversion [4], i.e., second harmonic generation and spontaneous parametric down-conversion for the generation of entangled-photon pairs [2,4], and nonlinear metasurfaces [5] for mode-matched nonlinear frequency conversion.

Finally, we exploit crystal-engineered 3R-MoS2 to tailor the nonlinear geometric phase, enabling direct generation and all-optical switching of nonlinear structured light [6].

Together, these approaches establish layered materials as a versatile, efficient, ultracompact and dynamically reconfigurable platform for integrated nonlinear and quantum photonics, enabling on-chip operations and novel functionalities over sub-wavelength pathlengths.


References
[1] C. Trovatello et al. "Tunable Optical Nonlinearities in Layered Materials" ACS Photonics 11, 2860-2873 (2024).
[2] M. A. Weissflog et al. “A tunable transition metal dichalcogenide entangled photon-pair source” Nat. Commun. 15, 7600 (2024).
[3] X. Xu, C. Trovatello et al. “Towards compact phase-matched and waveguided nonlinear optics in atomically layered semiconductors” Nat. Photonics 16, 698-706 (2022).
[4] C. Trovatello et al. "Quasi-phase-matched up- and down-conversion in periodically poled layered semiconductors" Nat. Photonics 19, 291–299 (2025).
[5] Z.H. Peng, M. Cotrufo […] C. Trovatello. 3R-stacked transition metal dichalcogenide non-local metasurface for efficient second-harmonic generation. Nat. Photonics 19, 1376–1384 (2025).
[6] P. Valisa, […], C. Trovatello. All-optical switching of nonlinear structured light in crystal-engineered van der Waals materials, arXiv:2608.13548 [physics.optics] (2026).


*Join us for coffee starting 3:30 p.m. Refreshments will be served after the lecture.*
*For more information contact the host: Marcos Guimaraes (m.h.guimaraes@rug.nl)*
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