Entangled photon-pair source in 3R-MoS_2

Maximilian A. Weissflog[1], Anna Fedotova[1,2], Yilin Tang[3], Elkin A. Santos[1], Benjamin Laudert[1], Saniya Shinde[1], Fatemeh Abtahi[1], Mina Afsharnia[1], Inmaculada Pérez Pérez[1], Sebastian Ritter[1], Hao Qin[3], Jiri Janousek[3], Sai Shradha[1,4], Isabelle Staude[1,2], Sina Saravi[1], Thomas Pertsch[1,5], Frank Setzpfandt[1,5], Yuerui Lu[3] & Falk Eilenberger[1,5]

[1]*Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, 07745 Jena,Germany*

[2]*Institute of Solid State Physics, Friedrich Schiller University Jena, Helmholtzweg 3, Jena, 07743, Germany*

[3]*School of Engineering, College of Science and Computer Science, The Australian National University, Canberra, Australian Capital Territory, Australia*

[4]*Institute for Condensed Matter Physics, Technical University of Darmstadt, 64289 Darmstadt, Germany*

[5]*Fraunhofer Institute for Applied Optics and Precision Engineering IOF, 07745 Jena, Germany*

Entangled photon pairs are a cornerstone of quantum technologies, enabling applications in quantum communication, computing, and sensing. Transition metal dichalcogenides (TMDs) have emerged as promising materials for quantum photonics due to their high nonlinear susceptibility and excitonic properties. In this study, we demonstrate polarization-entangled photon-pair generation via spontaneous parametric down-conversion (SPDC) in 3R-MoS_2. The intrinsic in-plane nonlinear tensor components of 3R-MoS_2 enable the generation of maximally entangled Bell states, tunable via pump polarization while maintaining constant generation efficiency [1]. Furthermore, the study demonstrates enhanced SPDC efficiency through quasi-phase-matching (QPM) using van der Waals stacking of 3R-MoS_2, enabling precise control over the phase-matching condition [2]. This work establishes 3R-MoS_2 as a promising material for efficient and tunable SPDC-based quantum light sources, paving the way for advanced integrated quantum photonic devices.

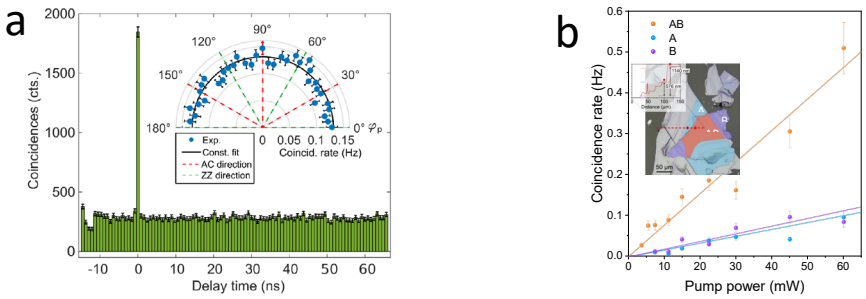

Figure. 1| (a) Coincidence histogram showing pair-generation with CAR=5.5. Inset: constant pair-generation rate for varying pump polarization angle φ_P. (b), Power-dependent coincidence rate of the A, B and AB region. Inset: Optical image of the 3R-MoS_2 homo-structure (AB), with 60° twist of two 3R-MoS_2 flakes A and B.

References

[1] Weissflog, M. A. *et al. Nature Communications* **15**, 7600 (2024).
[2]Tang, Yilin, et al. *Nature Communications* 15.1 (2024): 9979.