Deep-Learning-Designed AlGaAs Interface Linking Trapped Ions to Telecom Quantum Networks

I.P. De Simeone[1], G. Maltese[2], V. Cambier[1] , J-P Likforman[1], M. Ravaro[1], L. Guidoni[1], F. Baboux[1], S. Ducci[1]

[1]*Université Paris Cité, CNRS, Laboratoire Matériaux et Phénomènes Quantiques, 75013 Paris, France*

[2]*Microsoft Azure Fiber, Romsey, United Kingdom*

Quantum technology encompasses a broad range of physical platforms, each characterized by distinct physical mechanisms, technical requirements, and experimental challenges. Over the past decades, several material systems have been developed and optimized to implement specific quantum functionalities, each offering unique advantages as well as inherent limitations. A central challenge for the advancement of quantum technologies is therefore the realization of direct interfaces between quantum nodes based on different platforms, enabling heterogeneous quantum networks.

In this work, we present a machine-learning-assisted design of an ion–photon interface based on spontaneous parametric down-conversion (SPDC) in a multilayer AlGaAs waveguide [1]. The proposed device is engineered to generate narrowband, non-degenerate entangled photon pairs at 1092 nm—resonant with a transition in $^{88}Sr^{+}$, particularly well-suited for fiber-based quantum links [2]—and at 1550 nm in the telecom C-band (Fig. 1). This configuration enables the distribution of entanglement between a stationary ion qubit and a telecom-wavelength photonic flying qubit. The device therefore combines the long coherence times and high two-qubit gate fidelities of trapped Sr^{+} ions [3] with the low transmission losses and robustness to noise of telecom photons, providing a promising route toward the implementation of hybrid quantum networks.

The machine-learning framework introduced here can be readily generalized by training the neural networks on alternative epitaxial structures, extending its applicability to a wide class of photonic devices and material platforms.

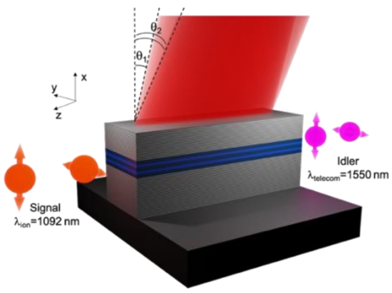

Fig. 1: *Schematic of the device and the pump-incidence geometry for the generation of non-degenerate polarization-entangled photons*

Funding acknowledgement

This work was supported by the Plan France 2030 through projects ANR-22-PETQ-0006 and ANR 22-PETQ-0011, and by the European Union's Horizon Europe research and innovation programme under the project Quantum Secure Networks Partnership (QSNP, Grant Agreement No. 101114043).

References

[1] I.P. De Simeone *et al*, 'Deep-Learning-Designed AlGaAs Interface Linking Trapped Ions to Telecom Quantum Networks', submitted (to appear in arXiv on March 16th 2026)

[2] M.A. Zalewski *et al*, e-print arXiv:2506.11257 (2025)

[3] J.L. Stephenson et al. Phys. Rev. Lett. 124, 110501 (2020)