Hermetic packaging for cryogenic spin qubit experiments

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Realizing a spin qubit universal quantum computer is an extremely complex task. Some of the most challenging tasks include reduced cooling power at the mixing chamber of dilution refrigerators, heating effects due to pulse sequences as well as active cryogenic electronics [1]. Recent results showed that it is possible to operate SiMOS spin qubits above 1K while maintaining high qubit fidelities [2,3] as well as reduced heating effects (without compromising fidelities) when operating SiGe spin qubits at 200 mK [4]. A valuable way forward for large scale spin qubit solution could be operating processors in closed-loop liquid Helium systems, enabling the possibility to harness large cooling power as well as optimal cryogenic chips thermalisation.

In this talk we introduce our newest commercial packaging, used to perform experiments in completely sealed environments at cryogenic temperatures while offering as many as 60 I/O lines with only 2 indium seals. The technology is based on our recently developed QCage chip carrier, which has been optimized for CQED experiments [5,6], essential to demonstrate long range coupling with spin qubits [7]. We demonstrate the superfluid helium tightness of this packaging by investigating how the resonance frequency of superconducting coplanar waveguide resonators is evolving as the chip cavity is filled with superfluid helium at cryogenic temperatures.

[1] Acharya *et al.*, *Nat Electron,* **6**, 900 (2023)
[2] Huang, J.Y *et al.*, *Nature,* **627**, 772 (2024)
[3] Petit, L., *et al. Nature,* **580**, 355 (2020)
[4] Undseth, B. *et al., Phys. Rev. X,* **13**, 041015 (2023)
[5] Crowley K.D. et al., *Phys. Rev. X,* **13**, 041005 (2023)
[6] Elfeky *et al., PRX Quantum*, **4**, 030339 (2023)
[7] Dijkema, J. *et al.,* arXiv: 2310.16805 (2023)