Contribution ID: **21** Type: **Invited**

The superconducting quantum computing center "Partenope": progresses and quantum algorithm

Wednesday 10 December 2025 10:50 (30 minutes)

The engineerable quantum macroscopic and artificial nature of superconducting quantum platforms [1], also recognized by the recent Nobel prize to Clarke, Martinis and Devoret, has favored noticeable advancements towards both quantum utility in the Noisy and Intermediate Scale Quantum (NISQ) era and quantum error correction for fault-tolerant quantum computing [2-5]. Nevertheless, the incredibly fast development of superconducting quantum computers prevents their use as "black boxes"to unlock their full potential in the NISQ era.

In this work, we discuss the strategy pursued to build the first superconducting quantum computing center in Italy, "Partenope", funded by the National Center for High-Performance, Big Data and Quantum Computing (ICSC) [6,7]. We will first report on the Quantum Characterization, Validation and Verification (QCVV) of a Quantum Processing Unit (QPU) made of 25 transmon qubits, and then delve into the future evolutions of the infrastructure towards a multi-node platform.

Specifically, we will focus on the study of its computational resources, e.g. the well-known superposition and entanglement, but also the more advanced magic, a computational resource that quantifies how much a quantum state deviates from being a stabilizer state [8]. Stabilizer operations give access to entanglement, but no magic; local operations to magic, but no entanglement. The onset of quantum advantage then resides in the interplay between entanglement and magic. Non-local magic is recognized as the quantity that measures the interplay between them [9], although not commonly investigated experimentally, and notably depends on the level of errors in the hardware at hand. The direct access to our QPU's characteristics unlocked the first demonstration of non-local magic in a superconducting platform [10], further motivating the strong request for a full knowledge of the hardware at hand as a tool to advance knowledge.

These results have been pivotal also for the implementation of proof-of-concepts algorithms applied to Quantum Finance [11]. In collaboration with G2Q Computing and Intesa SanPaolo, we applied Quantum Amplitude Estimation (QAE) methods for Credit Risk Analysis, i.e. the Gaussian Conditional-Independence (GCI) model [12]. Here, a key role is played by the generation of Gaussian distributions encoded in a qubits register. We demonstrate that hardware- aware quantum circuit transpilation based on a variational-like approach directly at the machine level allows to overcome the limited connectivity and gate errors in our NISQ QPU, with reasonable outcome for such use-case.

[1] M. Devoret et al., Phys. Rev. Lett. 53, 1260 (1984).
[2] Arute, F., et al., Nature 574, 505–510 (2019)
[3] Kim, Y., et al., Nature 618, 500–505 (2023)
[4] Google Quantum AI and Collaborators. Nature 638, 920–926 (2025).
[5] Google Quantum AI and Collaborators. Nature 646, 825–830 (2025).
[6] Ahmad H.G., et al., Adv Quantum Technol. 2024, 2300400
[7] Mastrovito, P., et al., Commun Phys 8, 295 (2025).
[8] Oliviero, S.F.E., et al., Npj Quantum Information 8(1), 1–8 (2022).
[9] D. Qian, et al., Phys. Rev. A 111, 052443 (2025).
[10] Ahmad H.G., et al., manuscript in submission.
[11] Ahmad H.G., et al., manuscript in preparation.
[12] M. Rutkowski, et al., International Journal of Theoretical and Applied Finance 18, 1550034 (2015)

Presenter: AHMAD, Halima Giovanna (University of Napoli ”Federico II”)

Session Classification: Halima Giovanna Ahmad: The superconducting quantum computing center “Partenope”: progresses and quantum algorithm