Adapting Variational Quantum Eigensolver for High-Dimensional Quantum Systems (Qudits)

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The presentation explores the use of the Variational Quantum Eigensolver (VQE) algorithm in high-dimensional quantum systems, known as qudits, within quantum computing. Traditionally reliant on two-level qubits, quantum computing faces scalability issues as system complexity grows. By integrating qudits, which support multiple states per unit, the research demonstrates potential for enhanced information density, reduced circuit complexity, and improved error management. The presentation covers the challenges and technical adaptations required to apply VQE to qudit-based systems, particularly on trapped ion quantum computers. Additionally, it addresses algorithmic and hardware developments needed to overcome challenges like state control, gate fidelity, and error correction in qudit systems. Collaborative efforts with experimental teams underscore the goal of bridging theoretical advancements and practical implementation. The presentation concludes by evaluating hybrid qubit-qudit systems, which combine the simplicity of qubits with the data efficiency of qudits, as a promising pathway toward scalable, resource-efficient quantum computing solutions.

References:

- Wang, Y., Hu, Z., Sanders, B. C., & Kais, S. (2020). Qudits and High-Dimensional Quantum Computing. *Frontiers in Physics, 8*, 589504.
- Senjean, B., Yalouz, S., & Saubanère, M. (2023). Toward Density Functional Theory on Quantum Computers? *SciPost Physics, 14*(3), 055.
- Bertlmann, R. A., & Krammer, P. (2008). Bloch vectors for qudits. *Journal of Physics A: Mathematical and Theoretical, 41*(23), 235303.