# Neural Quantum State Optimization

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Domain: Quantum Technologies, Machine Learning, Global Optimisation

## Introduction

Artificial neural networks have been used to describe and analyze quantum many-body wave functions [1, 2]. However, existing models, known as neural quantum states (NQS), rely on complex-parameter networks. In this project, we propose an alternative approach that simplifies the model to a real-parameter network, reducing the dimensionality of the parameter space, enhancing compatibility with advanced optimization techniques, and improving computational efficiency. This approach is broad and applicable to both research and various industries. Beyond offering an efficient and accurate method for quantum science studies, the project aims to deliver innovative solutions for large-scale industrial challenges.

## Task

Within the scope of this project, we aim to accomplish the following objectives:

- Develop real-parameter NQS (R-NQS) with enhanced computational efficiency.
- Validate R-NQS's expressibility, trainability, and scalability.
- Create a user-friendly toolbox for easy deployment.
- Apply R-NQS to solve many-body quantum problems, including the characterization of quantum correlations in many-body systems.
- Apply R-NQS to real-world complex logistics challenges, such as the Vehicle Routing Problem and Tail Assignment Problem, benefiting companies in the automotive and aviation industries.
- Apply R-NQS to solve problems like the Minimum Spanning Tree (MST), which is key to modeling and optimizing financial challenges and similar problems.
- Compare R-NQS with methods like QAOA and adiabatic annealing.

To test and validate the method on real-world problems, we aim to expand our partnerships across various sectors, including logistics, finance, and healthcare.

## Required expertise

- Good understanding of Python programming
- Basic understanding of machine learning / willingness to learn about machine learning, neural networks, quantum information processing, and optimisation

## References

1. G. Carleo, M. Troyer, Solving the quantum many-body problem with artificial neural networks, Science 355 (6325), 602–606 (2017).
2. J. Tilly et al, The Variational Quantum Eigensolver: A review of methods and best practices, Physics Reports 986, 1–128 (2022).