# Introduction

Dear collegues, thank you and welcome to the initial presentation of my thesis. The thesis titile Estimating ground state wavefunctions using QPE vs VQE. Supervised by Dr. Peter Thoman and Prof. Gerhard Kirchmair from the institute of experimental physics.

Lets start with a quick motivation: In QM, time evolution of a system is described by the Schrödinger equation, as you can see here. It is Differential Equation, where i is the usual complex i, hbar is Plancks const., psy in the so called dirac ket denotes the system state and H is the Hamiltonian, i.e. an operator acting on the system. May be repr. As vector and matrices.

# Eigenvalue equation

It turns out that the eigenvalue equation of this Hamiltonian matrix is very important. This is because the eigenvalue corresponds to the energy of the system. The corresponding eigenvectors are called eigenstates Especially important is the ground state, i.e. the state with the lowest possible energy.

# Classical Intractability

You might say what is the big deal? Eigenvalue problems can be computed in O(n^p), where p might be as low as 2 or 3, depending on the algorithm. However, for a system of m qubits, the state vector psy has size 2^m, so also the eigenvalue equation is exponential in m. And we know that exponential algorithms are no fun

# Quantum algorithms

But what better way to calculate quantum systems than by using quantum systems, i.e. QCs. By the way, this is also the original use case that lead to QC being conceived. So, some promising quantum algorithms for this problem:

* QPE
* VQE – less accurate, but more efficient.

# QPE

To the right hand side, you can see a little schema in circuit form. Starts with a guess psi\_prime. Next, some connection is created to the helper qubits via the so called Hadamard Transform and Controlled operations. Lastly, we do QFT^-1 and measurements of the helper states. The lowest energy we measure will be the groundstate.

# VQE

Uses parameterized gates to create a so called Ansatz state. Then again, some operations are done on this state, followed by a measurement. We then use the measured result and feed it into an optimizer, such as GD. We do this until the measured energy converges, which will be the ground state.

# Thesis goals

The goals are to create numerical implementations of both algorithms, to also solve the eigenvalue equation analytically, and also to simulate the whole thing on a QC simulator on the cloud. Then I will compare the results and discuss the advantages/ disadvantages of the algorithms.

# Time Schedule

# Thank you