THE UNIVERSITY of EDINBURGH
School of Physics and Astronomy

Quantum Harmonic Oscillator on a Computer

Supervisors: Dr. Anthony Kennedy, Dr. Roger Horsley

Sahaj Porwal

Introduction

This project simulates a Quantum Harmonic and a Quantum An-harmonic oscillator, and looks at how these two systems evolve using the Metropolis version of the Markov Chain Monte Carlo Method.

As one of the few Quantum Mechanical systems with an analytical solution, the Quantum Harmonic Oscillator is the ideal system to simulate as it can help model problems and make predictions in many areas of Modern Physics: The study of Phonons and in the study of Molecular Vibrations, among others.

Method

The Metropolis Method uses randomly generated increments to the displacement from the equilibrium position of a line(1D lattice) of particles based on the principle of minimising the potential energy.

Results

The main results were the representative paths for both the cases(harmonic and an-harmonic), which arose from their potentials and the metropolis algorithm.

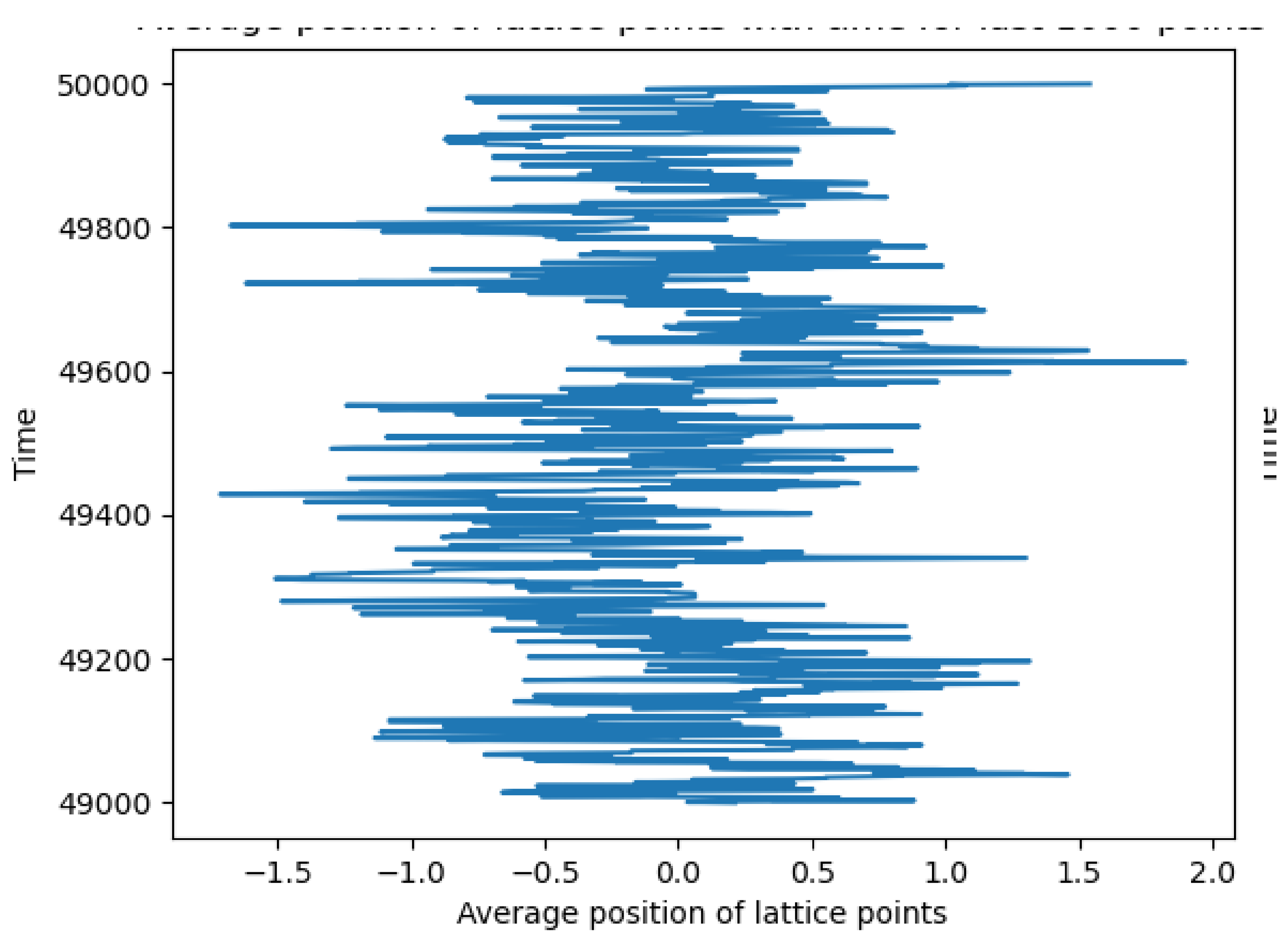

Figure 1: Oscillations of a Quantum Harmonic Oscillator, oscillating about the equilibrium position x = 0.0

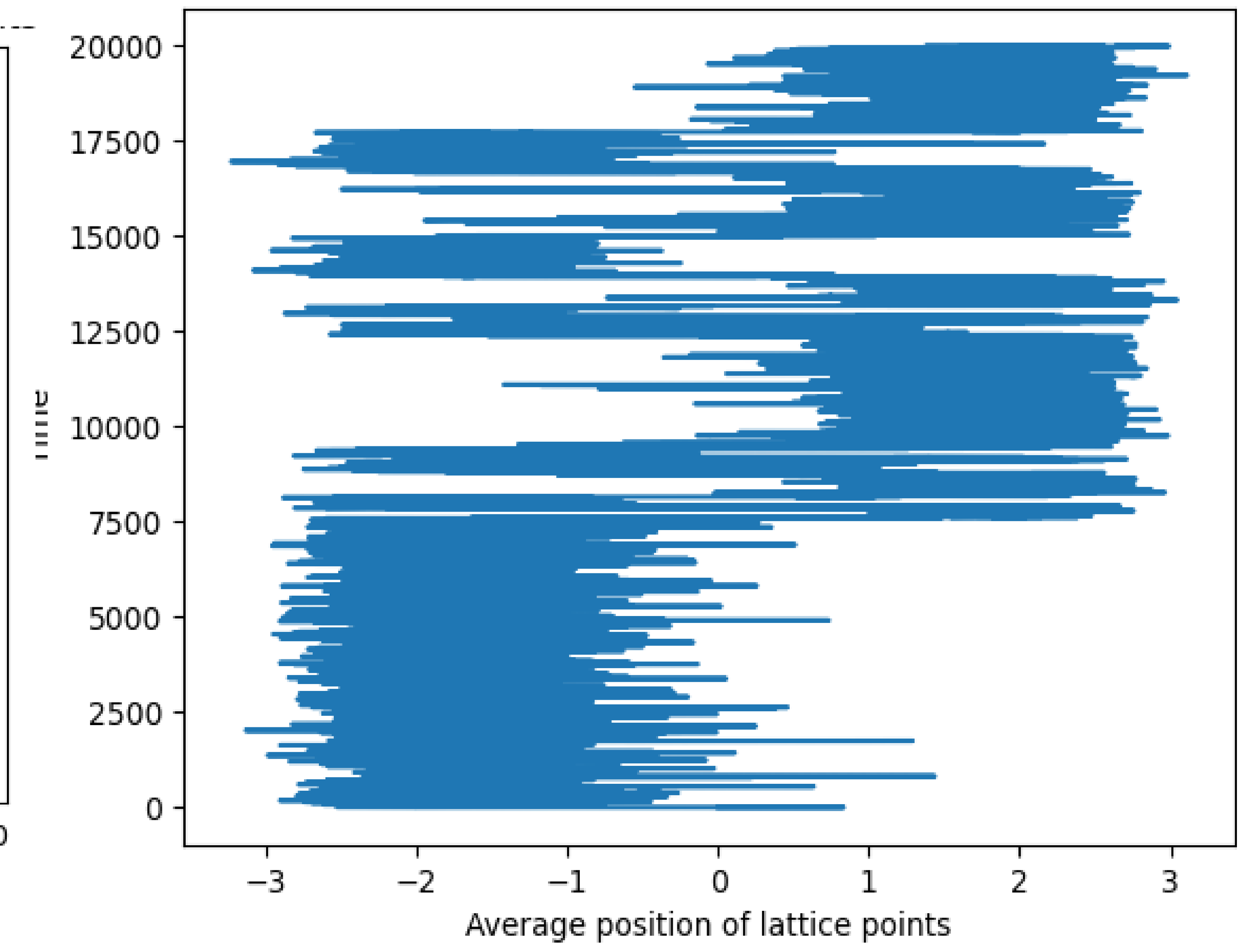

Figure 2: Oscillations of a Quantum An-Harmonic Oscillator, oscillating about the two minima positions x = +2, and -2. Also showcases tunnelling(instantaneous transfer between the two minima).

Conclusions

Implemented the Quantum Harmonic Oscillator and reproduced its expected behaviours. Also made a reasonable model for the an-harmonic oscillator which shows the expected trajectories(with tunnelling between the two minima positions).

Future work could include: higher dimensional harmonic oscillator to model spherical potentials, interactions between multiple chains of harmonic oscillators, and other systems.

Acknowledgements

Thanks to Dr. Kennedy and Dr. Horsley for their guidance and support through the project.