DYNAMICS OF BOSE-EINSTEIN CONDENSATES IN DIFFERENT RANDOM POTENTIALS

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BEC IN RANDOM POTENTIALS EQUATION

$$i\partial_t \psi = [-\frac{\partial_x^2}{2} + V_{ho}(x) + V(x) + g|\psi|^2 - \mu]\psi$$

- V_{ho} – Harmonic potential
- V – Random potential
- $g|\Psi|^2 -$ Interaction between particles
- μ – Chemical potential

METHOD

- Finite Difference – a method for solving differential equations by approximating them with difference equations. For example,

$$f'(x_j) = \frac{f(x_{j+1}) - f(x_j)}{\Delta x} + O(\Delta x^2)$$

- Crank-Nicolson – a finite difference method.

$$\frac{f_j^{n+1} - f_j^n}{\Delta t} = \frac{1}{2}\left(\frac{f_{j+1}^{n+1} - 2f_j^{n+1} + f_{j-1}^{n+1}}{(\Delta x)^2} + \frac{f_{j+1}^n - 2f_j^n + f_{j-1}^n}{(\Delta x)^2}\right)$$

HPX – HIGH PERFORMANCE PARALLEX (HTTP://STELLAR.CCT.LSU.EDU/PUBS/HPX_1.PDF)

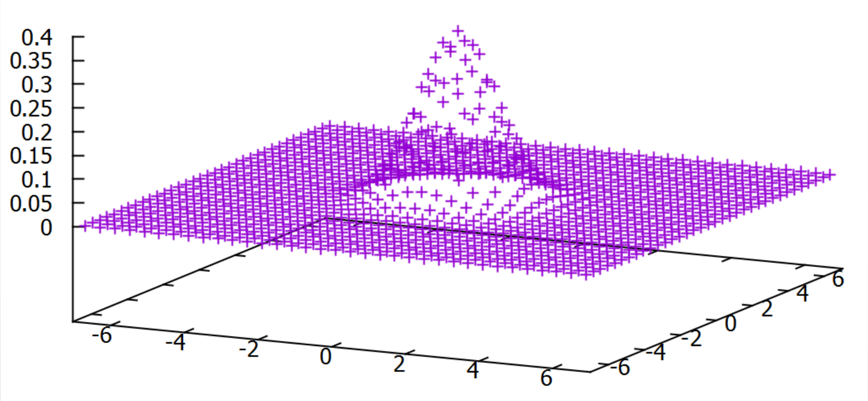
- HPX – a c++ library that distributes the works to different nodes of a cluster.
- HPX minimizes slow
  - **S**tarvation occurs when there is not enough computation for the program to maintain high performance and utilize all resources
  - **L**atencies cause stoppage in the code due to the waiting for information to be received
  - **O**verhead is the work required to manage parallel actions
  - **W**aiting for Contention resolution is the time delays for different parts of the program to get an overshared information
- Improves slow in many ways, for examples:
  - Dataflow
  - Future

PROCESS

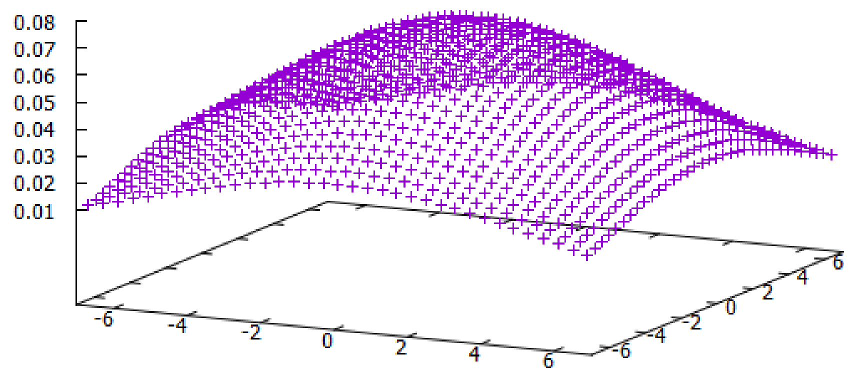
- To test the program, we solve for wave functions of different potentials such as
  - Zero potential
  - Harmonic potential
  - Harmonic potential with disorder

SCHRODINGER EQUATION WITH NO POTENTIAL

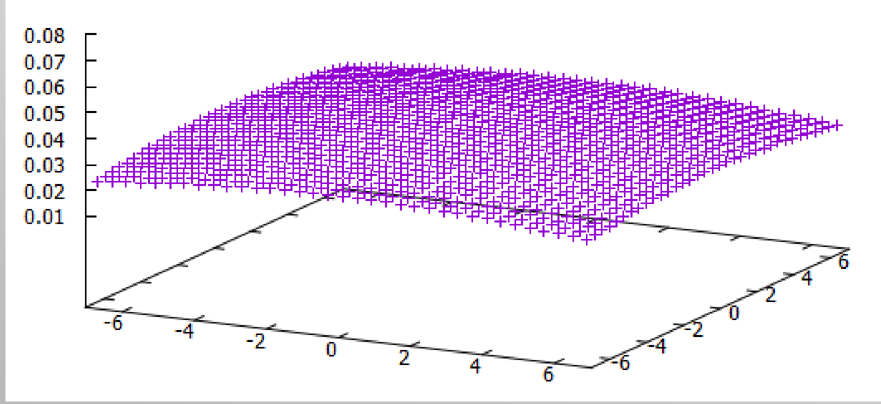
Probability amplitude at the earliest time



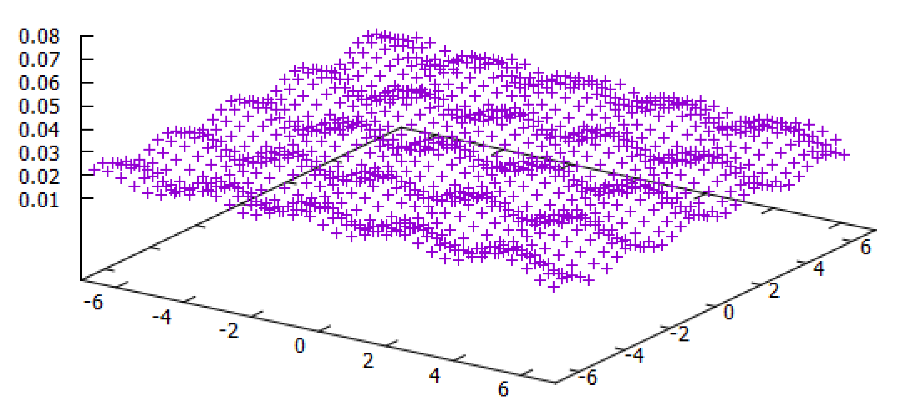
Probability amplitude after a fourth of the total time has passed



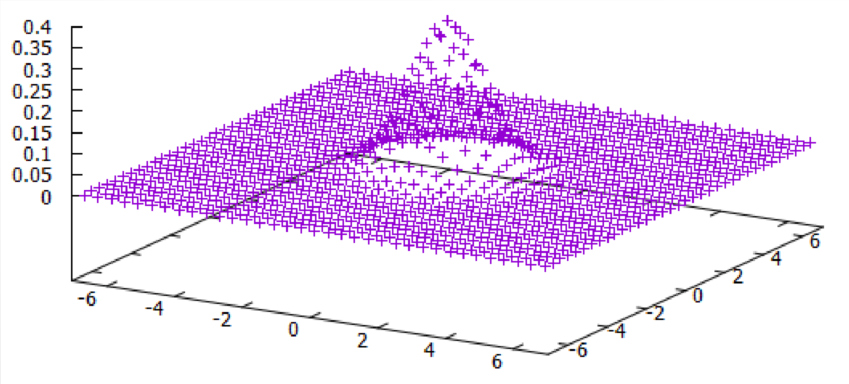
Probability amplitude after half of the total time has passed

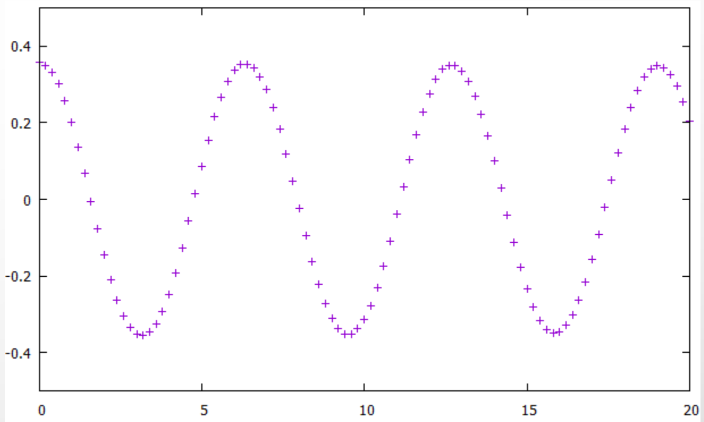


Probability amplitude at the latest time



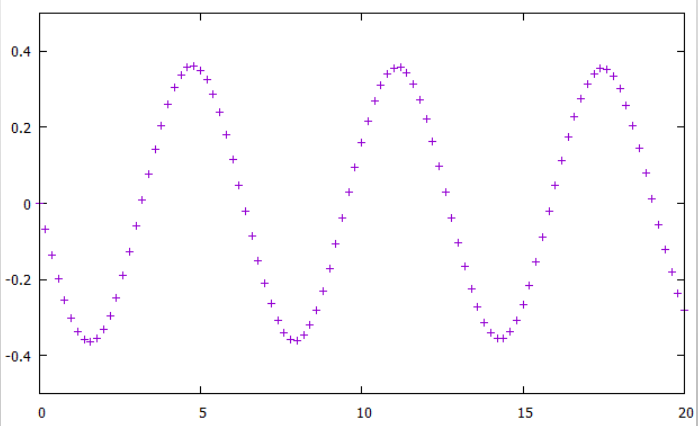
SCHRODINGER EQUATION WITH HARMONIC POTENTIAL





Real part of $\Psi(0)$

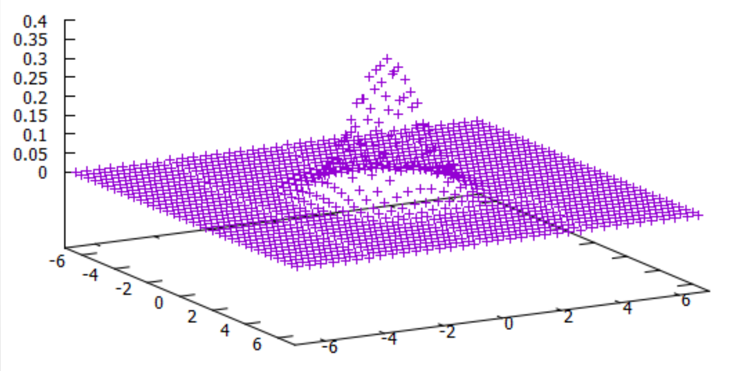
The probability amplitude of the wave function over time.



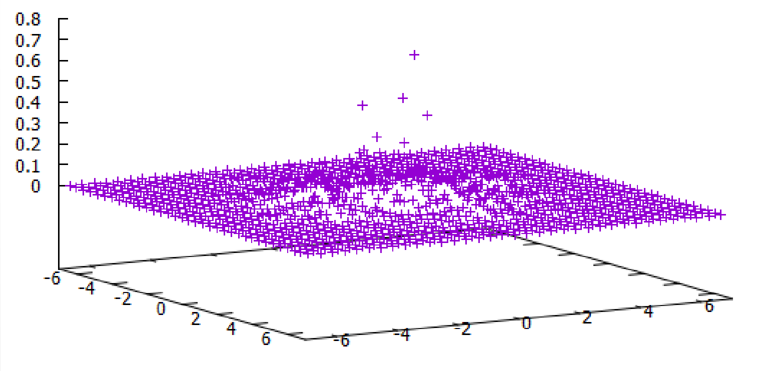
Imaginary part of $\Psi(0)$

SCHRODINGER EQUATION WITH RANDOM HARMONIC POTENTIAL

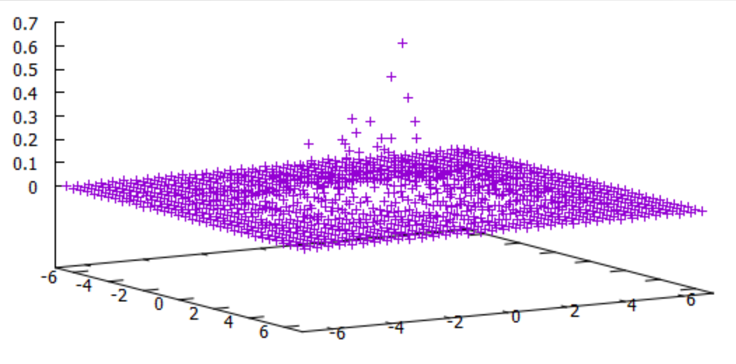
Probability amplitude at the earliest time



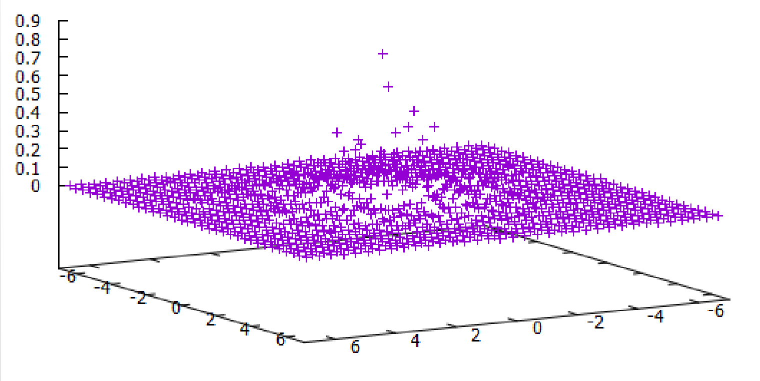
Probability amplitude after a fourth of the total time has passed



Probability amplitude after half of the total time has passed



Probability amplitude at the latest time



SUMMARY

- THUS FAR, THE CODE IS FULLY FUNCTIONAL AND CAN SIMULATE MANY WAVE FUNCTION WITH DIFFERENT POTENTIALS.
- READY TO ADD IN NON-LINEAR TERM $g|\Psi|^2$.

QUESTIONS?