Quantum Reflection Project: List of figures

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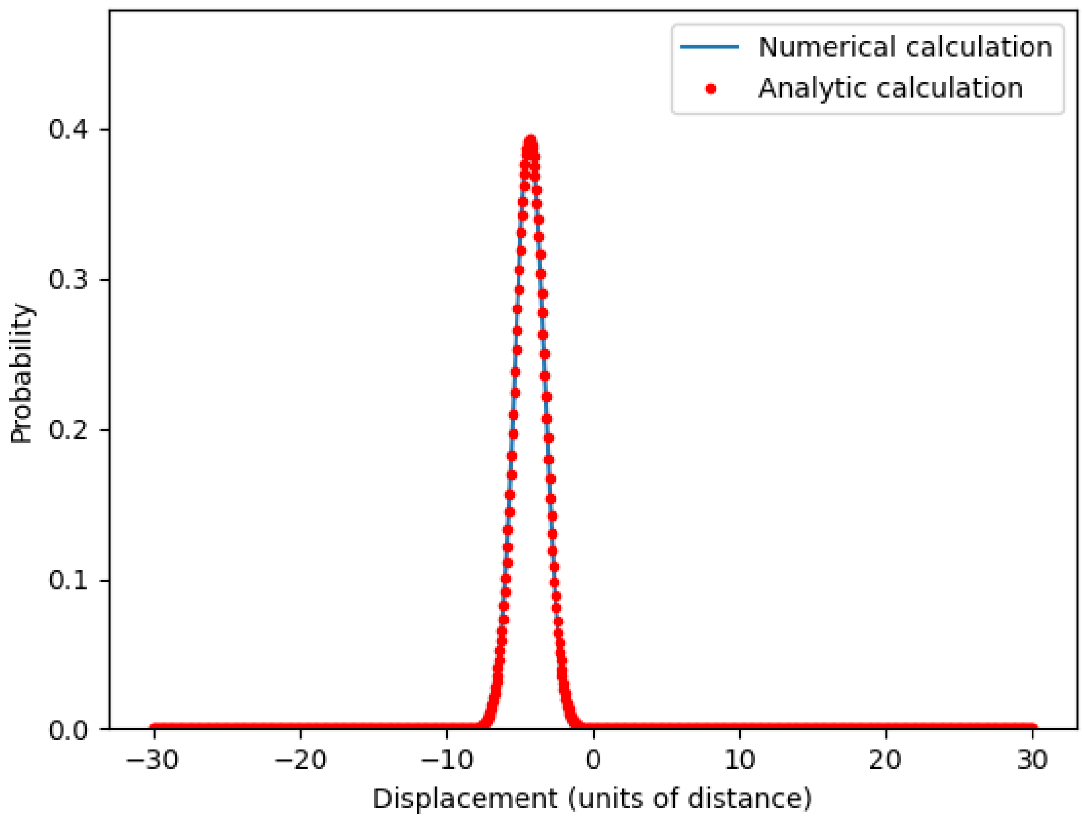


Figure 1: This first figure is the snapshot of the time-evolution of probability ($|\phi|^2$) vs distance. The values of σ, $\hbar$ and m are all 1, so the distance is scaled to those values. The points shown in red dots is the analytical known result given by the equation in the briefing document. A 1000 points were used, so the resolution was high and the animation was smooth.

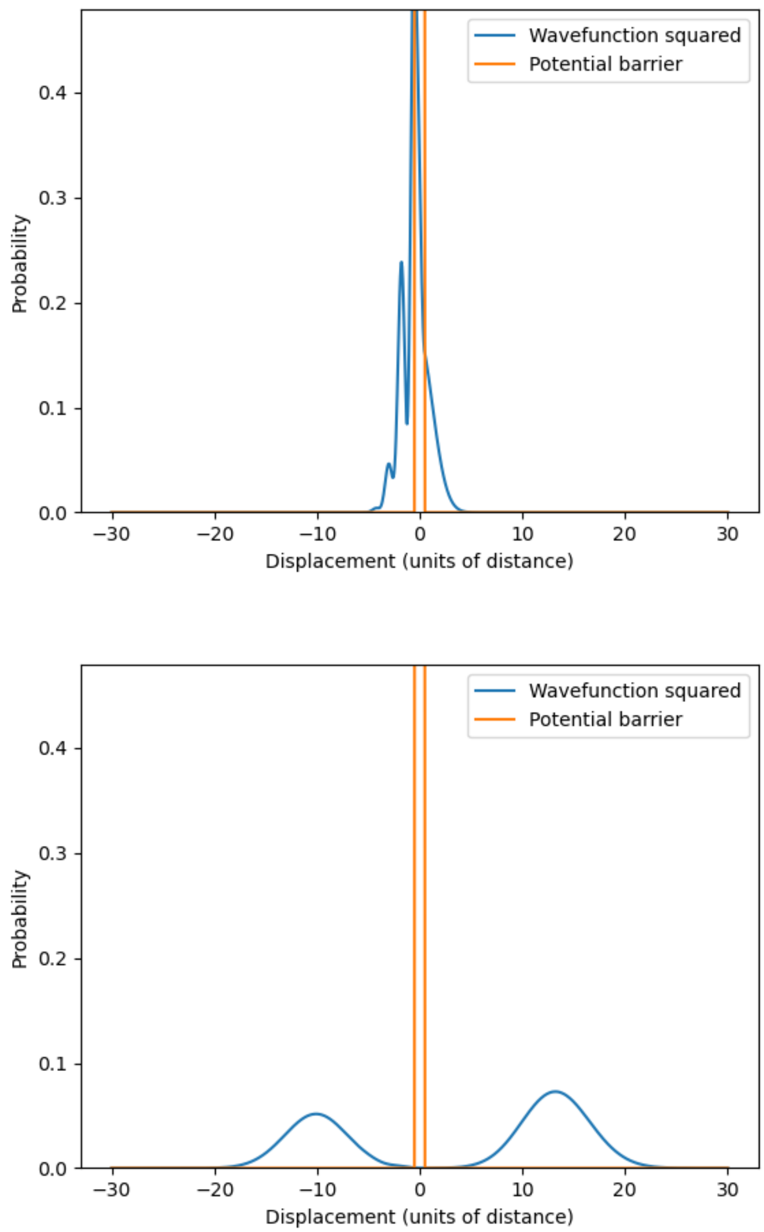


Figure 2: Again, we have 2 snapshots of the time-evolution of probability ($|\phi|^2$) vs distance of the wavepacket. Here, the orange plot shows a potential barrier of height 2.5 units. The first snapshot is the wavepacket in the potential, the second shows the reflected and the transmitted waves.

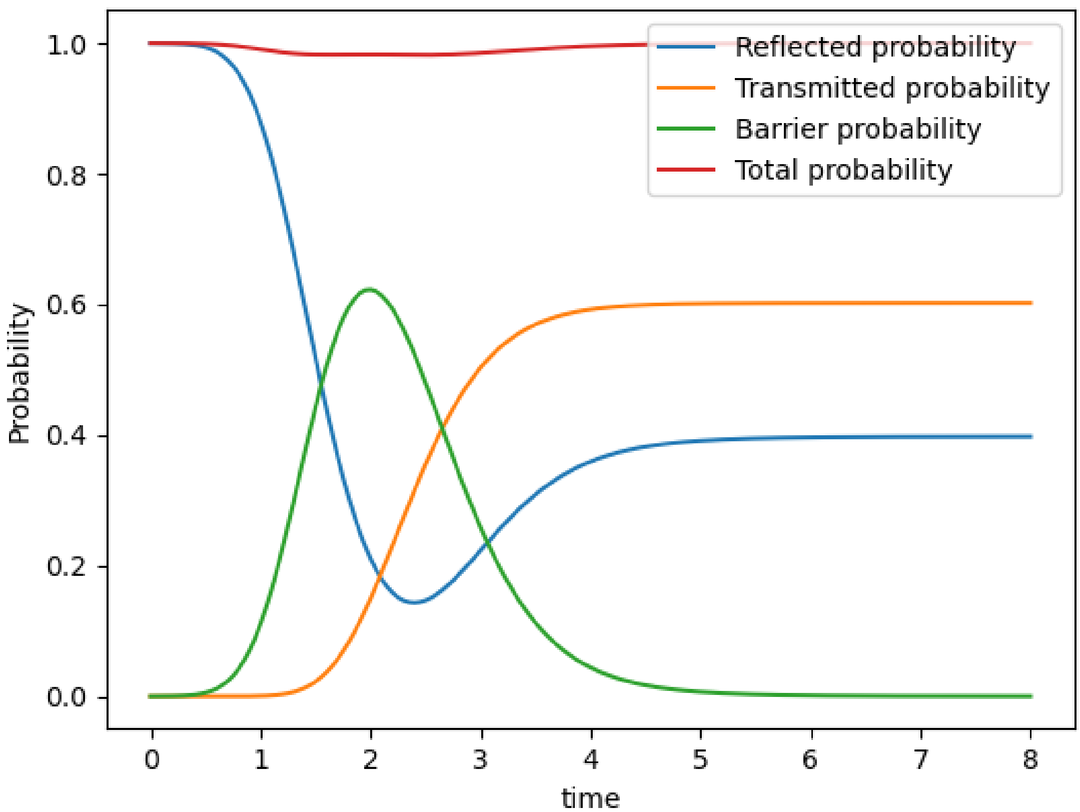


Figure 3: This graph shows the probabilities of the reflected and transmitted waves, along with the probability in the potential and the total probability for the parameters given in Figure 2. As we can see, the total probability is almost 1 during the time, which shows us that the discretisation error is low. An analysis of the discretisation error is in Figure 5.

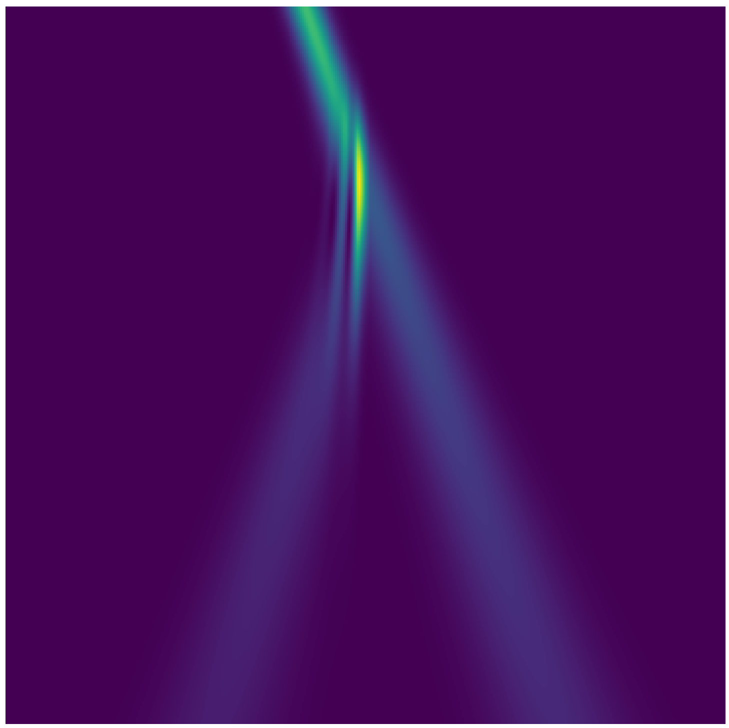


Figure 4: This is a plot of the reflection and transmission over the whole time using the `imshow` method. We can see the incident wave coming in from the top and the transmitted wave propagating in the direction of the incident wave. The reflected wave is propagating at an angle away from the incident wave.

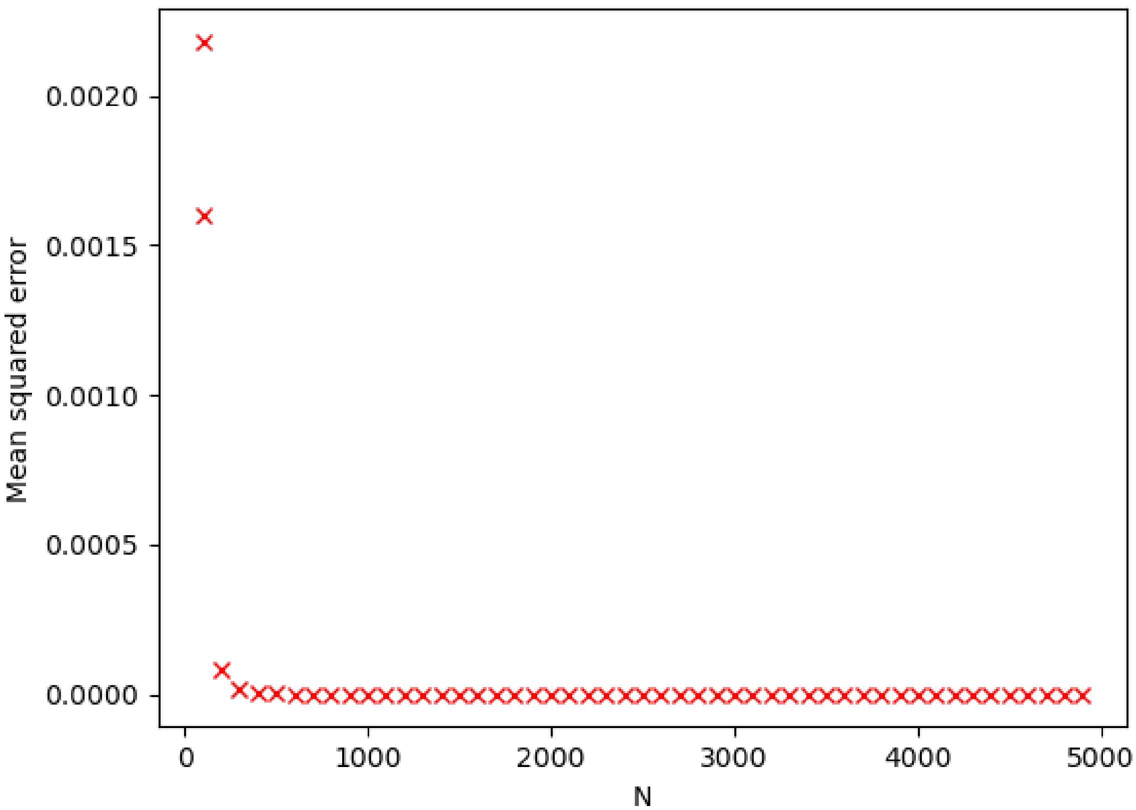


Figure 5: To do a proper analysis of the discretisation error, I took the mean squared error (MSE) of the analytic and the numerical wavepacket without the potential barrier for the various values of N. To find the optimal N value, I found the squared difference between a previous value of N with the current value in the loop, and then took N for which the squared difference was a minimum. The optimal value found was 3900, however for the sake of the project, I continued using 2000 for faster processing for the 1D case.

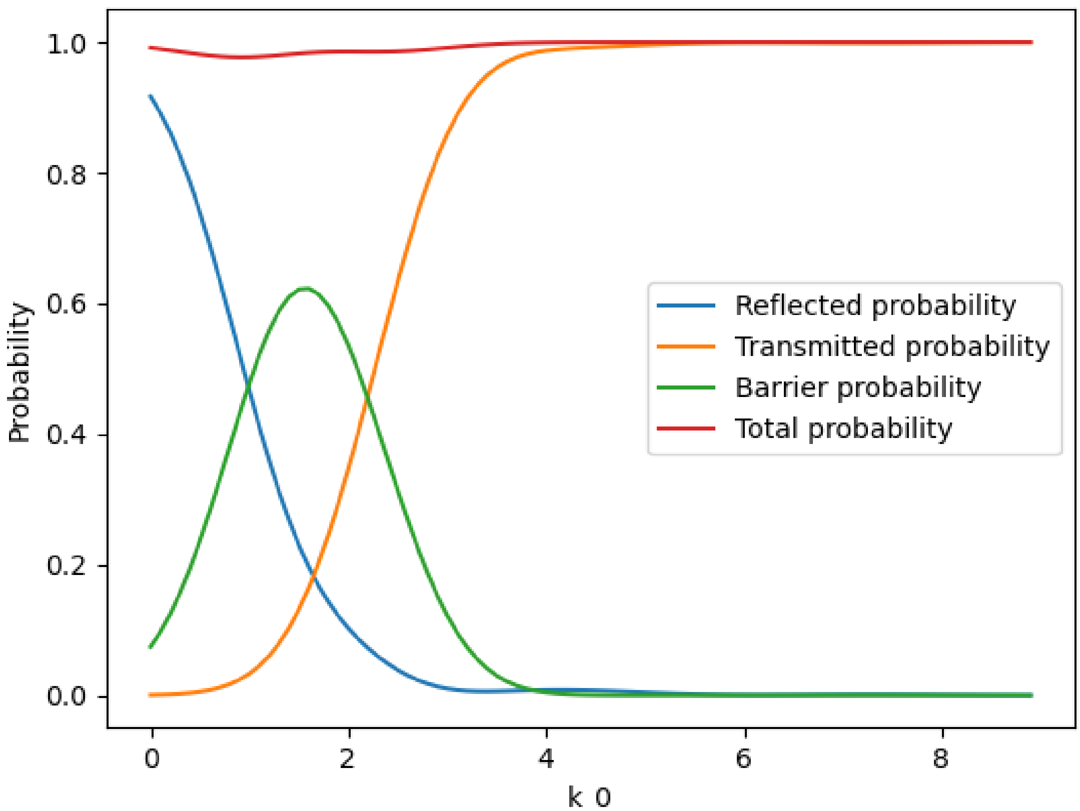
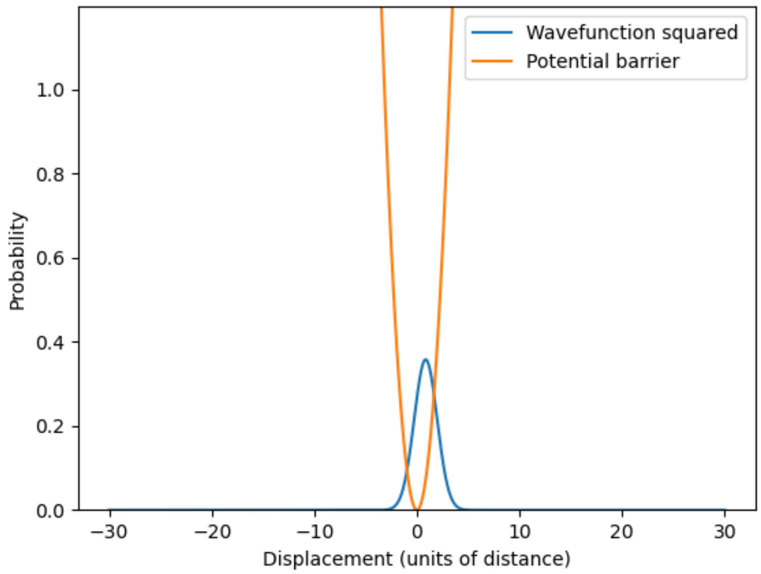


Figure 6: This graph shows the probabilities of the reflected and transmitted waves at t=2 for various values of k_0, along with the probability in the potential and the total probability. We can see that at high values of k, we almost get reflection free waves.



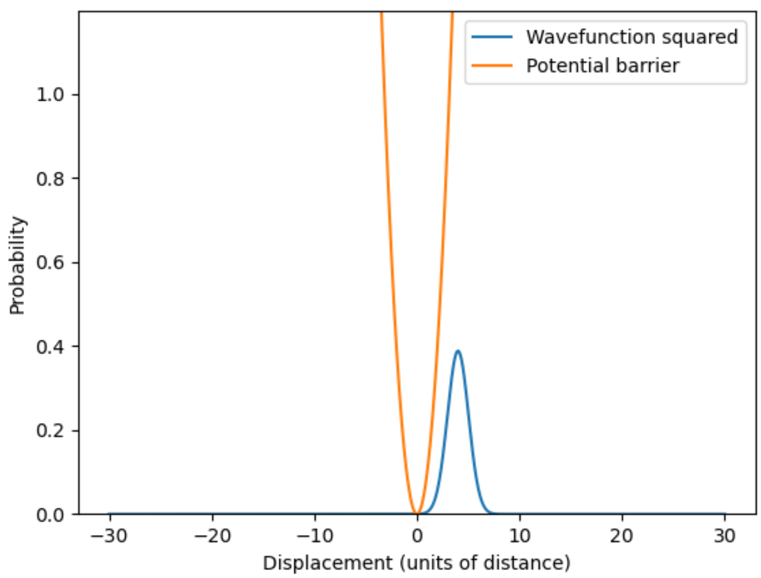


Figure 7: I also did an investigation of a Gaussian wavepacket in a harmonic potential. The k-value for this specific potential was 0.1. The first thing I noticed was that there wasn't any reflection with the harmonic potential. As you increased the value of k_0 for the wavepacket, the wavepacket oscillated faster and had larger amplitudes. To see this more clearly see Figure 8.

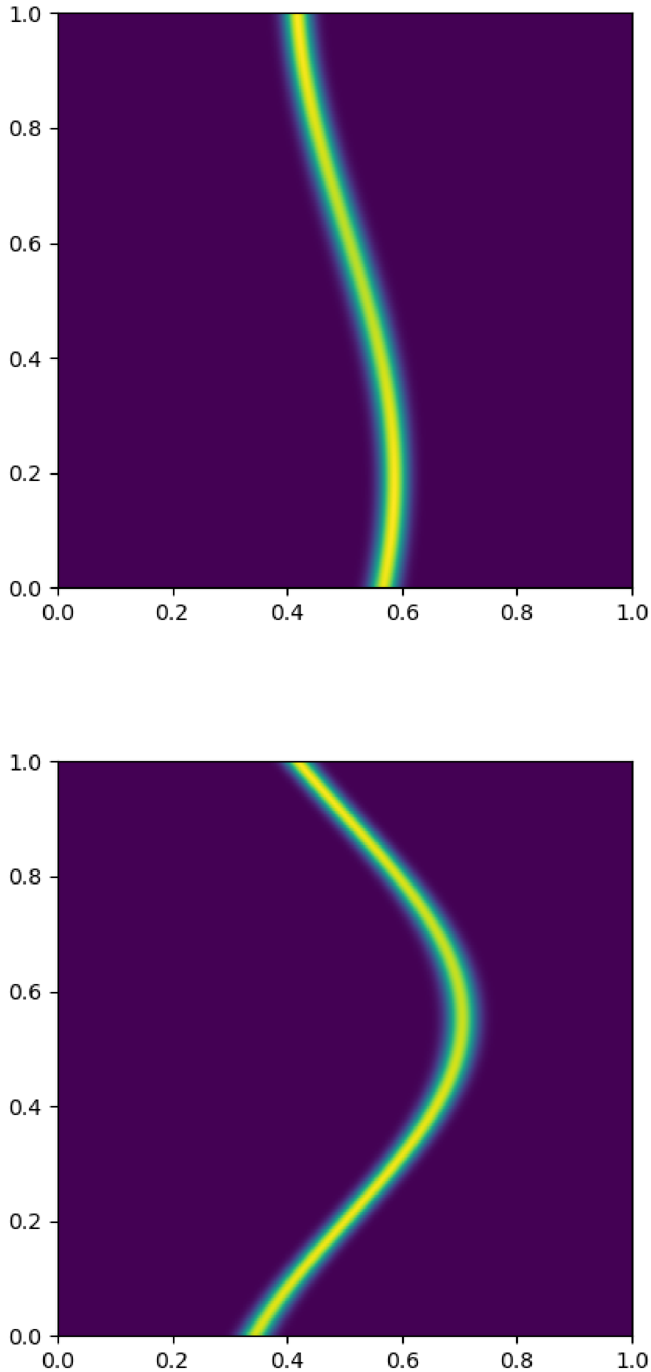


Figure 8: This images were obtained using `imshow`. The image on the top was obtained with k_0=0.1, the bottom as obtained with k_0=5. We can see the increase of the amplitude of the oscillation.

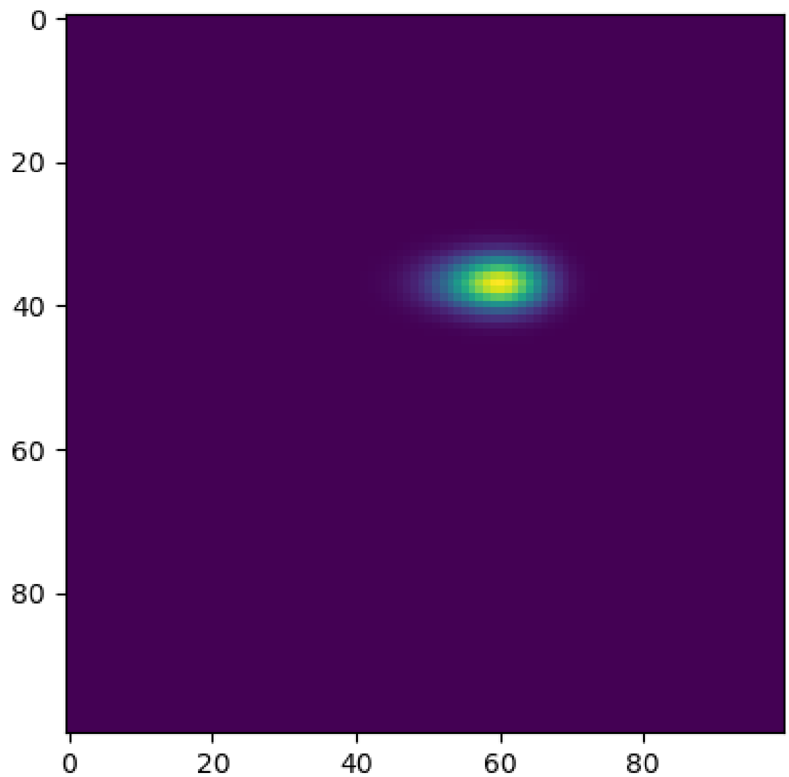


Figure 9: And finally, I tried doing the 2D version. I was able to get a propagating wavepacket, but I couldn't get the potential to work. So the code gives you a propagating wavepacket with no reflection or transmission. Here is the `imshow` plot of a 2D wavepacket at a time $t \neq 0$.