1 Width of momentum-space and position-space wavepackets

(a) Consider a momentum-space Gaussian:

$$\phi(p) = \left(\frac{1}{2\pi\beta^2}\right)^{1/4} e^{-(p-p_0)^2/4\beta^2}$$

Calculate the corresponding position-space wavefunction.

(b) Use your favorite computational plotting tool to plot the momentum-space distribution and the position-space wavefunction. How are the widths of these two distributions related to each other? Include some plots to demonstrate the variation.

2 Momentum-Space Probability Distribution

A beam of particles is described by the wave function:

$$\psi(x) = \begin{cases} Ae^{ip_0x/\hbar}(b - |x|) & |x| < b \\ 0 & |x| > b \end{cases}$$

where $b > 0$.

(a) Normalize the wave function.

(b) Plot the real and imaginary parts of the wavefunction.

(c) Plot the position probability density.

(d) Calculate and plot the momentum probability distribution.

3 Estimate Ground State Energy of the Hydrogen Atom

Use the uncertainty principle to estimate the ground state energy of the hydrogen atom.