Wavefunctions in 1D

- Complex phases shown as color hues as in Thaller, *Visual Quantum Mechanics*.
- The vertical axis on these plots is probability density.

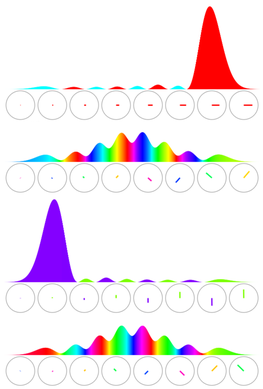
Momentum eigenstates

Large positive momentum

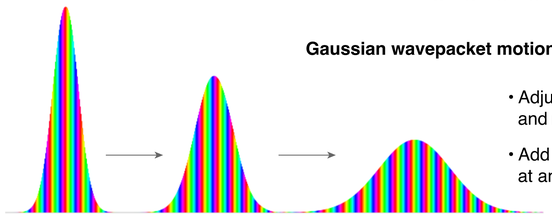
Small negative momentum

Time evolution of superposition states

- Infinite square well or harmonic oscillator
- 8 basis states
- Arbitrary complex superpositions
- For a much more capable version, see the *1-D Quantum Mechanics Applet* (now ported to JavaScript) at falstad.com.

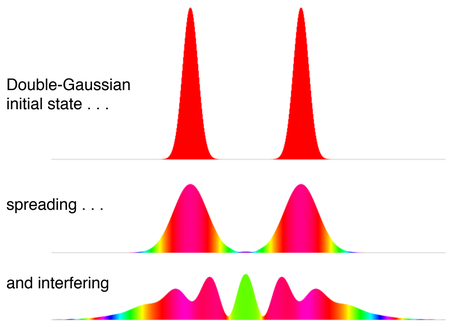


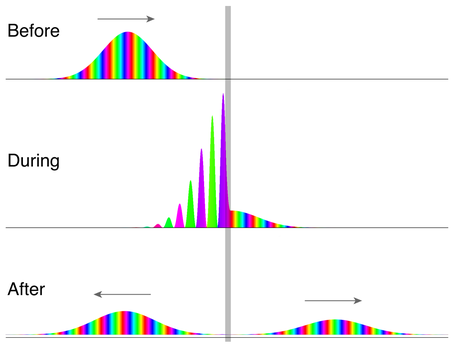
Gaussian wavepacket motion and spreading



- Adjust the initial width and momentum.
- Add more Gaussians at any time.

These wavepacket and scattering simulations integrate the time-dependent Schrödinger equation using a simple centered-difference algorithm as in Visscher, Comp. Phys. **5**, 596-598 (1991).





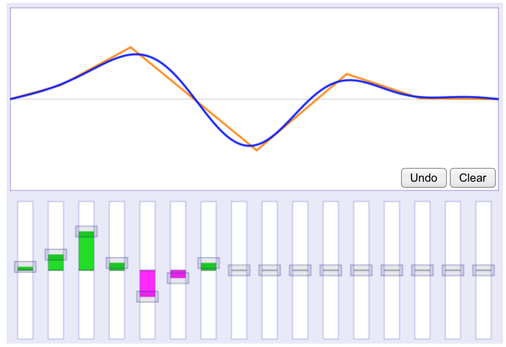
Barrier scattering

- Adjust the energy of the incoming Gaussian.
- Adjust the barrier strength, width, and smoothness.
- Explore transmission, reflection, filtering, and tunneling.
- These snapshots are boring! Run the interactive, animated version at physics.weber.edu/schroeder/software.

No plugins! No installation process! Run these simulations in any modern browser, including mobile devices.

Wave Builder

- Try to match wave forms with superpositions of 16 basis states.
- Or draw a wave form and watch the computer match it.
- Choose from 3 sets of basis functions.
- Inspired in part by the PhET Java app *Fourier: Making Waves.*
- Think *you* can match all the target wave forms? Find out at physics.weber.edu/schroeder/software.

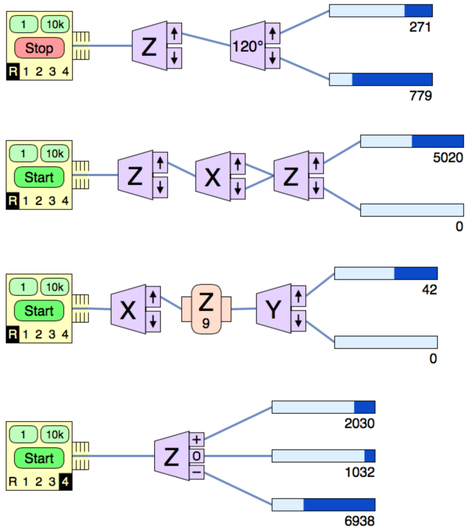


Web Apps for Wavefunctions, Spins, and Entanglement

Dan Schroeder, Weber State University

http://physics.weber.edu/schroeder/software

Spins Laboratory



Link together Stern-Gerlach devices for spin-1/2 and spin-1 systems to determine unknown initial states and explore the Born rule, incompatible observables, interference, and precession in a magnetic field.

This is a new port of the software described in AJP **61**(9), 798-805 (1993), and used in Moore, *Six Ideas That Shaped Physics*, and McIntyre, *Quantum Mechanics: A Paradigms Approach*.

Design and run your *own* experiments at physics.weber.edu/schroeder/software.

Wavefunctions in 2D

Genuine two-dimensional calculations done before your eyes, in your browser!

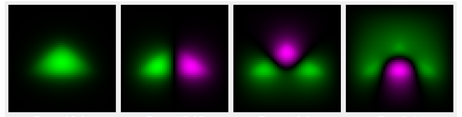
Stationary states in 2D potential wells

Green is positive
Magenta is negative

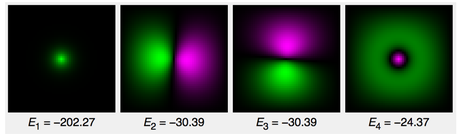
Choose from 8 potential shapes, all with adjustable parameters.

For the algorithm used, see arXiv:1701.08934.

Finite triangular well



Pseudo-Coulomb potential



Barrier with two holes

Circular well

Scattering of a wavepacket incident from the left, by direct integration of the time-dependent Schrödinger equation.

Choose from 7 adjustable potential shapes.

Quit wasting time reading this poster! Just go to physics.weber.edu/schroeder/software and run the software!

Two Particles in 1D

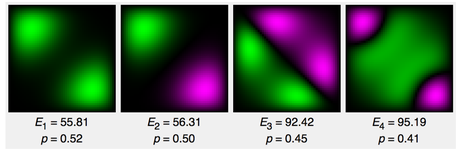
- The two-particle wavefunction lives in 2D configuration space.
- In these images, x_1 is plotted horizontally and x_2 vertically.
- The particles are distinguishable, but have equal masses.
- Any wavefunction that doesn't factor into the form $f(x_1)g(x_2)$ is *entangled*.
- Virtually any interaction between the particles leads to entanglement.
- For context, come to talk GH11 or see arXiv:1703.10620.

Two particles trapped in an infinite square well

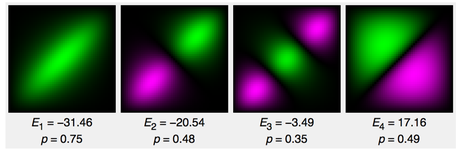
Adjust the strength and range of the interaction.

Smaller p means more entanglement.

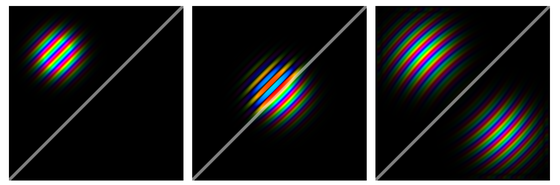
Repulsive interaction



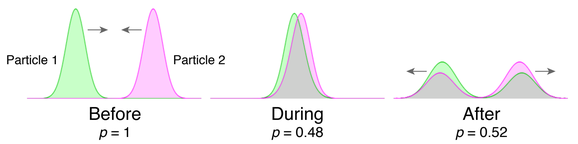
Attractive interaction



Two colliding particles with short-range repulsion



Wavefunctions



Probability densities

Want to see the source code? Just select View Source (or Page Source) in your browser, and Save Page As to download a copy. Not only are these apps free and open-source software; they were written by a full-time physics teacher who doesn't know any fancy coding tricks. Each app is a *single HTML file*, < 64k.