

## 1 Eigenvectors of the Rotation Matrix

The orthogonal matrix

$$R_z(\theta) = \begin{pmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

corresponds to a rotation around the  $z$ -axis by the angle  $\theta$ .

- (a) Find the eigenvalues of this matrix.
- (b) Find the normalized eigenvectors of this matrix.
- (c) Describe how the eigenvectors do or do not correspond to the vectors which are held constant or “only stretched” by this transformation.

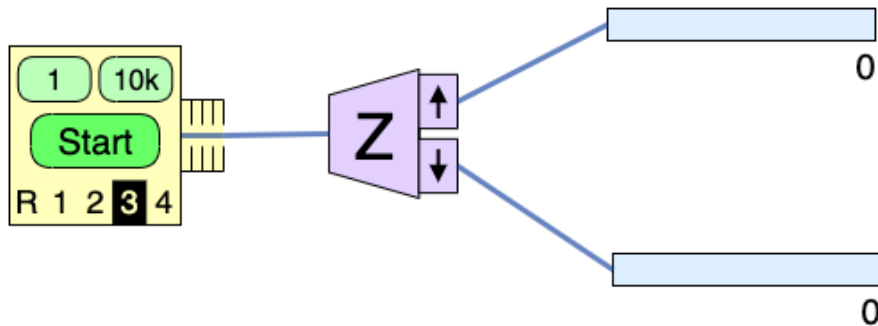
## 2 Stern Gerlach Explain

- (a) Use words and equations to explain the key features of the Stern-Gerlach experiment.
- (b) *Contrast Classical/Quantum* Explain what you would predict based only on classical physics for the Stern-Gerlach experiment and describe the difference between the classical prediction and the actual experimental results.

## 3 Statistical Analysis of the Spins Sim

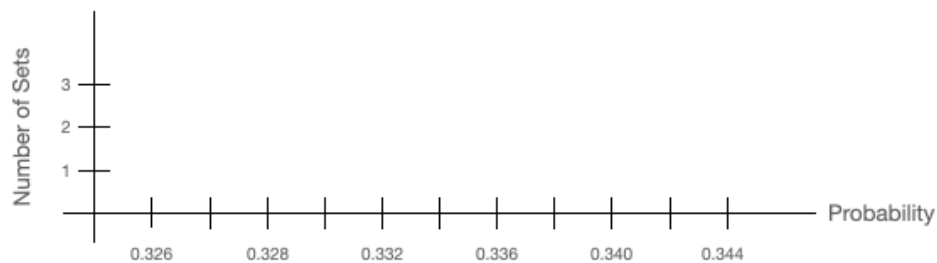
In the spins sim, the oven can be set to emit particles in a particular unknown prepared state (instead of in a random state).

- Set the oven to Unknown #3.
- Orient the analyzer in the  $z$ -direction.
- Perform 5 sets of 10,000 Stern-Gerlach experiments (10,000 particles are sent through a Stern-Gerlach Analyzer) and record the number of particles that end up in the top counter.
- For each set of experiments, calculate the probability that a single particle was measured to have  $S_z = +\hbar/2$ .



Do all of the following calculations by hand (you can use a calculator to help with the arithmetic).

- (a) Plot a histogram of the probabilities you measured for each set. Use a bin size of 0.002 for the horizontal axis. (Choose appropriate values on the horizontal axis. You don't need to plot the full possible values 0-1. You may use a computer to make the histogram or you can sketch it by hand.)



- (b) What is your best estimate of the probability that, when you measure  $S_z$  of a particle in the Unknown #3 state, you will get a result of  $+\hbar/2$ ? Mark this value on your histogram.