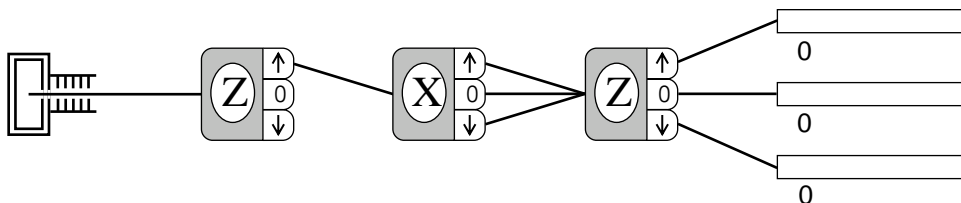


SPINS Lab 3

1. Choose the Spin-1 case under the Design menu. Set up an experiment for successive measurement of spin projections. The first analyzer will prepare the atom in a state  $|\psi\rangle$ . The second analyzer will then project this state vector onto one of the eigenstates corresponding to the spin projection along the axis of the second analyzer. If we call this eigenstate  $|\phi\rangle$ , then the probability that the atom is detected in that channel is  $|\langle\phi|\psi\rangle|^2$ . Your experiment will allow you to measure this probability. Remember that this is the probability that an atom leaving the first analyzer also makes it through the second analyzer to the appropriate detector, and not the total probability for getting from the oven to the detector. Fill in the experimental table on the worksheet with your measured values corresponding to all three choices of axes for each analyzer. Use the expressions for the spin eigenkets on the spin reference sheet to calculate all these same probabilities and fill in the theory table.

2. Choose Unknown #1 under the Initialize menu. This will cause the atoms to leave the oven in a definite quantum state, which we call  $|\psi_1\rangle$ . Now measure the nine probabilities  $|\langle\phi|\psi_1\rangle|^2$ , where  $|\phi\rangle$  corresponds to spin projections of  $\hbar$ , 0,  $-\hbar$  along the three axes. Fill in the table on the worksheet. Figure out what  $|\psi_1\rangle$  is. Repeat for Unknown #2 ( $|\psi_2\rangle$ ), Unknown #3 ( $|\psi_3\rangle$ ), and Unknown #4 ( $|\psi_4\rangle$ ). In solving for the unknown states, use the convention that the coefficient of  $|1\rangle$  is chosen to be real and positive. Design an experiment to verify your results. (Note that this problem is also part of Practice problem set #2).

3. Make an interferometer as shown:



Use Random as the initial state. Measure the relative probabilities after the final SG device. Do this for the seven possible cases where one beam, a pair of beams, or all three beams from the middle SG device are used. Record your results in the experiment part of the worksheet table. Use the projection postulate to calculate and fill in the theory part of the table and compare to the experiment. (Note that this theory calculation is also part of Homework set #3).

SPINS Lab 3 Worksheet

Experimental Table

$ \langle\phi \psi\rangle ^2$	$ 1\rangle$	$ 0\rangle$	$ -1\rangle$	$ 1\rangle_x$	$ 0\rangle_x$	$ -1\rangle_x$	$ 1\rangle_y$	$ 0\rangle_y$	$ -1\rangle_y$
$\langle 1 $									
$\langle 0 $									
$\langle -1 $									
${}_x\langle 1 $									
${}_x\langle 0 $									
${}_x\langle -1 $									
${}_y\langle 1 $									
${}_y\langle 0 $									
${}_y\langle -1 $									

Theory Table

$ \langle\phi \psi\rangle ^2$	$ 1\rangle$	$ 0\rangle$	$ -1\rangle$	$ 1\rangle_x$	$ 0\rangle_x$	$ -1\rangle_x$	$ 1\rangle_y$	$ 0\rangle_y$	$ -1\rangle_y$
$\langle 1 $									
$\langle 0 $									
$\langle -1 $									
${}_x\langle 1 $									
${}_x\langle 0 $									
${}_x\langle -1 $									
${}_y\langle 1 $									
${}_y\langle 0 $									
${}_y\langle -1 $									

Unknown  $|\psi_1\rangle$ 

Probabilities	Axis		
Result	x	y	z
$S_i = \hbar$			
$S_i = 0$			
$S_i = -\hbar$			

Unknown  $|\psi_2\rangle$ 

Probabilities	Axis		
Result	x	y	z
$S_i = \hbar$			
$S_i = 0$			
$S_i = -\hbar$			

Unknown  $|\psi_3\rangle$ 

Probabilities	Axis		
Result	x	y	z
$S_i = \hbar$			
$S_i = 0$			
$S_i = -\hbar$			

Unknown  $|\psi_4\rangle$ 

Probabilities	Axis		
Result	x	y	z
$S_i = \hbar$			
$S_i = 0$			
$S_i = -\hbar$			

## Spin 1 Interferometer

Beams	Experiment			Theory		
	$\mathcal{P}(1)$	$\mathcal{P}(0)$	$\mathcal{P}(-1)$	$\mathcal{P}(1)$	$\mathcal{P}(0)$	$\mathcal{P}(-1)$
$ 1\rangle_x$						
$ 0\rangle_x$						
$ -1\rangle_x$						
$ 1\rangle_x,  0\rangle_x$						
$ 1\rangle_x,  -1\rangle_x$						
$ 0\rangle_x,  -1\rangle_x$						
$ 1\rangle_x,  0\rangle_x,  -1\rangle_x$						