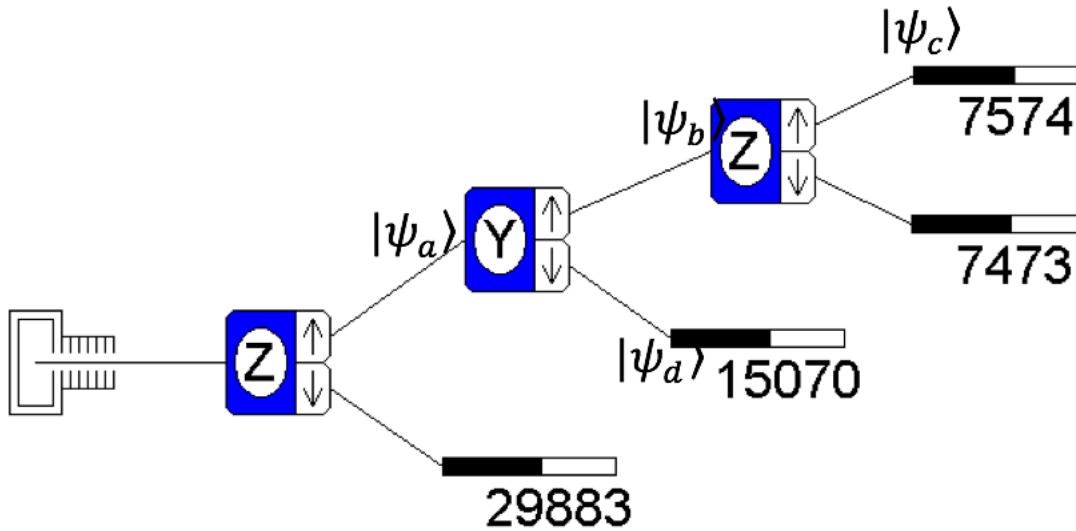


1 Chained Stern-Gerlach (Brief)

Consider the Stern-Gerlach set-up shown, with a thermal oven source, and some state vectors associated with various analyzer outputs:



- How many particles were released from the oven?
- Write down Dirac notation expressions for $|\Psi_a\rangle$, $|\Psi_b\rangle$, $|\Psi_c\rangle$, and $|\Psi_d\rangle$ in the S_z basis (i.e., as linear superpositions of $|+\rangle_z$ and $|-\rangle_z$).

2 Spin One Half Unknowns (Brief)

Using the SPINS simulation for a spin- $\frac{1}{2}$ system (Spins simulation), for the unknown initial state $|\psi_4\rangle$, perform measurements of S_x , S_y , and S_z separately, and for each measurement determine the probability of obtaining each possible measurement value. (We carried out the same procedure for $|\psi_3\rangle$ in class; you may refer to that example.)

- Use the probabilities you observed from the measurements to express $|\psi_4\rangle$ as a linear superposition of the S_z -basis states $|+\rangle$ and $|-\rangle$.
- Articulate a Process:* Write a set of general instructions that would allow another student in next year's class to find an unknown state from probabilities obtained from spin measurements.
- Compare Theory with Experiment:* Design an experiment that will allow you to test whether the state you identified in Question (a) for the unknown state $|\psi_4\rangle$ is correct. Describe your experiment here, clearly but succinctly, as if you were writing it up for a paper. Do the experiment and discuss your results.

- (d) *Make a Conceptual Connection:* In general, are the probabilities obtained from spin-component measurements along only two spin directions (for example, the z direction and the y direction) sufficient to determine a spin- $\frac{1}{2}$ quantum state? Why or why not?

3 Spin Calculations (brief)

A set of spin-1/2 particles are identically prepared in the state

$$|\psi_A\rangle = N \left(\sqrt{3} |+\rangle + e^{i\pi/3} |-\rangle \right)$$

- .
- (a) Determine N so that the state is normalized.
 - (b) What values of the z -component of spin might you measure and with what probabilities?
 - (c) What values of the y -component of spin might you measure and with what probabilities?
 - (d) Write this state in the S_x basis (i.e., as a linear superposition of $|+\rangle_x$ and $|-\rangle_x$).
 - (e) In what direction would you have to orient a Stern-Gerlach analyzer so that ALL the particles prepared in the state $|\psi_A\rangle$ would be measured to have a spin component in that direction equal to $+\hbar/2$? Give the direction in spherical coordinates, θ and ϕ .