1 Prerequisite Knowledge

- Be familiar with the results of Stern-Gerlach measurement results for spin-1/2 systems
- Quantum states are generally in superpositions of eignstates of the observable quantity.
- The probability of measuring a particular value is the norm squared of the expansion coefficient of the term that corresponds to the appropriate eigenstate when the state is written in the basis of the measured observable.
- A projection operator is a linear transformation that picks off a component of a state vector
- Quantum state vectors must be normalized.

2 Activity: Introduction

The instructor ask for volunteers for an activity that is a conceptual play of what happens during a quantum measurement.

The instructor can remind students of the prerequisite understandings as a lead into the activity.

3 Activity: Overview

- The instructor should narrate each aspect of the play as they give instructions to the volunteers throughout the play.
- Each student volunteer should line up on one end of the room with a small whiteboard.
- Each student should write down a spin-1/2 quantum state on their whiteboard in whatever basis they want.

$$|\psi_{student}\rangle = c_{+,n}|+\rangle_n + c_{-,n}|-\rangle_n$$

- The instructor represents a Stern-Gerlach analyzer, and has a stack of projection operators corresponding to the eigenstates of the observable. The instructor should also have something that represents a die.
- A student approaches the instructor, who represents a measurement device. The instructor tells the student what observable the instructor measures.
  - The play works best when the instructor measures either S_x and S_y (but not S_z). (For this description, I'll use S_y.)
- The instructor asks the other students in the class to re-represent the students' state in the basis of the observable. The student erases their whiteboard and writes the same state in the new basis.

$$|\psi_{student}\rangle = c_{+,x}|+\rangle_x + c_{-,x}|-\rangle_x$$

- The instructor asks the class to turn each probability amplitude into a probability.

- The instructor uses those probabilities to weight their die (in the interest of time, this can be stated but not literally done)
- The instructor casts the die and observes the result (e.g., $+\hbar/2$ because this is value of spin component that you read off the measurement device.)
- The instructor selects the projection operator corresponding to the result and lets that operator act on the state.

$$\Big(|+\rangle_y \, {}_y\langle +|\Big)|\psi_{student}\rangle$$

- The student renormalizes their state.

$$|\psi_{new}\rangle = {}_y\langle +|\cancel{\psi_{student}\rangle}|+\rangle_y$$

- the students passes the instructor in the direction that corrsponds to the result of the measurement.
- The play continues with the next student until several students have been "measured".