Application for ISAQC's Research Team

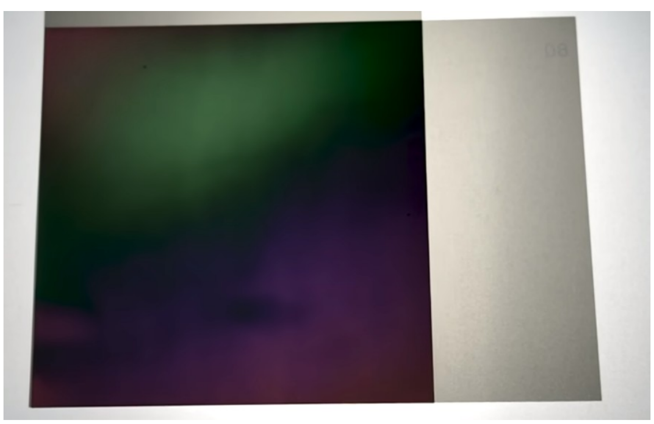
Name: Aryaman Kolhe
Batch: UG2
Roll Number: 2022121002
Email: aryaman.kolhe@research.iiit.ac.in

Problem Statement:
The superposition principal states that a state function can be expressed as a linear combination of it's normalized eigenstates. When a measurement is performed, the statefunction collapses to one of these eigenstates.
Your question: The measurement performed above is a quantum measurement, however, humans can only observe classical information. How would you "see/observe" the result of the above collapse?

Hypothesis:
We can observe the effects of a measurement on qubit using known physical phenomena based on the nature of the qubit.

Reasoning:
For example, if use photons to represent qubits, then passing the photons through a polarizer would imply a measurement.

Consider the following experiment -
If we orient 2 polarizers at an angle of 90 degrees, then no light will pass through.
This is because the first polarizer will allow light which is horizontally polarized, and the second would have allowed light which is vertically polarized, but since there is none, it doesn't pass any light.



2 polarizes at 90 degrees [1]

Now, if you place a 3rd polarizer at some angle, you'll see that light appears to pass through all 3 polarizers (counter intuitively).

This is because through the intermediate polarizer, the qubit is in a superposition of being in both horizontal and vertical polarization.

This can be mathematically modelled using the wave function.

Initially, the qubit is in an unknown state. After passing through the first polarizer, the wave function collapses to a state. WLOG, assume that the qubit collapses to ket 0 = |0>

Also note that whenever we use the term measurement, we imply measurement along a particular orthonormal basis. Assume that this basis is the computational basis (Z basis) {|0>, |1>} for the first collapse.

After the photon passes through the 2nd polarizer, its state gets changed. If the polarizer was at an angle of 45 degrees, then the photon will get *measured* along the X basis, and collapse to state |+>

|+> = (1/root(2)) * (|0> + |1>)

Now, the 3rd polarizer will perform a measurement along the Z basis, and the qubit will collapse to state |1> (since it is at and angle of 90 degrees)

If the intermediate polarizer did not exist, then we would get no light out of the last one.

This experiment works for photons, but similar experiments can be performed based on the qubit's realization (through electron spin, nuclear spin, and more).

Conclusion:
Therefore, the connection between our theoretical understanding of quantum mechanics and how it behaves in reality has been shown.

References
[1] Images from https://www.youtube.com/watch?v=txlCvCSefYQ&t=648s