**Short Report QCC**

**Name: Vinit Mehta**

**Batch: CSD 2022**

**Email id:** [**vinit.mehta@research.iiit.ac.in**](mailto:vinit.mehta@research.iiit.ac.in)

***Hypothesis:* What is the difference between classical and quantum vector superposition?**

***Reasoning:*** When we think of vector superposition the first thing that comes to our high school mind is that there are two vectors and we are adding those two vectors together to get a third vector which we call the resultant of the two vectors being added. This is just the classical mechanics view of vectors and vector addition. In quantum mechanics the things are completely different and the basis vectors here represent different possible states that the system can be in. It is very difficult for people at first to wrap their head around this concept, like what do you mean by vectors being states and how can we add different states together? This is due to the mental barrier that we face because of the reason that we have been taught all our lives only the classical mechanics as it is also sufficient for most of our practical everyday usage. To understand the quantum mechanical view you first need to let go of this classical thinking and start accepting the facts of quantum world. It presents us with a completely different universe which is not intuitive for us who have learnt classical picture of universe for whole our life.

Let us start with the most fundamental question: what are states of a system? For understanding let us consider an example of a box filled with different chocolates. Now there are some restrictions on what kind of chocolates there can be, either it can be red or blue in color and either it can be circle or square in shape. So there are 4 possible combinations that is 4 different kind of chocolates in the box. Now if we randomly take out a chocolate from the box, each chocolate has it’s own probability of coming out based on the number of each chocolates present in the box. If there are equal number of all sorts of chocolates than all 4 chocolates have an equal probability of coming out and similarly if some kind of chocolates are more than others than it has more probability of coming out than the others. So now if we define a mathematical entity that gives us the probability distribution of each chocolate coming out for a particular collection of chocolates than it is called the state of the box for that particular collection. There can be various different collections of chocolates in the box and based on it there can be various different probability distributions which are called states of the box. Mixture of different states is also called a state.

Now let us answer another question as what superposition exactly means? Superposition of different states is like overlapping of states. In classical mechanics we think like that a system will either be in one state or another at a time but it is not the case in quantum mechanics. Here the system can be in many different states all at the same time and it collapses (it’s wave function collapses, wave function is a mathematical function that contains all the information about the system and which describes the system for all possible measurements, whose square modulus gives us the probability distribution of the quantity of the system we are looking at.) in one state when we make a measurement on the system until than it is said to be in superposition of all different possible states. But there is a probability associated with each state, like what is the probability that we will find the system in a particular state when we make the measurement. To understand this consider that we are performing an experiment on a quantum system that has two possible states. Now if we perform the experiment on the same system many a times and note the outcome, we in case find that for 40% of the time the system was measured to be in state 1 and for the rest 60% of the time the system was measured to be in state 2, than we say that 0.4 is the probability associated with state 1 and 0.6 is associated with state 2. Combining these we get the final superposition state of the system.

Superposition state = A x state1 + B x state2

Where A and B are coefficients of different states which on squaring gives the probabilities of system being in those individual states. It is just analogous to the vectors in classical mechanics where the coefficients denote the contribution of each basis vector in the resultant vector.

***Conclusion:*** In classical vector superposition we are taking two basis vectors and adding them together with different contributions to get a resultant vector. But the quantum vector superposition represents the superposition of various quantum states of a system. The basis vectors represent different quantum states that the system can be in and combining them together gives us the current superposed state of the system which is represented by the wave function of the system. So quantum superposition is like being dead and alive at the same time until and unless one of your friends asks you whether you are alive or not because you haven’t texted him in a while :)