# Interpretations of
# **Quantum Mechanics**


## Abstract:

In this article at first there is a historical note of experiments and observations that lead to Quantum mechanics and after that some interpretations of QM (**Complementarity, Copenhagen, and Choice interpretation)** are briefly introduced.


Name of course: Technical language


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# Introduction

About the beginning of $20^{th}$ century some experiments and observations could not be explained by classical physics. And it was appeared that classical physics is incomplete to explain microscopic size events that occur in these experiments.
The first real challenge came in 1900 when Max Plank introduced the concept of the quantum of energy. Then in 1905 Einstein showed that light itself is made of discreet bits of energy (or tiny particles), called photons, each of energy $h\nu$ , $\nu$ being the frequency of the light (particle like behavior of wave).
Then in 1923 made an important discovery that gave the most conclusive confirmation for the corpuscular aspect of light.
In 1923 postulated that not only does radiation exhibit particle like behavior but, conversely, material particles themselves display wave like behavior. This concept was confirmed experimentally in 1927 by Davisson and Germer; they showed that interference patterns can be obtained with material particles such as electrons.
This was wave particle duality. That was a beginning for QM, and physicists started to explain it with their theories and interpretations. [1]

# Interpretations of Quantum Mechanics

### 1. Complementarity interpretation

There is a favorite statement of Bohr's principle of Complementarity, that try to explain wave particle duality:

"But what is light really? Is it a wave or a shower of photons? There seems no likelihood for forming a consistent description of the phenomena of light by a choice of only one of the two languages. It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do." -- Albert Einstein and Leopold Infeld, **The Evolution of Physics**, pg. 262-263.
He wanted to say that we can think of for example an electron as a wave or as a particle, but we can not think of it as both at once. But in fact electron is both at once. [3]

### 2. Copenhagen interpretation

There is a brief explanation about Copenhagen interpretation: We can not do measurement on a system without disturbing it, but sometimes, disturbing is ignorable and sometimes is not. An example by Bohr may clarify:

We customarily think of the outside world as separate from ourselves, and the boundary between the two is the surface of our skin. However, think of a blind person who gets around with the assistance of a cane. In time that person will probably treat the cane as part of his or

her body, and will think of the outside world as beginning just at the tip of the cane. Now imagine the blind man's sense of touch extending out of the tip of the cane and into the roadway itself. Imagine it extending further, down the block, into the countryside, to the whole world. There is no point where the blind man ends and the world begins. Similarly, we can not say which is the system and which is us observing it.
This is the heart of the Copenhagen interpretation. [3]

## 3. Choice interpretation

This interpretation says that our world design intelligently and has a purpose. And uncertainty is because of intelligent choices that particles do.
A good explanation of this interpretation is this experiment:

### College experiment

On the outskirts of a large metropolis, a group of highly intelligent college students was given a project: to investigate the “strange” behavior of electromagnetic (EM) waves in the frequency range around 1.9 GHz, without being told that this frequency range is used for the digital mobile phone network.
To quantify their observations students have chosen two parameters: the frequency and the intensity of EM oscillations. Using receivers, scanners and spectrum analyzers they soon concluded that the EM waves in the above frequency range behaved in an unpredictable random way.
They found that at any particular frequency the intensity of EM oscillations was highly uncertain. They also noticed, that there was a high degree of certainty that at “some” frequency a particular intensity level actually occurred at any given time. The problem was that it was impossible to predict at “which” frequency it happened at any given moment. They also encountered serious problems with the accuracy of their measurements. For example they noticed that their frequency estimates appeared "blurred" because the EM waves appeared in "lumps" or "bursts" that were very brief.
Inspired by “quantum mechanics”, highly promoted in the 20$^{th}$ century, students decided to adopt a similar approach. They defined their own “uncertainty principle”, established bounds for their “uncertainty” and adopted a clever statistical approach, focusing on predicting the “probability” of observable events.
After a few months of work, the students had become very proud of their “theory”, because it could actually *predict probabilities* of many events in their frequency band. They had become quite convinced that their theory actually “described the Reality”. Statistically speaking - it DID...

Did you notice, however, that by adopting a statistical approach our students have completely MISSED millions of very real intelligent conversations? Isn’t it obvious that their conclusion has been determined and limited by their imagination?

Our students just couldn't imagine that what *appeared* to them as "random" was actually the consequence of a very intelligently encoded information transfer. As a result - they didn't even try to decode anything.
Let's analyse in more detail why and how our students developed their belief in a "random process". The primary reason for their belief was that they couldn't make any deterministic predictions about the EM waves they observed.
Note that there was nothing "random" in the EM waves. In reality, millions of people were making billions of intelligent CHOICES in their individual conversations every hour. For the purpose of the information transfer, all these choices were being continuously encoded into EM waves several thousand times per second. Our students had failed to imagine and explore this possibility, so they concluded that they had observed a "random" process.
Don't you feel uneasy about the fact that the entire science on Earth in the 21st century is built around the "uncertainty principle"? Aren't we missing something truly important about the Universe?
"Not appearances, but what is *behind* them is the most important" [2]

# Conclusion

There are some interpretations of QM but some physicists such as Richard Feynman stated that they never understand QM.
This may be because QM is not understandable, at least in usual sense of the meaning of the world understandable or may be because QM is incomplete and we need to a newer theory that can explain our world.
I think that the last interpretation (choice interpretation) can be a beginning for a new theory.

# References

[1] Zettili, N., Quantum Mechanics: Concepts and Applications, vol 1
[2] Chalko, T.J., Is chance or choice the essence of Nature? NU Journal of Discovery Vol 2, March 2001, (c) Natural Uni 2001, http://NUjournal.net
[3] Harrison, D.M., Dep. Of physics, University of Toronto, harrison@physics.utoronto.ca in March 2000.