Determinism, Quantum mechanics and things in between

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Abstract

All of us, at some point in our lives, have thought about the question, does all of this even mean anything? And soon enough we delve into deeper questions like what will be of humankind? Or will we ever truly understand things the way they are? Although physics doesn't aim to answer these exact questions, it does try to understand our place in the universe. Here we will be looking at the causal nature of physics and where it breaks down. I start off by explaining why determinism is necessary to study from sciences' point of view and briefly look into the tendency of the human mind to look for causation. Further, I expand on the topic of Determinism in physics, its history, how we reached where we are today, and how our definition of determinism has changed over time. As necessary, I introduce certain new topics to explain my point. In conclusion, I make remarks about anthropocentrism and how it affects our perceptions of reality and our understanding of things around us.

Keywords: Causal Determinism, Quantum physics, Classical Physics

1 Introduction

"The search for causation is an instinctive tendency of the human mind"

-De Broglie

Evolutionary psychology may very well have something to do with us trying to search for hidden patterns everywhere and trying to associate particular causes to their effects. Other than the ethological aspects and it being an evolutionarily beneficial trait, these could be futile attempts and we could be searching for patterns when there aren't any. Or there could really be an underlying causal and deterministic infrastructure holding all scientific phenomena together and we just need to look deeper.

The basis of determinism, especially causal determinism can be summed up in the following phrase "ex nihilo nihil fit" or "Nothing comes from nothing".We

want to explain why the universe is the way it is, why certain things are the way they are. We want to know what the limits of human knowledge are and whether all phenomena can be explained. These questions have risen time and again throughout history and refuse to die down. Simply because we haven't found a definitive answer.

2 Determinism in Physics

Physics up until the advent of Quantum physics had a very strict notion of determinism. Cultural and religious influences also left very little room for free will. Quantum physics, was thought to be the end of determinism because of its probabilistic nature. However, here we discuss arguments that make an attempt to show indeterminacy or pseudo-determinacy in classical physics and determinacy in quantum physics.

Quantum physics is deterministic in most of the cases, however, being causally deterministic is something we cannot say certainly. The determinism of Quantum mechanics is different from that of Classical mechanics. Classical mechanics (in most cases) works on strict causal principles. Quantum mechanics, on the other hand, bases itself on probability and statistical determinism.

When we talk about single-particle dynamics, this is where causal determinism seems to break down. Let us start by understanding what leads to this breakdown. On performing the double-slit experiment with single particles, say photons, we come across the wave-particle duality. In simple terms, when the single-photon is not observed (by a detector prior to it reaching the final detector after passing through the slits) it behaves like a wave and its outcome (interference) can be calculated using wave mechanics. However, if we do place a detector before the photon reaches its final destination, it behaves like a classical particle and no interference is observed. Nothing has challenged these observations yet. The calculation of the outcomes in such cases had to be done using probability. This led to the death of determinism. In the Mach Zehnder experiment with single particles, multiple causes giving rise to the same effect (the indistinguishability principle) proves that causality in its strict sense is not there. However, the outcomes are very much predictable by mathematics, in terms of probability. The greater the probability, the more predictable it is. Its predictability proves its deterministic nature. So Quantum physics may not all be indeterministic. It has deterministic elements and hence we cannot outrightly reject the theory.

Speaking about Classical mechanics, although causation may exist, this does not guarantee the predictability of events. Much as the existence of an all-encompassing theory is implausible, there could always be certain micro-events that we may fail to consider, hence losing the predictable nature of a phenomenon. Hence, events may well not be strictly deterministic in that sense.

An example in the case of Classical indeterminacy could be the Three-body problem. The solutions of an 'n- body' problem are not strictly deterministic, as

we see in case of other classical problems. It may have solutions but we do not have a general solution, and so these solutions have strict causal determinism to offer. Newtonian mechanics, with its assumptions and conditions, gave us a definite causal answer. This shift from the rigidness is what is being referred to. We do not want to restrict our definition of causality however at the same time we do not want to broaden our definition so much that it becomes very inclusive.

3 Conclusion

For all we know, we may be looking at an incomplete painting or only a part of the painting, based on our narrow definition of knowledge and information. All the probable reasons to explain such phenomena come from our ideas and intuition. These ideas are, on a deeper level are influenced by our understanding of the macroscopic world. This understanding limits us. The way we perceive the world traps us so as to not look at things or imagine them in any other way. What we define as information and what we define as knowledge and even intelligence for that matter added with our experience, influence our understanding. We need to broaden these definitions, make it inclusive of aspects that fall beyond our anthropocentric standpoint, and make sure that our knowledge excludes luck.

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