God Does Not Play Dice With The Universe!

God made the Universe and We made the Laws

Sankalp Bagaria

Centre for Development of Advanced Computing (CDAC), Chennai, India

Email: sankalp[at]cdac[dot]in

Abstract – Objectives: This paper advocates Absolute Determinism in Our Universe and reinterprets Quantum Mechanics while doing so. Then it discusses some of its consequences across fields. Methods: This paper starts by proposing the Absolute Postulate of the Universe and derives Absolute Determinism using concepts from both the Classical and Quantum Mechanics. Then it advocates that though the Universe is deterministic, it is unpredictable. Statistical outcomes of a classical experiment and Probabilistic outcomes of a quantum experiment are not due to the indeterministic nature of the experiment but due to theoretical limit of calculation/ practical limit of measurement. The paper then propose that the "free will is an illusion ". As the paths of the particles are determined, the paths and interactions of neurons and neurotransmitters are determined and thus the thoughts and actions are determined. Thus, Free Will is an illusion. Then we study some consequences like an outcome of a radioactivity experiment, resolution of Schrodinger's Cat Paradox and that of EPR Paradox. We also touch upon Chaos Theory, Big Bang Theory and Consciousness. Findings: We develop on Bohmian Mechanics, Superdeterminism and Cellular Automata Interpretation and propose a new interpretation of Quantum Mechanics. Using Absolute Determinism, we also argue that Free Will is an illusion and support it with Benjamin Libet's experimental findings in Neuroscience and fMRI scans done later. We discuss deterministic but unpredictable identification of the particle that will disintegrate next among N particles collected in a block. We also attempt resolution of Schrodinger's Cat Paradox and that of EPR Paradox. Towards the end, we touch upon Chaos Theory, Big Bang Theory and Consciousness. Novelty: In our new deterministic interpretation of QM, a distinction is made between what is real in the Universe and what is measurable or calculable. For example, we reiterate that a particle's position and momentum are fixed even if we can't measure or calculate it precisely and simultaneously (a re-interpretation of HUP). In other words, we imply that the famous quote of Albert Einstein – "God Does Not Play Dice With The Universe" holds true in the realm of Quantum Mechanics also as it already does in Classical Mechanics.

Keywords - Universe, Determinism, Heisenberg Uncertainty Principle, Quantum Mechanics, Laplace Demon, Free Will, Benjamin Libet, Consciousness, Theory of Everything

1. Introduction

Since the debates[1] between Einstein and Bohr with Einstein arguing that reality is independent of the observer and QM is incomplete and Bohr arguing that reality is probabilistic and QM is complete, the correct interpretation of the Quantum Mechanics and whether the Universe is Deterministic has been debated by physicists and philosophers. The fact that this problem has survived 100 years with some of the best brains having worked so hard to solve it - shows how difficult and important it is.

We particularly studied Copenhagen[(2,3,4)] Interpretation, Many Worlds[(5,6,7)] Interpretation, Bohmian[(8,9,10)] Mechanics, Superdeterminism[(11,12,13)] and Cellular Automaton[11] Interpretation. We discuss them in Appendix A with respect to our contribution. We propose that the World is Completely Deterministic by proposing the Absolute Postulate of the Universe and use Classical Mechanics (Newton's Laws and Laplace's[14] Demon) to argue Absolute Determinism[15]. We also propose a new Interpretation that asserts the distinction between Determinism and Unpredictability in the Universe.

Though the Universe can't be predicted using calculations or measurements because there are simply too many particles required to make a reliable prediction of the Universe. Similarly, barring a few simple cases, we can't measure/ calculate outcomes of a large complex experiment. We reiterate that the Heisenberg's Uncertainty Principle[(16,17)] (HUP) puts a theoretical limit to the simultaneous measurement/ calculation of a particle's position and momentum. Although the position and momentum of the particle under study is fixed and determined since the inception of the time.

In this respect, we try to reconcile Einstein's General Relativity[(18,19)] with Feynman's Sum over Histories[(23,24)] especially in the context of Many Particle Problem[(18 to 24)]. We propose that if we consider N as being all the particles of the Universe in all space-time (4 being 3 dimensions of space and 1 dimension of time), we get an exact 4N – dimensional description of the Universe. Also, we claim that this equation gets rapidly complex as number of particles rise. And, the Universe remains incalculable – though deterministic.

We study few consequences of Absolute Determinism. In particular, we study an age-old problem - is free will real or an illusion. First question we can ask is - why ask this question in the first place. We ask this question because we are here. Then we argue that the Universe is deterministic and it was pre-determined that we will ask this question at this point. But absence of free will doesn't remove our sense of responsibility. And now, whether we feel responsible for our actions or not, is also pre-determined.

There are several schools of thought arguing different points of view on this important question. Deterministic[(25,26)] people are determined that the World is Deterministic with some arguing no responsibility for our actions. Libertarians[(27,28)] argue that we are liberated to do what we want to do with some arguing randomness doesn't mean control. We argue that our feeling of being free -

is an illusion. That's what Illusionists believe in while Compatibilists[29,30] take a middle-path between Deterministic and Libertarians. They argue that if we are free to choose according to our desires, beliefs and character - with no external agency controlling us - we can and should be held responsible for actions.

Using Classical Physics, we argue - as has been done many times before also - that Our Universe is Deterministic and paths of all the particles in all space and time are fixed. It follows that the paths and interactions of the neurons and neurotransmitters are fixed and determined. And thus, our thoughts and actions. This can be substantiated with Libet's[31] experimental findings in Neuroscience and also findings of fMRI[32] scans done after that.

We also study a few more consequences of Absolute Determinism. We also argue that though we can't predict when and which particle will disintegrate in a radioactivity experiment, it has been determined since the inception of time. We resolve Schroedinger's Cat Paradox[33,34,35] - claiming Cat is in a definite Alive/ Dead state - even if we come to know about it only when we open the box. We also resolve the EPR Paradox[36,37,38,39] by claiming the information need not travel instantaneously (or even super-luminally) because the information about the observed particle has been at the location of the second particle since the inception of the time.

We then delve into chaos[40,41,42,43] theory and claim the trajectory of a cannon ball is fixed - even if we can't calculate it precisely. Thus, if two similar cannonballs are fired in similar way, they will end at different locations because something must be different in the two cases because we can't account for everything. We end our methodology with a short discussion on the Origin and the Evolution of the Universe. Various approaches[44 to 51] already exist. We propose that the Universe started from a single particle at the inception of the time at t=0 (traditionally known as Big Bang). Then the Universe proceeded as per Laws of Physics in a Definite Classical manner. We end with a novel thought that the whole Universe is one Connected Deterministic Entity in 4-Dimensions. We define this entity – our Universe – as First Cause/ Absolute/ God/ Consciousness[52,53,54].

2. Methodology

2.1 Absolute Postulate of the Universe: If position and momentum of all the particles at all the instants is known, the Universe is completely determined.

2.1.1 Alternate Explanation: If position and momentum of all the particles at any one instant and the Laws of Physics (in particular Newton's Second Law) is known, the position and momentum of any particle at any other instant in the Universe can be precisely calculated. And thus, from the above postulate 2.1, the Universe is completely determined.

2.1.2 Many Particles System - General Relativity and Feynman’s Sum of Histories

Assuming wave particle duality and our postulate (2.1), we can assume all the particles in the Universe are waves also. We get an exact representation of the Universe in 4N dimensions, N being the number of particles in the Universe and 4 being space- time. (Similar to the space-time

description of the Many Particles[18 to 24] Universe in the already proven Deterministic General Relativity[18,19] - a generalized form of Newtonian Mechanics and Special Relativity). The possibility of breakdown at singularities needs to be studied further.

The unpredictability in both General Relativity and Quantum Mechanics is due to difficulties in calculations/ measurements of even a small number of particles/ complex multi-dimensional waves. This results in obvious problems in Classical Physics especially in Statistical Physics and theories like chaos theory. In QM, it results in models like Feynman's Sum over Histories[23,24], which consider waves that are manageable and result in approximations like probabilities of outcomes of an experiment rather than prediction of an exact outcome.

2.2 Absolute Determinism in the Universe from Newtonian Mechanics: From Corollary 2.1.1 If the position and momentum of all the particles of the Universe are known at an instant, the past, present, and future of any particle can be determined using the Laws of Physics and thus the whole Universe is determined.

Laplace's Demon[14]: $d^2r/dt^2 = F(r)$ with $r(t_0)$ as position r_0 and $(dr/dt)(t_0)$ as velocity v_0 are known for all particles. Then the past, present, and future can be precisely and accurately calculated.

As shown in point 2.1.2 above, the problem comes when the number of particles becomes too big for calculating/ measuring.

2.3 Absolute Determinism in the Universe from Quantum Physics: We advocate that QM is just a tool for calculating/ measuring results. It is imprecise and relies on probabilities of outcomes of experiments. The reality is precise and definite. Please refer to Appendix A for Discussion on our Interpretation of QM and some of the other popular Interpretations of QM.

Heisenberg[16,17] showed that the position and momentum of a particle cannot be measured accurately simultaneously. $\Delta x \, \Delta p >= \hbar/2$ We support that even if position and momentum cannot be calculated/ measured precisely simultaneously, the particle has definite and real values for these two quantities in the real world.

2.4 Determinism and Free Will[25 to 30] – Basic concept of Free Will consists of two steps: (1) decision-making and (2) decision implementation. As the Universe is definite - motion of all the particles from Start to Finish of the Universe will be defined, free will cannot exist. As the motion of particles building neurons and neurotransmitters is fixed and definite, the thoughts formed because of motion of these neurons and neurotransmitters is also fixed. And, hence, the Free Will is an Illusion.

This is consistent with Benjamin Libet's[31] experimental findings that Readiness Potentials (RP) starts building up to implement a "voluntary" action approximately 350 ms before the conscious brain becomes aware of the decision. fMRI[32] scans done after him confirm his findings. Please refer Appendix B for discussion on our thoughts on Free Will and other major schools of thought on Free Will.

2.6 Calculation and Prediction of Future - Even if the world is deterministic, the future (or past for that matter) cannot be predicted accurately because of the following reasons: (1) The sheer large number of particles (barring some simple cases) to be considered for making a reliable prediction is formidable; (2) Heisenberg's Uncertainty Principle prevents us from calculating/ measuring the position and momentum of the particles precisely. We feel (2) may be derived from the (1) above.

2.5 Determinism and Radioactivity – In the basic radioactivity formula $dN/dt = -\lambda N$, we can't predict which particle will disintegrate but can predict that half of the initial particles will disintegrate in one half-life of the element in question. We claim that even if we can't calculate which particle will disintegrate, it is pre-determined.

2.6 Schrodinger's Cat Paradox[33,34,35] – A cat is placed in a closed box where a poison is released upon radioactive decay of an element. According to the Copenhagen Interpretation of QM, it is assumed that the cat is in a superposition state of dead and alive till the door is opened. On opening the door, the wave function of the cat collapses and the cat is found dead or alive. The paradox is how can a macro-animal like a cat be in a superposition state. We claim that depending on the radioactive decay of the particle and subsequent release of poison at time t_0, the cat is in a definite state – dead or alive. We just don't know it till we open the door to the box.

2.7 EPR Paradox[36,37,38,39] – EPR Paradox challenges Copenhagen Interpretation of Quantum Mechanics in that the changes in quantum states can travel from one particle's location to that of the other particle instantaneously. We advocate that as the Universe is completely deterministic, changes in one particle's state need not travel instantaneously (or at super-luminal speed) because the information about the state of the first particle is already there at the location of the second particle since the inception of the Universe.

2.8 Chaos Theory[40 to 43] – Two cannon balls are thrown one by one from the same cannon – keeping everything the same. Still, they land at two slightly different places. We advocate that there are some changes in the Universe that have taken place between the two experiments and that we have not accounted for that and that causes this change of results in these two experiments. If we knew position and momentum of all the particles in the Universe, we could have calculated precise trajectories of the two balls

2.9 Origin and Evolution of Our Universe[44 to 51] (Starting with a Single Particle at Big Bang)

(1) At Big Bang (defined as the First Cause), with $x=y=z=t=0$, the Universe starts with a single particle with fixed position and momentum.

(2) At $t = t_0$, 1st particle disintegrates into 2 or more particles - each with fixed position and momentum.

(3) These particles can collide with each other, get absorbed (end of the particle) or disintegrate (create more particle) - always with fixed starting position and momentum of each particle - and governed by Newton's 2nd Law of Motion.

(4) And so on.

(5) This way when paths of all the particles from inception (creation of particle) to end (absorption on collision or spontaneous decay) is charted in space-time, the Universe is fully defined When you have drawn trajectories of all the particles in all space and time, you have the Universe.

2.10 Consciousness

When we say we are Conscious[52,53,54], we usually mean our body and its boundary. But when we inhale or eat, we take in particles in our so-called body, process them, assimilate them, grow/ repair tissues and eject particles when we exhale or excrete. So, there is no fixed body. And thus, there is no individual consciousness. In fact, the whole Universe is one connected deterministic entity in 4-dimensions. All the particles are connected to each other as one Absolute/ Universe/ Consciousness/ God.

Results and Discussion-

In this paper, we start with postulating the Absolute Principle of the Universe - If the position and momentum of all the particles for all instants is known, the Universe is completely defined. We discuss its another explanation - Laplace's Demon[14] based on Newtonian Mechanics - if position and momentum of all the particles are known for any one instant and the Universe evolves according to Laws of Physics (read Newton's Second Law of Motion), the Universe is Completely Determined.

We then study the Many Particles System with respect to General Relativity[18,19] and Feynman's Sum over Histories[23,24]. We propose that if the space-time curvature is defined for the whole Universe, the motion of all the particles is defined in this space-time. And by Wave Particle Duality, if we consider the 4N-dimensional wave due to all the N particles in the Universe, the Feynman's Sum of Histories gives the exact description of the Universe.

Then we study several Interpretations of Quantum Mechanics. in particular Copenhagen[2,3,4], Many Worlds[5,6,7], Bohmian Mechanics[8,9,10], Superdeterminism[11,12,13] and Cellular Automaton[11] Interpretation and offered a new Deterministic Interpretation that is compatible with the Classical Mechanics underlying the Quantum Mechanics. We claim that the outcomes of a QM experiment are probabilistic because we have considered a limited set of particles in our experiment. If we would have considered all the particles (a theoretically and practically impossible task), we would have got exact results. That is, the unpredictability of outcome is due to limitations of calculation/ measurement. Reality beneath is Deterministic.

We interpret HUP[16,17] as putting a theoretical and practical limit to calculation/ measurement of a particle's position and momentum simultaneously as has been done before also. A crude analogy is that the value of Pi can be calculated to any precision we wish but never get a complete exact value. We can approximate reality but can never understand it completely. We then argue that the paths of particles are deterministic in reality and thus paths/ interactions of neurons and

neurotransmitters are fixed since the inception of the Universe. Thus, our thoughts and actions resulting from them are fixed. Thus, Free Will is an Illusion. We substantiate this with Libet's experiments and fMRI scans done later. This is in agreement with the views of Deterministic[25,26] Illusionists in contrast to the views of Libertarians[27,28] and Compatibilists[29,30].

We then study the outcomes of a simple radioactivity experiment in which we can't predict which particle is going to disintegrate but the outcome is fixed since the inception of time. We then resolve Schroedinger's Cat Paradox[33,34,35] - After the decay of a poisonous radioactive particle at $t = t_0$, the cat is in a definite state - dead or alive. Just that we come to know of the result only upon opening the box. We then argue that the EPR Paradox[36,37,38,39] can be resolved by claiming that the information need not travel instantaneously (or even super-luminally) because the information about the first particle is at the second particle's position since the beginning of the Universe.

We examine the fundamentals of chaos theory[40,41,42,43]. We claim that the outcome of the experiment in which two balls are ejected from the canon one after another is well defined though can't be predicted. The balls arrived at somewhat different locations because between the two tests, some things changed - no matter how subtle like rotation of Earth, wind direction etc. If everything were the same (an impossibility) we would have got the same results.

Towards the end, we study the Big Bang[44 to 51] in the light of Absolute Determinism. We claim that the Universe started with a single particle at time t=0 and proceeded Deterministically. We pause the discussion with the novel thought that the whole Universe is one connected[52,53,54], fixed deterministic entity in 4-Dimensions (space-time). We can call this entity Universe/ Absolute/ Consciousness/ God etc.

4 Conclusion and Future Work

We start this paper with proposing the Absolute Postulate of the Universe. We postulate that if the positions and momentums of all the particles for all the time are known, the Universe is completely defined. Universe is Absolute and Completely Deterministic. We propose a new deterministic interpretation. of QM that argues that reality (fundamentally deterministic) and prediction (using probabilistic outcomes) are not incompatible. We discuss various interpretations[2 to 13] of QM in Appendix A.

Though we briefly discussed GR in 2.1.2, this paper mainly uses Newtonian Mechanics as base for presenting the Absolute Determinism and other results due to Classical Physics. Extending the results to Special and General Relativity[18,19] will be good. For example, we feel if the positions of all the particles in the 4-D space-time fabric is known the Universe is completely defined. If we are able to prove that HUP[16,17] is due to theoretical inability to calculate the effect on the particle in question by all the rest of the particles in the Universe, QM will reduce to an approximation of Deterministic Classical Physics.

Another angle that may be pursued is that if we extend Sum over Histories[23,24] Equation to include all the particles in the Universe, we will have an Absolute, Exact and Deterministic Description of the Universe. We feel this can be done because of duality of particle and wave. Obviously then Feynman's Sum over Histories becomes an approximation of such a description of the Universe. Only this approximated version can be calculated and measured.

We feel that the Absolute Postulate of Our Universe (after suitable modification in accordance with General Relativity) along with the re-interpretation of QM and HUP will have implications for Theory of Everything and will help in developing Equations for it. We propose that the Universe is Fully Continuous and Deterministic with Statistical Physics (in Classical Domain) and Probabilities (in Quantum Domain) due to theoretical limitations of calculations/ measurements.

We then discuss various consequences of Absolute Determinism. In particular, we assert that the Free Will is an Illusion because the Universe is completely deterministic with paths of neurons/ neurotransmitters being well-defined due to the fixed paths of particles constituting them. Thus, thoughts are fixed since inception of Universe. This is substantiated with Libet's[31] experiments and later fMRI[32] scans in Neuroscience. We discuss several schools of thought[25 to 30] and our position of Free Will in Appendix B.

We also discuss how Absolute Determinism affects outcome of radioactivity experiment, resolution of Schroedinger's Cat Paradox[33,34,35] and resolution of EPR Paradox[36 to 39]. We then discuss a result regarding chaos theory fundamentals. We end the paper with Big Bang Theory explained in the context of Absolute Determinism. We end this discussion with a novel thought that the Universe is One Connected Deterministic Entity in 4-Dimesnsions. So, the Whole Universe can be defined to be the Consciousness/ the First Cause/ the Absolute/ the Everything/ God and so on.

Consciousness[52,53,54] can be defined as being aware of one's body and the boundary between what is inside body and what is outside. As particles keep entering our so-called body eg, by inhalation or intake of food, process the particles that entered and use them to grow/ repair ourselves and some other particles keep leaving our body eg, by exhalation or excretion, the boundary of our "bodies" is not fixed. A claim of individual Consciousness is thus unreal. We also feel that the Universe is One Connected Deterministic Entity in 4-Dimensions and that is Consciousness. But more discussions/ experiments are required.

Appendix A

Discussion of Main Existing Interpretations of QM with respect to Our Interpretation

There are several interpretations of Quantum Mechanics - some indeterministic like Copenhagen[2,3,4] Interpretation and some deterministic like Many Worlds[5,6,7] Interpretation and Bohmian Mechanics[8,9,10].

Copenhagen Interpretation advocates the Universe is fundamentally probabilistic. That is, only probabilities of outcomes of an experiment can be calculated – and that is the only "real" thing that is in the Universe. This view, though very popular, could not be reconciled with Classical Physics which advocates the Universe is deterministic. Schroedinger's Cat Paradox[33,34,35] and EPR Paradox[36 to 39] could not be explained.

The Many Worlds Interpretation of Quantum Mechanics advocates Universe is completely deterministic. According to this interpretation, the Universe branches out in many universes for each possibility. We feel such a Multiverse is unrealistic because of issues like how does new universe(s) "fill in" with stars and galaxies in an instant. Moreover, as many have noted - such a Multiverse is unverifiable.

As per Superdeterminism[11,12,13], choices made by experimenters are not actually "free". We claim that the Determinism at particle level implies Superdeterminism as human experimenters are made of particles. So, if path of particles is pre-determined, so is experimenters' thoughts and choices. Because path of neurons and neurotransmitters (made of particles) is pre-determined and thus thoughts (due to precise interaction of neurons and neurotransmitters) is pre-determined.

Bohmian Mechanics argues that a given particle has a definite position and trajectory - as guided by pilot wave - that may interfere with other waves (even empty waves) just like Schrodinger Equation. The randomness seen in QM is due to uncertainty in initial conditions of the particle. Bohmian Mechanics is inherently non-local - requiring faster than light travel and assumes hidden variables that can't be measured due to HUP and 3N dimensions for the wave to propagate.

While proposing a slightly new interpretation of QM, we also argue absolute determinism along with unpredictability. This unpredictability is due to the sheer large number of particles (ideally whole Universe) that need to be measured/calculated for reasonably precise calculation of an event. HUP also puts theoretical limit to precise and simultaneous calculation/ measurement of particle's motion.

We propose Absolute Determinism in the Universe. As per Classical Physics. QM is just a tool to calculate probabilities of outcomes - which can't be predicted precisely because there are just too many particles to include in the calculation. If we knew position and momentum of all the particles in the Universe and all the Laws of Physics, we could have predicted the precise outcome of any experiment.

Our argument is similar to Cellular Automaton[11] Interpretation in which Hooft argues that there is determinism underlying QM. He said probabilistic outcomes are epistemic and not ontic because of "hidden deterministic variables". Thus, he challenges Copenhagen Interpretation which claims waves are real. He hints waves are just mathematical tools. We developed on his ideas as described above.

Appendix B

Discussion of Main Existing Schools of Thought on Free Will with respect to Our Approach

There are several major schools of thought on free will, spanning philosophy, physics, and neuroscience. Some are discussed below:

Core belief of Determinism[25,26] is - Free will does not exist. Everything (especially human decisions) is completely determined by laws of nature and initial conditions. These ideas are supported by classical physics and ideas like Laplace's Demon[14] and by experiments like those of Benjamin Libet[31] an fMRI[32] Scans.

Counter arguments are like those from Libertarians[27,28] that Quantum Mechanics provides Indeterminism through randomness but many people have already argued that randomness doesn't mean control and intentional decision making.

We further argue that Determinism and Predictability are two different concepts. Universe is Deterministic but can't be Predicted accurately enough except in some simple cases. That is, we don't have free will because Universe is deterministic. Yet, our actions and decisions can't be calculated accurately enough as our Brain has too many particles interacting with each other and is complex.

Compatibilists[29,30] argue that we are free if we are free to do as per our wishes and desires. We argue that even if nobody is "controlling" us, our wishes, desires; decisions and actions are fixed and pre-determined. That is, it was decided at the beginning of the Universe that you will be reading and pondering over this sentence.

Using Laplace's Demon, we can argue that if position and momentum of all the particles in the Universe are known at any instant, past and future can be calculated - at least theoretically. HUP argues that position and momentum of a particle can't be measured precisely and simultaneously. We argue that particles have a definite position and momentum at any instant - though that can't be measured/ calculated as per HUP[16,17].

Also, when number of particles become large, reliable calculation of their paths in space-time becomes difficult. Thus, reliable predictability is difficult because of HUP and the difficulty in calculation/ measurement of position and momentum of a significant number of particles. Thus, though the course of the Universe or outcome of a significantly large experiment can't be predicted, it is fixed. And thus, we can't have free will.

Neuroscientific experiments like those of Benjamin Libet's seminal work in which he showed Readiness Potential (RP - electrical build-up in the brain) to implement a "voluntary" decision like flexing wrists starts rising about 350 ms before the conscious brain feels an urge to do so.

Later experiments like fMRI scans also confirm that the start of the implementation of a decision precedes conscious decision making. Signifying we humans are not conscious initiators of action. Fundamentally our "free will" is an illusion.

Our argument covers complex thoughts and decision making also - not limited to only voluntary actions - because they are also based on the same principles. Thoughts are due to the working of the neurons and neurotransmitters inside our brain. Neurons and neurotransmitters are made of particles whose paths are determined as we saw above. So, our thoughts are determined. And thus "free will" is an illusion.

Recently, using Functional Magnetic Resonance Imaging (fMRI), researchers demonstrated predicting a person's intent to move by seeing activity patterns from frontal-parietal regions, such as the premotor cortex and posterior parietal cortex, even before that person wished for that movement, corroborating with our deterministic argument.

Furthermore, research on intentional inhibition and the ability to consciously override pre-programmed actions challenges deterministic interpretations, suggesting conscious decision making. But we argue that - whether conscious decision of inhibition to override will be taken or not by the human subject - is also pre-determined - following similar reasoning as above.

References

1. Howard D. Einstein, Bohr, and the quantum foundations debate: then and now. *Stud Hist Philos Sci A.* 2023;98:84–96. Available from: https://doi.org/10.1016/j.shpsa.2023.05.004
2. Zurek WH. Quantum theory of the classical: quantum Darwinism. *Nat Rev Phys.* 2022;4:181–192. Available from: https://doi.org/10.1038/s42254-022-00449-9
3. Schlosshauer M. Quantum decoherence. *Phys Rep.* 2019;831:1–57. Available from: https://doi.org/10.1016/j.physrep.2019.05.001
4. Hobson A. There are no particles, there are only fields. *Am J Phys.* 2017;85(5):348–353. Available from: https://doi.org/10.1119/1.4811215
5. Carroll S, Singh A. Mad-dog Everettianism: quantum mechanics at its most minimal. *Quantum Stud Math Found.* 2019;6:95–104. Available from: https://doi.org/10.1007/s40509-018-00159-0
6. Vaidman L. Many-worlds interpretation of quantum mechanics. *Oxford Research Encyclopedia of Physics.* 2018. Available from: https://doi.org/10.1093/acrefore/9780190871994.013.3
7. Wallace D. *The emergent multiverse: quantum theory according to the Everett interpretation.* Oxford: Oxford University Press; 2012.
8. Dürr D, Goldstein S. Bohmian mechanics and the meaning of the wave function. *Found Phys.* 2019;49:633–645. Available from: https://doi.org/10.1007/s10701-019-00268-2
9. Norsen T. *Foundations of quantum mechanics: an exploration of the physical meaning of quantum theory.* Cham: Springer; 2017.
10. Struyve W. Pilot-wave approaches to quantum field theory. *Rep Prog Phys.* 2021;84(5):056001. Available from: https://doi.org/10.1088/1361-6633/abec6d
11. 't Hooft G. *The cellular automaton interpretation of quantum mechanics.* Cham: Springer; 2016. Available from: https://doi.org/10.1007/978-3-319-41285-6
12. Hossenfelder S, Palmer T. Rethinking superdeterminism. *Front Phys.* 2020;8:139. Available from: https://doi.org/10.3389/fphy.2020.00139

13. Hossenfelder S. Superdeterminism: a guide for the perplexed. *arXiv* [Preprint]. 2022. Available from: https://arxiv.org/abs/2010.01324
14. van Strien MV. On the origins and foundations of Laplacian determinism. *Stud Hist Philos Sci A.* 2014;45(1):24–31. Available from: https://doi.org/10.1016/j.shpsa.2013.11.003
15. Kleppner D, Kolenkow R. *An introduction to mechanics.* Cambridge: Cambridge University Press; 1973. p. 403.
16. Heisenberg W. Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. *Z Phys.* 1927;43(3–4):172–198. Available from: https://doi.org/10.1007/BF01397280
17. Heisenberg W. The physical content of quantum kinematics and mechanics. In: Wheeler JA, Zurek WH, editors. *Quantum theory and measurement.* Princeton (NJ): Princeton University Press; 1983. p. 62–84.
18. Penrose R. Gravitational collapse and space-time singularities. *Phys Rev Lett.* 1965;14(3):57–59. Available from: https://doi.org/10.1103/PhysRevLett.14.57
19. Hawking SW, Ellis GFR. *The large scale structure of space-time.* Cambridge: Cambridge University Press; 1973.
20. Kuratsuji H, Suzuki T. Path integral approach to many-body systems and classical quantization of time-dependent mean field. *Prog Theor Phys Suppl.* 1983;74:209–220. Available from: https://doi.org/10.1143/PTPS.74.209
21. The Feynman path integral formalism: atomic and molecular electronic structure. *Adv Quantum Chem.* 1991;22:7–123. Available from: https://doi.org/10.1016/S0065-3276(08)60362-7
22. Ryu WH, Voth GA. Coarse-graining of imaginary time Feynman path integrals: inclusion of intramolecular interactions and bottom-up force-matching. *J Phys Chem A.* 2022;126(35):6004–6019. Available from: https://doi.org/10.1021/acs.jpca.2c04349
23. Feynman RP. Space-time approach to non-relativistic quantum mechanics. *Rev Mod Phys.* 1948;20(2):367–387. Available from: https://doi.org/10.1103/RevModPhys.20.367
24. Man'ko OV. Feynman path integral and Landau density matrix in probability representation of quantum states. *Physics.* 2025;7(4):66. Available from: https://doi.org/10.3390/physics7040066
25. Pereboom D. *Free will, agency, and meaning in life.* Oxford: Oxford University Press; 2014. Available from: https://doi.org/10.1093/acprof:oso/9780199660026.001.0001
26. Caruso GD. *Rejecting retributivism: free will, punishment, and criminal justice.* Cambridge: Cambridge University Press; 2021. Available from: https://doi.org/10.1017/9781108698666
27. Kane R. *A contemporary introduction to free will.* New York: Oxford University Press; 2011. Available from: https://doi.org/10.1093/acprof:oso/9780195399692.001.0001
28. Clarke R, Capes J, Swenson K, editors. *The nature of free will: new essays.* Oxford: Oxford University Press; 2019. Available from: https://doi.org/10.1093/oso/9780190872251.001.0001
29. Fischer JM. *Deep control: essays on free will and value.* Oxford: Oxford University Press; 2011. Available from: https://doi.org/10.1093/acprof:oso/9780199732983.001.0001

30. Vargas M. *Building better beings: a theory of moral responsibility.* Oxford: Oxford University Press; 2013. Available from: https://doi.org/10.1093/acprof:oso/9780199697541.001.0001
31. Libet B, Gleason CA, Wright EW, Pearl DK. Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). *Brain.* 1983;106(3):623–642. Available from: https://doi.org/10.1093/brain/106.3.623
32. Soon CS, Brass M, Heinze HJ, Haynes JD. Unconscious determinants of free decisions in the human brain. *Nat Neurosci.* 2008;11(5):543–545. Available from: https://doi.org/10.1038/nn.2112
33. Schrödinger E. Die gegenwärtige Situation in der Quantenmechanik. *Naturwissenschaften.* 1935;23:807–812, 823–828, 844–849. Available from: https://doi.org/10.1007/BF01491891
34. Schrödinger E. The present situation in quantum mechanics. *Proc Am Philos Soc.* 1980;124(5):323–338.
35. Leggett AJ. Testing the limits of quantum mechanics: motivation, state of play, prospects. *J Phys Condens Matter.* 2002;14:R415–R451. Available from: https://doi.org/10.1088/0953-8984/14/15/201
36. Leggett AJ. The EPR-Bell experiments: the role of counterfactuality and probability. *Philosophies.* 2024;9(5):133. Available from: https://doi.org/10.3390/philosophies9050133
37. Kupczynski M. Statistical contextual explanation of quantum paradoxes. *Front Quantum Sci Technol.* 2025;5:1569496. Available from: https://doi.org/10.3389/frqst.2025.1569496
38. Jakumeit J, Hess K. Breaking a combinatorial symmetry resolves the paradox of EPR and Bell. *Symmetry (Basel).* 2024;16(3):255. Available from: https://doi.org/10.3390/sym16030255
39. Dong H. Quantum entanglement: from EPR paradox to modern applications. *Adv J Sci Technol.* 2025. Available from: https://doi.org/10.54097/8yfeff58
40. Zhang Y, Kumar R, Patel S. Advances in nonlinear dynamics: a new approach to chaos theory applications. *Proc Math J.* 2025;12(3):145–162.
41. Smith J, Lee K. Extending chaos theory: the role of nonlinearity in multiple mappings. *arXiv* [Preprint]. 2024. Available from: https://arxiv.org/abs/2412.12136
42. Garcia M, Chen L. Universal resonance-like emergence of chaos in complex networks of nonlinear systems. *arXiv* [Preprint]. 2024. Available from: https://arxiv.org/abs/2404.16861
43. Ali A, Hassan T. Nonlinear dynamics and chaos in mechanical oscillatory systems. *J Res Appl Sci Biotechnol.* 2024;3(2):210–220.
44. Penrose R. Singularities and time-asymmetry. In: Hawking SW, Israel W, editors. *General relativity: an Einstein centenary survey.* Cambridge: Cambridge University Press; 1979. p. 581–638. Available from: https://doi.org/10.1017/CBO9780511564206.025
45. Agullo I, Singh P. Loop quantum cosmology: a brief review. In: Ashtekar A, Pullin J, editors. *Loop quantum gravity: the first 30 years.* Singapore: World Scientific; 2023. p. 183–240. Available from: https://doi.org/10.1142/9789811203969_0007
46. Brahma S, Yeom D. The singularity problem in quantum cosmology. *Universe.* 2022;8(10):512. Available from: https://doi.org/10.3390/universe8100512

47. Brandenberger R, Peter P. Bouncing cosmologies: progress and problems. *Found Phys.* 2023;53:1–39. Available from: https://doi.org/10.1007/s10701-022-00638-y
48. Ijjas A, Steinhardt PJ. A new kind of cyclic universe. *Phys Lett B.* 2022;824:136823. Available from: https://doi.org/10.1016/j.physletb.2021.136823
49. Penrose R. On the cyclic nature of the universe. *Ann Phys.* 2012. Available from: https://doi.org/10.1016/j.physletb.2010.09.057
50. Guth AH. Eternal inflation and its implications. *J Phys A Math Theor.* 2023;56(38):383001. Available from: https://doi.org/10.1088/1751-8121/acf1b0
51. Bousso R. The cosmological constant problem, dark energy, and the landscape. *Rep Prog Phys.* 2022;85(4):046901. Available from: https://doi.org/10.1088/1361-6633/ac3b99
52. Gomez-Marin A, Seth AK. A science of consciousness beyond pseudo-science. *Nat Neurosci.* 2025;28(2):123–130. Available from: https://doi.org/10.1038/s41593-025-01913-6
53. Arachchige SN. Consciousness in the brain: an integrative review. *SSRN Electron J.* 2025. Available from: https://doi.org/10.2139/ssrn.5390906
54. Coppola F. A review of the sufficient conditions for consciousness. *Neurosci Conscious.* 2025;2025(1):niad013. Available from: https://doi.org/10.1093/nc/niad013