Undecidability, Uncomputability and Unpredictability – the three pillars of Anti-realism

Jose P Koshy (josepkoshy@gmail.com)

Introduction:

The question of reality has been a subject of debate among philosophers of the past. There have been two classes of thought, Realism and Anti-realism; the former implies that there is reality independent of any perceptions and beliefs, while the latter implies that there is no reality other than the perceptions and beliefs we have about reality. The personal experience in our day to day life makes us think that the objects that exist, including ourselves, are real. These are physical structures having mass and occupying space. So the primary question that confronts us is whether these physical structures are real or non-real. Physics deals with the study of these structures. The world described by physics is independent of what we think it to be, and it exists and continues to exist even if no one is observing or explaining it; we can call it the Physical Reality. The nature of Physical Reality, whether it is real or non-real is a subject of discussion both in physics and metaphysics.

Realism and Anti- realism in connection with physical systems:

Can there be a physically real system made up of real physical objects? Then what should be the criteria for it? Physical objects, by definition, are three-dimensional. The mere existence of these imply that there has to be space and time. The concept of Realism implies that space, time and objects are real. In the simplest case, these objects will be made up of the same fundamental units. To be real, these units and their properties should be real. That is, the units and their properties do not vanish, but get added up during integration, and hence are conserved.

To be conserved, the properties should be finite, non-varying and non inter-convertible. That is, at the fundamental level, the properties cannot be ambiguous or transferable or infinite. That means, decidability or certainty is the primary requirement for a system to be real. Adding up such properties is like adding up whole numbers, which always yields a finite number. Even if the addition goes on infinitely, at any given time, the result will be finite. That is, the system formed by such units will always be finite. Removing infinity makes the system computable.

Changes in a real system cannot be magical; that is, the changes have to happen by way of actual motion of objects from one position to the other. So motion should be a property of the objects. As properties have to be finite, the fundamental unit should be moving at a finite speed. Speed being finite, nothing can happen at infinite speed; this removes magical properties like instantaneous changes, vanishing by moving to infinity and remaining simultaneously at different places. Motion is a space-time relation that strictly follows mathematical laws. So the integration of units and the consequent changes obey mathematical laws, and so are predictable.

Anti-realism implies that our ability to observe physical objects does not confer any 'status of reality' to them. It is a subjective experience; the bodies need not actually exist. Thus it brings in undecidability; we cannot decide whether it exists or not. This view is exactly opposite to that of Realism. Naturally, the properties need not be real, that is, need not be finite, non-varying or non inter-convertible, and can be ambiguous and infinite. The bodies and properties, being not real, can just vanish; so the properties cannot add up, or are non-computable. Changes can be magical and instantaneous and need not obey any rules and so will be unpredictable.

If all the properties are non-real, the objects together cannot form a system, and this eliminates the existence of a perfectly non-real system. However, if some of the properties are real and some are non-real, there can be a physical system in which decidability, computability and predictability exist to some extent, that is, in some areas. So there will be an uncertainty regarding whether it is a real or non-real system. We will have to be satisfied with the conclusion that it is a partially-real system.

Thus, decidability, computability and predictability are the features associated with real world (Realism), and undecidability, uncomputability and unpredictability are the features associated with non-real world (Anti-realism). A physical system or its Physical Reality can be either real or partially-real, depending upon the features present in the system, but cannot be non-real.

The u-turn in the history of physics:

The history of modern physics started with the laws of motion and gravity put forth by Newton. Classical Newtonian concepts view the world as real. Laplace's determinism is its essence. Anti-realism was regarded as a subject of metaphysics by the then physicists, and they were sure that physics would triumph and a complete understanding of the physical world was immediate. But this lasted only for a brief time. Physicists came up with new theories, Quantum Mechanics (QM) based on uncertainty, and Relativity Mechanics (RM) based on spacetime. It was found that these theories could explain things at particle and cosmic levels in a better way than Newtonian Mechanics (NM). This caused confusion, and physicists started doubting whether the physical world is real.

Subsequently, QM and RM became the accepted theories at particle and cosmic levels respectively. Along with this came new ideas in the field of mathematics. Godel's incompleteness theorems and Turing's non-computable values created further confusion regarding reality. The end result was a u-turn in the history of physics; the physical world is no more regarded as real, and the deterministic idea is completely abandoned. Undecidability, uncomputability and unpredictability, the features of Anti-realism, are expected to have a crucial role in the physical world, and these have become serious subjects of discussion among physicists. But is this u-turn completely justifiable?

Any conclusion regarding the nature of Physical Reality should be based on a complete theory. As at present, all the three theories are incomplete, and it is impossible to decide which of these theories will become complete in future. A possibility of going back to Newtonian concepts cannot be ruled out at this stage. Based on Godel's incompleteness theorems, some argue that a complete theory is impossible. But these theorems are about mathematical systems, stating that a complete theory of arithmetic cannot be created based on arithmetical axioms. We can interpret this as referring to the impossibility of creating a complete theory in a given area with axioms pertaining to that area alone, and not a total denial of any theory becoming complete.

A complete physical theory cannot be created from physical axioms alone. The basic axioms, however, should be physical; but the logical arguments that follow these should be mathematical. In combination, this may lead to a complete theory. A physical theory based on mathematical axioms will lead to a mathematical universe, not a physical universe. The 'uncertainty' in QM and the 'spacetime' in RM are mathematical axioms. So, as in the present form, both cannot be regarded as physical theories. Only Newtonian mechanics can be regarded as a physical theory.

A physical theory is normally bottom-up, starting from fundamental units and ending up in a complex system. This bottom-up adding becomes non-computable only if the properties are ambiguous and infinite. Turing's findings has relevance only in such cases. In short, the u-turn is not fully justified. Let us wait for a unified theory, a Theory of Everything, before arriving at any conclusion regarding Physical Reality.

A Theory of Everything:

Combining QM and RM into a single unified theory is regarded as the ultimate goal in physics. But, these two are mutually incompatible, and so a unified theory based on these two appears to be nearly impossible. Einstein, in spite of his contributions to quantum concept, did not accept the 'uncertainty' in QM. He devoted the later years of his life for framing a unified theory, but could not succeed. Here we will consider the possibility of formulating a Theory of Everything (TOE) based on the individual theories.

QM is based on uncertainty principle. It rejects certainty or decidability, the most important requirement for a real physical system. However, we are able to predict many things; all our machines, including the supercomputers, work because of this predictability. That means there are some real factors in the universe. If QM is correct, there will be some non-real factors also. So the universe is a partially-real physical system based on QM; undecidability, uncomputability and unpredictability will then have a role in deciding things in the world.

The characteristics associated with QM make it logically impossible to formulate a TOE based on QM. Uncertainty principle is an axiom in QM. If a TOE is possible, then QM is deterministic and that makes its axiom wrong. If the axiom is correct, TOE is impossible and QM will always be incomplete. The undecidability in QM limits the scope of verifying its correctness. Any verification will give uncertain results. A Godel-like situation arises here: It is impossible to decide whether QM is correct or not, based on QM alone. For verification, we will have to use deterministic theories outside QM.

Relativity Mechanics is supposed to be classical theory, but the concepts of space-time and mass-energy equivalence go against classical Newtonian approach. Mass and energy being inter-convertible, the system will not be physically real. However, practically, RM gets reduced to three results: (i). 'c' is the speed-limit (ii). Emission of light (radiations) causes decrease in mass, and (iii). Gravity curves the space around bodies. As is explained subsequently, these results can be obtained by modifying Newtonian mechanics. So barring the concepts of space-time and mass-energy equivalence, the rest of RM can be merged in Newtonian mechanics.

Newtonian mechanics is based on the certainty of the properties of matter. Based on it, the physical world is real; decidability, computability and predictability are its characteristics. But as a theory, Newtonian mechanics is incomplete. It states that bodies have mass and volume, can remain in motion, have gravity (force) and gravity can cause changes in motion. But it does not say from where bodies acquire motion, and why motion and gravity are related.

Newton could have put forth some hypothesis, irrespective of whether it will withstand future scrutiny or not, and made his theory complete. A good example is that of Einstein; he proposed space-time as a hypothesis, and even after hundred years, this hypothesis cannot be proved wrong, even though physicists are still not completely sure whether it is right. But Newton just refrained from making any hypothesis, because that was considered less scientific at that time. But now, physicists are happy to hypothesize anything.

With its deterministic characteristics, it should be possible to arrive at a complete theory based on NM. So the future lies in NM. Modifying it to make it applicable to quantum and cosmic levels should be the immediate goal. A slight change in the basic axioms may be enough for that. But no such attempts have been made by the main stream physicists so far. If it is impossible to arrive at a Theory of Everything based on NM, then we will have to go back to QM.

Modifying Newtonian mechanics:

A simple hypothesis can fill the above mentioned gaps in NM. Assume that motion is a fundamental property of matter, and force (forces of nature like gravity) is reaction to motion; that implies motion (energy) and force are equal and opposite. If motion is a property, what should be the natural speed? The speed of light is unique and that can be right choice. Only the fundamental particle can move at that speed. The larger structures will have internal motion and so cannot attain that speed, thus making 'c' the limit, as in RM. As the universe is a multilevel system composed of 'orbiting-systems' like planetary systems and galaxies, the largest orbiting-systems (gravitationally bound super clusters of galaxies) will have the maximum speed.

The particles moving at speed 'c' can be the particles of light – in Newtonian concepts, light is particles. So emission of light (radiations) causes a decrease in mass, as in RM. Here, radiations have mass and kinetic energy. The energy released, $E = mc^2/2$, where 'm' is the decrease in mass (in RM, energy released, $E = mc^2$, but the actual energy released is never measured, but inferred from the equation). Light, being matter, has gravity, and so moving gravitational fields will drag light, and this explains why light has the same speed in all inertial frames (as in RM).

In the modified form, force is reaction to motion, so the orbits of planets represent the equilibrium between force and motion, and so are dynamic. Thus the effect of gravity is similar to 'body bending the space around it'. So the precision of elliptical orbits is natural, and its value depends on 'c' (as in RM), the natural speed of the fundamental particle. Newton has never stated that the orbits of planets are static, nor has he stated that a 'state of rest' or a 'state of uniform straight-line motion' is a property of objects (planets). These are later interpretations based on his laws; he did not introduce any hypothesis regarding motion and gravity; he just put forth the mathematical laws. It is these later interpretations that led to the wrong conclusion that Newtonian mechanics does not allow precision of elliptical orbits.

With this modification, Newtonian Mechanics gets extended to particle and cosmic levels; at the particle level, there is only one type of fundamental particles and these have finite properties, and at the cosmic level, the largest structures can move at very high speeds, comparable to but lower than the speed of light. As there are only four properties at the basic level, predictions are easy. At the middle level, there are about 120 different atoms and millions of different molecules each having its own emergent properties; this makes predictions difficult. But this diversity does not affect the interaction between the large objects, where the mass only counts; so the number of properties get reduced to four at higher levels and that makes predictions easy.

These put together gives a semblance of completeness. The basic properties of the fundamental particles, namely mass, volume, energy and force are finite, unambiguous and physically well defined. The integration of particles follows mathematical laws. With only four properties at particle and cosmic levels, it is easy to create a mathematical model of integration of particles into a finite system. Such a system satisfies the criteria required (mentioned earlier) for a real physical system. However, this is just a proposed modification; there may still be some small gaps here and there. But it demonstrates one thing: Newtonian mechanics has the capacity to become a complete theory. So we can be nearly confident that the universe is a real physical system; decidability, computability and predictability are its characteristics.

Mid-level diversity – computers, life, intelligence, mind:

Assuming the universe to be real, the most fascinating fact about it is its mid-level diversity. Here on Earth, there are millions of molecules each having its own emergent properties. Matter is not inert, it is energetic, or motion (energy) is its property. Arrange various atoms in any manner (either as a lattice or as molecules), and the structure thus formed will show some emergent property. These properties are allowed by nature and we are just discovering these, and these can be explained based on the basic properties namely mass, volume, energy and force.

We invent machines using the discovered emergent properties. Our supercomputers work just because nature allows that. Life is an emergent property allowed by nature, so is intelligence and mind. The most exotic property of matter is 'mind'. Matter (atoms) arranged in a certain pattern becomes capable of thinking what matter is. It is matter achieving self-awareness. These self-conscious structures may be the limit of evolution, a deterministic end, not a chance coincidence. How these work is not understood fully; but we have a hint, we have created supercomputers and artificial intelligence. But nature puts a limit to our activities; we can never do anything disallowed by nature.

This diversity is unique for a particular level of the multilevel system. The Earth moving at 30Km/s allows chemical reactions that creates maximum diversity. The sun moving at nearly 8 times that speed allows only nuclear fusion reactions, and the milky way moving at a still higher speed allows only a 'singularity' (no diversity) in its central mass, which is a black hole. That means, we are exposed to a reduced energy level at which we and our machines can work. Because of this diversity, we will require Laplace's demon for predictions; the data may be very large, but is finite; so the question of unpredictability/uncomputability does not arise.

Discrete *vs* Continuous:

The essay would be incomplete without referring to the terms 'discrete' and 'continuous'. An entity can be either discrete or continuous, not both. The term 'discrete' implies that the entity has a fundamental unit having finite properties that can get added up. 'Continuous' implies that the entity has no such fundamental unit and extends to infinity. Only discrete entities can integrate into structures. Continuous entities can remain only as a frames of reference. A system requires an infinite frame and finite units, the properties of the units connecting them with the frame.

In the real physical world, space and time are continuous and so infinite, and these remain as arena or frames of reference. Matter is discrete and so finite. Volume and motion are the properties that connect matter to the frame. These properties are discrete. The space occupied (volume) and amount of motion (energy and force) of the fundamental particle are discrete and can add up and are thus conserved.

Physical structures made of discrete matter act as single objects like atoms, planetary systems, galaxies, etc. Inside atoms, the nuclei and electrons are separated by space, inside solar system, sun and the planets are separated, and inside the universe, the galaxies, clusters, etc remain separated. However, the universe is a single object held together by gravity. It is action at a distance (Newtonian concept) of forces of nature that keeps these as single objects.

Universe is a finite system of matter existing in an infinite frame of space and time. A finite universe implies that everything associated with it is finite; it always occupies only a finite region of the infinite space and every process associated with it ends in finite time. Can a finite universe exist for ever? The only possible way is to remain in an infinite loop of finite processes.

Bodies moving in elliptical or closed-helical paths are in infinite loops; the former is planar, and the latter is three-dimensional. In the latter, a body moves away from a point along a helical path, reaches a limit and then returns back. A system of bodies remaining in closed-helical paths and moving away from a common center in a synchronized manner will remain pulsating. This provides a suitable model for the universe, and such a possibility has to be verified.

Conclusion:

The limits in what we can prove, compute, and predict is decided by the nature of physical world. If the physical world is real, theoretically there can be no limit; but practically there will be limits. Laplace's determinism, which has no theoretical limit, is based on the Realism of Newtonian concepts. If the world is only partially real, as visualized by QM, then there will be limitations both theoretically and practically in what we can prove, compute, and predict. Undecidability, uncomputability and unpredictability will have a crucial role in such a world. However, QM with its uncertainty is destined to be incomplete, while Newtonian Mechanics has the capability of becoming a complete theory. So concerted action is required on the part of the main stream physicists to try for a complete theory based on Newtonian concepts.

As an alternate theorist, I have developed Newtonian models* applicable to electromagnetic radiations, particles and the universe. With these, I claim that Newtonian Mechanics becomes a Theory of Everything. Along with that, the question of 'Physical Reality' also gets settled. The physical world is real, not an illusion; we are real, and our sense organs are designed to observe the real physical world. Our indirect observations also reveal reality, only that our conclusions based on such observations may go wrong. So the question is, "Are the conclusions arrived in this paper true?" I leave it to the readers to decide.

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* Readers, if interested, can go through the models: 'Newton was right: light is particles', 'Internal structures of electron, proton and neutron', 'The pulsating model of the universe'.