The Progressive Recovering of Einstein’s Determinism under Strong Interactions

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Quantum mechanics relies on probabilities and uncertainties – for example, we cannot work out the outcome of a quantum system, but instead, we can suggest probabilities of certain outcomes. This has been troublesome for determinists, who instead believe that all outcomes are governed by a set of laws. Sir Professor Ruggero Maria Santilli from The Institute of Basic Research argues that if we extend our picture of quantum mechanics to his idea of hadronic mechanics, we can recover hidden variables and progressively recover determinism..

Einstein, Determinism and its Consequences in Quantum Mechanics

The formulation of a theory of quantum mechanics in the 1900s was not solely a pursuit of scientific thought – numerous philosophical approaches and arguments were made as well. For example, Einstein believed in determinism, the philosophical belief that the outcome of every event is governed by the preceding events and causal laws. During his lifetime, there were no deterministic interpretations of quantum mechanics. For example, the Born rule uses probabilities to suggest what the measurement outcome in a quantum system will be, and the Heisenberg uncertainty principle suggests that we cannot know about some pairs of properties of a quantum particle, such as position and momentum, at the same time.

This belief led Einstein, along with his students Podolsky and Rosen, to write their famous paper in 1935. This suggested that quantum mechanics was an incomplete theory and that, eventually, there would be some completion of the theory that would still allow for classical determinism. Sir Professor Ruggero Maria Santilli from The Institute for Basic Research in Florida has worked on his suggestion for this completion, working on extending quantum mechanics into his theory of hadronic mechanics.

Sir Santilli suggests that there is proof for Einstein, Podolsky and Rosen's (EPR) argument. He believes that the objections to the EPR argument are under the assumption that particles are considered to be point-like, meaning that their mass and charge are considered to be at a single point in space, in a vacuum and under Hamiltonian interactions – interactions at a distance that tell us about the kinetic and potential energy of the particles.

However, Santilli argues that this does not apply to structures such as sub-atomic particles like positively charged protons and neutrons, and structures made up of these hadrons like nuclei. Here, he argues that the charge is spread within the structure rather than at a single point, giving an extended charge distribution. Also, as the volume of the nucleus is less than the sum of the volumes of its constituent protons and neutrons, he argues that they are in a condition of mutual penetration. This leads to additional interactions, such as contact non-Hamiltonian interactions extended over the volume of hadron overlapping, due to the dynamics within the system itself.

By studying these interior conditions, Santilli uses isomathematics and isomechanics, which preserve the core axioms of quantum mechanics but realises them to account for the extended character of particles and their new interactions. Santilli refers to this extension of quantum mechanics as hadronic mechanics, namely, a mechanics intended for strongly interacting particles called hadrons.

Within his hadronic mechanics, Santilli suggests that this can progressively recover Einstein's determinism with the increase of the density in the transition from hadrons to nuclei and stars and fully recover Einstein's determinism at the limit of gravitational collapse. Santilli believes that this can complete quantum mechanics according to the EPR argument. To do this, Santilli introduces what is now known as the Santillian $\hat{T}$, sandwiched in between all the multiplications while maintaining the quantum axiom of associativity, to characterise the actual size of hadrons and their additional interactions, such as the non-Hamiltonian interactions in extended particles.

Bohm's Hidden Variables in Hadronic Mechanics

In support of the EPR argument, David Bohm suggested in 1952 that there would need to be some hidden variable. For example, instead of just having a quantum particle, there is also a hidden guiding wave that dictates the motion of the particle. In quantum systems, we often have quantum particles that are entangled,

which means that there is some correlation between the two particles. These particles can be separated over a large distance, and there can still be entanglement between them. Until we measure the particles, we don't know what state they are in, but by measuring one particle in the entangled pair, as they are correlated, the outcome of the first measurement will often give us information about the second particle as well.

As an example, for Bohm's hidden variable theory, for entangled particle two to gain information about entangled particle one when measured, there would need to be some vector travelling faster than the speed of light to transfer this information to the second particle or the theory should be non-local in the sense of being defined on volumes, thus being outside the consistent representational capabilities of quantum mechanics.

Santilli argues that, through the application of hadronic mathematics and mechanics, we can explain entanglement in a hidden variables theory without needing to rely on faster-than-light communication between the particles. To explain this entanglement, Sir Santilli suggests that between these particles, there is an overlap of their wave packets, the wavelike functions that determine the probability of the particle being measured in some state. This leads to non-linear, non-local, non-potential, and non-Hamiltonian interactions between the two particles at arbitrary distances that are represented by the Santillian $\hat{T}$. Santilli suggests that because of this, there is continuous and instantaneous contact between the two particles at arbitrary distances, and there is no need for the faster-than-light communication suggested in Bohm's theory.

These non-linear, non-local, non-potential, and thus, non-Hamiltonian interactions fit into Santilli's model of hadronic mechanics, where he introduces the aforementioned Santillian, $\hat{T}$, which can be solely treated via isomathematics. This gives a mathematical function that can tell us about the local variables of the particle, such as coordinates and momentum, with uncertainties progressively smaller than their quantum mechanical counterparts depending on the local density and the strength of the short-range interactions.

Furthermore, Santilli argues that T is hidden because it represents contact interactions without any potential energy, and T is sandwiched in between all products while conserving the quantum mechanical axiom of associativity. As a result, he argues that we can identify $\hat{T}$ with Bohm's hidden variable in hadronic mechanics.

An additional test of Bohm's hidden variables is also seen through Bell's inequalities. Bell found a set of mathematical inequalities, which link to the correlations seen between entangled particles when they are measured. If Bell's inequalities are verified, this suggests that quantum mechanics must describe the system. It is generally assumed that if Bell's inequalities are violated, then the correlations can be explained by classical physics. Bell's inequalities are often used to disprove hidden variables by stating that if there is a mathematical constraint between the two entangled particles, this would satisfy the Bell inequality, and the system would not need quantum mechanics to explain it.

However, Santilli argues that this is not the case for the extended particles in his hadronic mechanics. He highlights how Bell inequalities are valid for point like particles under the electromagnetic force. However, he aims to consider extended particles under the strong force and believes that Bell's original inequalities are no longer applicable here. Sir Santilli uses isomathematics to suggest generalised Bell's inequalities for strong interactions, which incorporates the hidden variable, $\hat{T}$. This allows him to retain a hidden variable theory whilst also retaining quantum correlations between particles.

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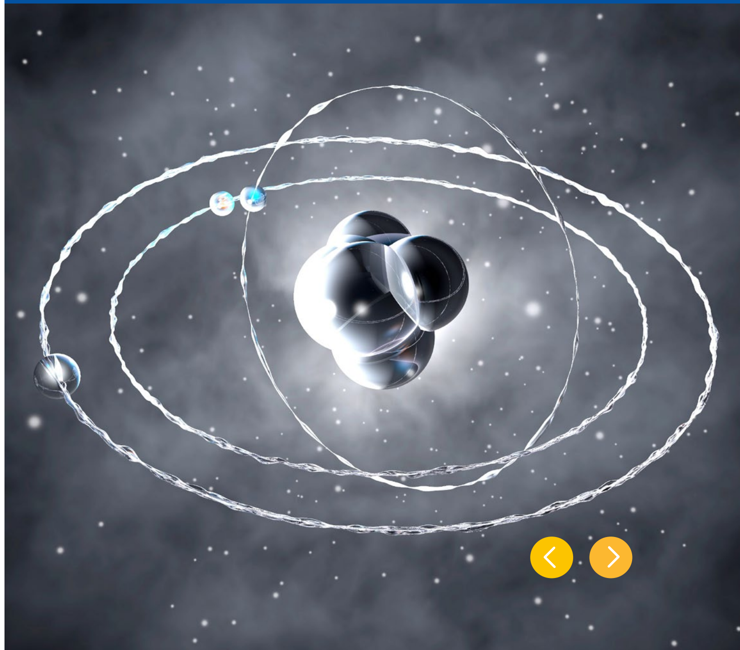

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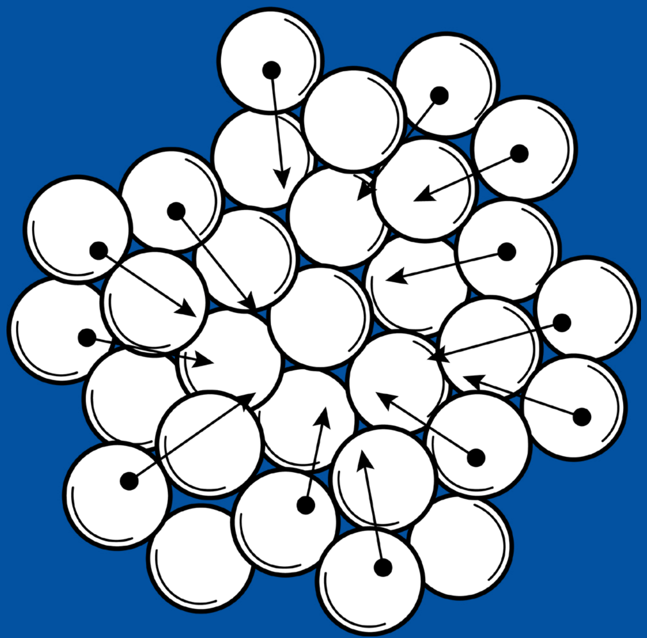

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Santilli's work on extended particles, with their constant contact with each other through mutual penetration, affects how we can consider atomic structure. As the proton and the neutron are confined in the nucleus of the atom, whilst the electrons orbit outside it, this means that their contact interactions differ. Furthermore, as protons and neutrons are made up of further subatomic particles called quarks, they are affected by strong force, whereas electrons aren't. Santilli's work highlights how, because of their confinement, the errors we associate with the proton and neutron in the nucleus must be smaller than those we associate with the electron. This can also be incorporated in his theory of isomechanics by showing that as the density increases here, $\hat{T}$ becomes smaller.

By beginning to reconcile this internal structure of the nuclei through hadronic mechanics, Santilli's work began to progressively move towards a recovery of Einstein's determinism. His theory highlighted how the increasing density of particles, nuclei and even stars links with a decrease of $\hat{T}$. This led Santilli to look at the limit of gravitational collapse, for example, the mass at which astronomical objects become so massive that they collapse under their own gravity.

Santilli's theory of hadronic mechanics can account for the limit of gravitational collapse – at this moment when the density of the star is extremely large, the Santillian $\hat{T}$ becomes zero. This suggests a full regaining of Einstein's determinism, as Santilli's model suggests how these astronomical events can occur through his description of the strong interaction.

Santilli continued to work on this, forming a general principle to account for uncertainties within the strong interaction in hadronic mechanics, which he called Einstein's isodeterminism. Through this theory, he can overcome the potential divergences of quantum mechanics surrounding the forces and interactions of these extended particles, which allows for a generalisation of quantum mechanics through his formulation of hadronic mechanics.

The Neutron Synthesis from Hydrogen and its Applications

The stars in our night sky begin life as clouds of dust and hydrogen, which grow progressively larger as they travel through space. Once suitably large and hot enough, they undergo a fusion process, where the protons and electrons from the hydrogen atoms are fused to become neutrons. If certain conditions are then reached, these neutrons can be fused with protons to create a bound state called deuteron. Fusion continues, fusing two deuterons to become helium, and the star begins to emit light due to excess energy in this process.

However, there is a suggestion that Heisenberg's uncertainty principle implies that the fusion of this neutron in a forming star cannot occur within quantum mechanics. If we consider energy and position in the Heisenberg uncertainty principle, the energy of the electron might have an uncertainty much larger than the energy of the neutron yet to be formed, or its coordinate might have an uncertainty much larger than where the fusion process will occur. We can't measure both quantities accurately, and it becomes difficult to account for this fusion process here.

Santilli can account for this with his theory of hadronic mechanics. Due to the inclusion of $\hat{T}$, in his theory, the proton and the electron are almost static in their location due to the large pressures around them in the forming star. The proton and electron are in a condition of total mutual penetration, and by non-Hamiltonian interactions, we get an incredibly strong Coulomb attraction between the oppositely charged proton and electron, allowing for the neutron to be synthesised. Santilli has worked on characterising this, achieving representations that are in accordance with measured values.

Santilli has also begun to run experiments on how we can synthesise a neutron from hydrogen in the lab. By engineering an electric arc that can be submerged into hydrogen gas, the gas can be ionised and produces a beam of neutrons. This has been developed into a commercial product called the Directional Neutron Source and can be used for different detection processes, such as locating precious metals in mines or testing for defects in welded structures used in shipbuilding.

Furthermore, as these neutrons naturally decay back to their constituent proton and electron in about 15 minutes, Santilli suggests that his work on neutrons and hadronic mechanics could be used to predict mechanisms to recycle radioactive waste in nuclear power plants. Exposing waste to photons of a certain energy could provide the additional energy needed to cause some neutrons to decay, reducing the lifetime of these radioactive byproducts. For example, atoms of Molybdenum-100, an unstable isotope, have an exceptionally long lifetime of 1019 years. With this process, Santilli suggests these could be recycled into Technetium-100 if just one of its neutrons decays, reducing its lifetime to just 18.5 seconds.

MEET THE RESEARCHER

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Sir Professor Ruggero Maria Santilli originally studied Physics at the University of Naples before completing his PhD in Theoretical Physics at the University of Torino in Italy. Following this, he has held numerous different academic positions in both Italy and the USA, culminating in his current roles as President and Professor of Physics at the Institute for Basic Research in Florida, which he has held since 1981, and Editor-in-Chief of the *Hadronic Journal* and *Algebras, Groups and Geometries*. Throughout his academic career, he has written and published extensively in a wide range of papers and monographs in mathematics, physics, chemistry and biology. His work focuses on areas such as hadron mechanics and Lie algebra, as well as the applications of this science in technologies, such as in generating clean energy. Sir Santilli has been recognised through numerous awards, including medals for scientific achievements and his knighthoods from the Republic of San Marino, Italy.

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