Completing Quantum Mechanics: Hadronic Mechanics and its Potential for Clean Energy

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Understanding how the building blocks of the world around us – such as protons and neutrons – can interact and synthesise various products can help us approach challenges such as clean energy. Sir Professor Ruggero Maria Santilli from The Institute for Basic Research considers how theories of quantum mechanics can be developed through his work on hadronic mechanics. By representing protons and neutrons as extended, Sir Santilli suggests how this could better account for processes in nuclear physics and a new outlook on clean nuclear energy via fusion.

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Hadrons, Fusion and the Coulomb Barrier

With our increased awareness of our impacts on the planet, searching for cleaner energy sources becomes even more important. Nuclear energy is a possible candidate, for example, nuclear fission. Atoms around us are made up of electrons orbiting a nucleus, and the nucleus is made up of positively charged particles called protons and neutrally charged particles called neutrons. In fission, a single neutron is collided with a larger nucleus. The incident neutron splits the initial large nucleus into smaller nuclei, releasing energy. This fission reaction is already used to generate nuclear energy in many grids worldwide.

However, researchers are also interested in nuclear fusion, where two or more lighter atomic nuclei combine to form a different, heavier nucleus, releasing energy in the process. While this occurs naturally in stars, getting this process to occur on Earth in a controlled form is more complex. For fusion to occur, the Coulomb Barrier must be exceeded. This barrier occurs because both the atomic nuclei are positively charged, so they repel each other with a very big repulsive force. So, for fusion to occur, we have to get the nuclei at such high energies to overcome the Coulomb barrier and bring the two nuclei together at such a small mutual distance to activate the strongly attractive nuclear force, at which point their fusion into a third lighter nucleus is unavoidable.

Sir Professor Ruggero Maria Santilli from The Institute for Basic Research argues how we could overcome the Coulomb barrier through a new bond between electrons and a naturally occurring nucleus, resulting in a negatively charged nucleus (Santilli pseudonucleus), which could be attracted by a positively charged natural nucleus, in a process Sir Santilli describes as hyperfusion.

However, the creation of such particles is seemingly forbidden under the Heisenberg Uncertainty Principle. This principle suggests that, in quantum mechanics, we cannot precisely know the values of some pairs of physical quantities at the same time, such as position and momentum. This is applied to point-like particles, or particles where the mass and charge are concentrated at a single point in space, in a vacuum and when the force between the particles is electromagnetic. If protons and neutrons under the strong force are considered under the same assumption, it would forbid the creation of Santilli's pseudo-nuclei.

Completing Quantum Mechanics into Hadronic Mechanics

In 1981, Sir Santilli expressed doubts on the exact validity of Heisenberg's uncertainty principle in nuclear structures because, in view of their strong mutual attraction, the uncertainties of protons and neutrons are expected to be smaller than the corresponding uncertainties of electrons moving in vacuum under Hamiltonian interactions. He approaches quantum mechanics with a view that was first proposed by Einstein, Podolsky, and Rosen in 1935, suggesting that quantum mechanics is an incomplete theory. Sir Santilli suggests that these shortcomings are evident in nuclear physics. For example, he identifies the insufficiency of quantum mechanics to represent how a proton and an electron in a star synthesise a neutron through fusion. He argues that, despite the proton and electron having opposite charges and having a strong attractive force between them, quantum mechanics cannot give a quantitative response here.

To Sir Santilli, this insufficiency arises due to protons and neutrons in the nucleus being represented as point-like particles rather than being extended. This means that, as the protons and the neutrons take up space, we consider their charges as being distributed over this space rather than being fixed at a single point. Similarly,

the nuclear volume of the nuclei is often smaller than the sum of the constituent volumes, so instead, Sir Santilli proposes that they are in a condition of partial mutual penetration – we can imagine them as partially overlapping to account for this difference in volumes.

By considering this charge and volume distribution of the nuclei, there are additional interactions to account for. There are interactions that occur regardless of which model of the nuclei we use, for example, interactions that are described by linear or potential interactions, which arise from the charge and distance between the particles. These interactions are Hamiltonian – Hamiltonians describe the kinetic and potential energy of the system. But by extending our description of the nuclei, there are additional interactions to account for. These include non-linear interactions and non-local interactions that occur as a result of the charge being spread over a volume, known as Santillian interactions.

Sir Santilli's belief that quantum mechanics can be completed to incorporate this leads to his suggestion of hadronic mechanics, where hadrons are particles like protons and neutrons. Sir Santilli uses isotopic methods, including Lie-isotopic mechanics and mathematics to extend quantum mechanics through preserving its axioms, or main principles. He also uses Lie algebra and Lie groups, a field of mathematics where this group is also a space to which we can apply calculus to allow for the conception of hadronic mechanics to account for the Hamiltonian and non-Hamiltonian interactions in the nuclei.

Sir Santilli's extension to hadronic mechanics requires a range of different mathematical methods, but the isotopic formulations are based on some main areas – for example, the aforementioned Heisenberg uncertainty principle is extended to the isouncertainty principle with comparatively smaller standard deviation, or uncertainties, to account for particles both under the strong and the electromagnetic force.

Hadronic mechanics, according to Sir Santilli, also proposes a realisation of Bohm's hidden variables. Bohm suggested that to fully explain quantum mechanical paradoxes, there would need to be some faster-than-light communication of extra variables between quantum particles and that these hidden variables would complete quantum mechanics. In his theory of hadronic mechanics, Sir Santilli proposes the Santillian, $\hat{T}$, similar to the Hamiltonian, but instead, the Santillian represents the extended characters of the nuclei, and their non-Hamiltonian interactions. This Santillian equates to hidden variables because it is hidden in the axiom of associativity of quantum mechanics.

Another example is shown through Sir Santilli's proposal of basing his formulations on the violation of Bell inequalities. Bell inequalities describe the relations between measurements on entangled particles, or quantum particles that have correlations between them. If they are violated, this means the system can be described by hadronic mechanics, so violation of a Bell inequality is often used as a test of quantum physics. Sir Santilli shows how Bell's inequalities are violated for his extended particle descriptions and uses this in his considerations of deuteron.

Deuteron, the nucleus of deuterium, is often referred to as 'heavy hydrogen' as it consists of one proton and one neutron, and is used in nuclear reactors. Sir Santilli goes through key experimental properties of the deuteron, considering how long it exists, or its lifetime, the radius its charge is spread over, its energy, the spin of the nuclei and its magnetic moment by reaching the first known numerically exact and time invariant representation of the experimental data of the deuteron and heavier nuclei and considers how the deuteron and other nuclei are stable despite the natural instability of the neutron and the strongly repulsive Coulombian protonic forces.

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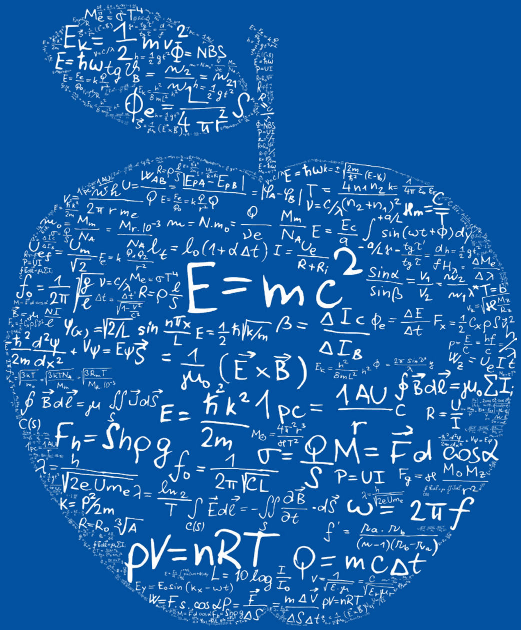
Credit: RM Santilli.



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Using Hadronic Mechanics to Create Hyperfusions

Sir Santilli proceeds to use this theory to consider the feasibility of synthesising a pseudo-nucleus called pseudo-Deuteron-2e, which consists of a hadronic bound state between one proton, one neutron and two electrons, giving it an overall negative charge. To do this, he studies the characteristics of pseudo-Deuteron-2e through his concept of hadronic mechanics. From this, Sir Santilli suggests that pseudo-Deuteron-2e would have a magnetic moment that is larger, and in the opposite direction to the magnetic moment of deuteron.

Having pseudo-Deuteron-2e magnetic moments and spins in the opposite direction, creating an attractive rather than a repulsive interaction with a natural deuteron, leads to Santilli's concept of hyperfusion. Sir Santilli believes this could be a possible source of clean energy that could also be readily and safely controlled by using intermediate controlled nuclear fusions (ICNF) to turn nuclei in some fuel made of hadrons into pseudo-nuclei.

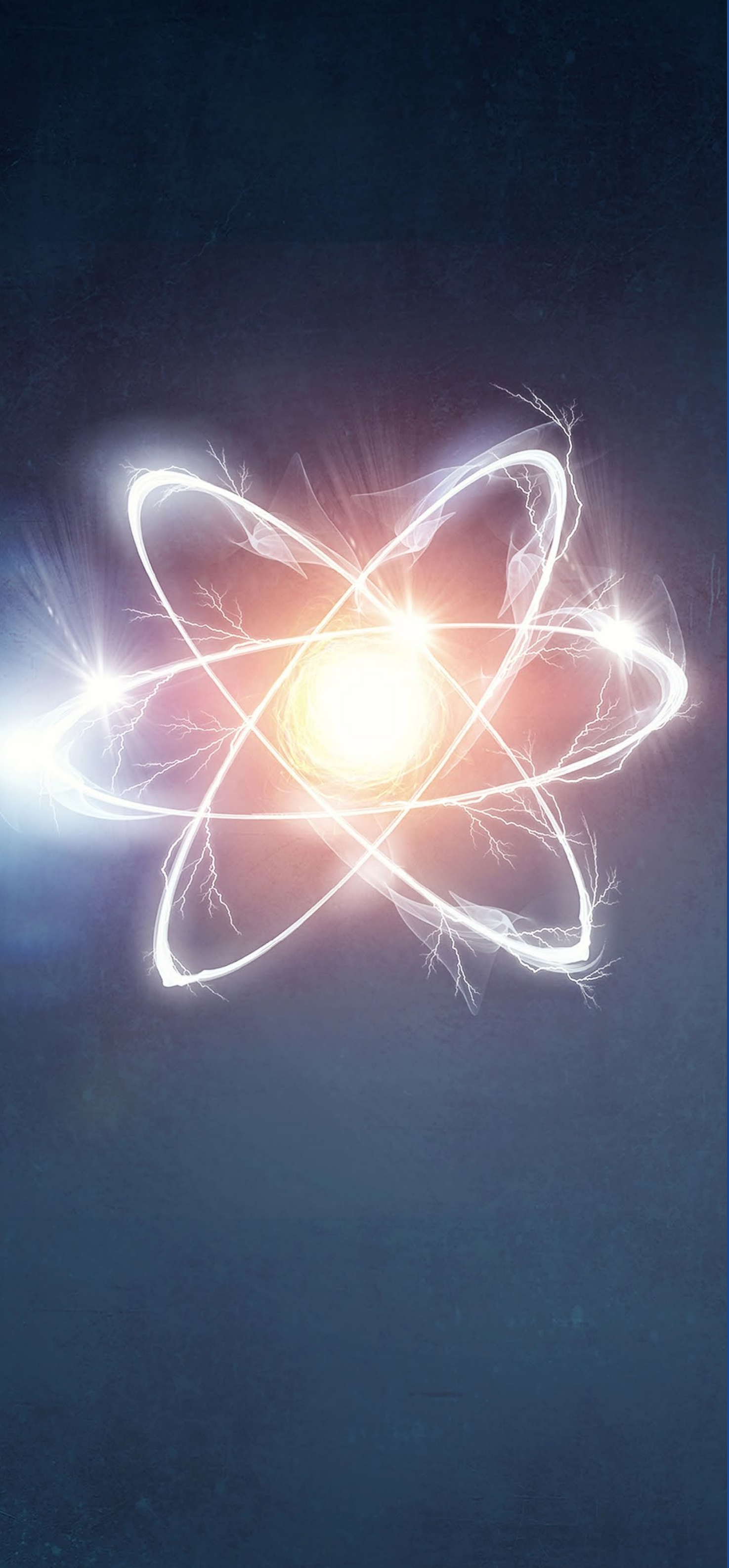
Sir Santilli has begun to construct a hadronic reactor where this ICNF process could occur, consisting of electrodes potentially made out of carbon that are being used in a gaseous hadronic fuel. Current can be passed through the electrode and travel through the gas to the second electrode to create an arc, ionising the gas into the plasma of nuclei, atoms and electrons. As the arcs of electricity also connect the two electrodes, they can also create a field which compresses the plasma. This plasma can then be used to synthesise Santilli's pseudo-nuclei. Sir Santilli and his team are both developing the reactor module for this to occur and testing how different materials work in the reactor to optimise the process.

Overall, Sir Santilli suggests that quantum mechanics is an incomplete theory, calling on the historical argument of Einstein, Podolsky, and Rosen, due to his belief in its insufficiency in nuclear physics. Sir Santilli suggests that this arises from a number of shortcomings, such as not accounting for the charge distribution in nuclei. To overcome this, he suggests extending quantum mechanics into a theory of hadronic mechanics and developing this using different mathematical approaches. Through hadronic mechanics, the possibility of Santilli's pseudo-nuclei, a different bond between natural nuclei and electrons, is realised, allowing for the possibility of hyperfusions using these particles to overcome the Coulomb barrier. From this, Sir Santilli has begun developing ideas for a potential new way to generate nuclear energy and has taken key steps towards developing a new and beneficial green technology.

Independent Verifications of ICNF and Hyperfusions

Sir Santilli's 2010 experimental demonstration of the ICNF synthesis of nitrogen from carbon and deuterium was subjected to a number of systematic experimental confirmations, including systematic, independent tests by scientists from Princeton Gamma Spectroscopy Corporation headed by Professor L Ying, a team of scientists headed by Professor Y Yang, and others.

Sir Santilli's systematic tests and their detailed experimental verifications provide robust evidence for the feasibility and applicability of ICNF and hyperfusions. These findings mark a transformative step in nuclear fusion research, paving the way for practical implementations in energy production via modular reactors and other technological advancements. The integration of experimental results with theoretical innovations further validates the potential of hadronic mechanics as a unifying framework for understanding and harnessing nuclear interactions at intermediate energy levels.



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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