Editorial Note

A Foundational Approach to Physics: Nilpotent Quantum Mechanics & Its Applications

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ABSTRACT

This issue of Prespactime Journal features Peter Rowlands' work on nilpotent quantum mechanics. In this note, I briefly trace its development and discuss its meaning and importance as an alternative foundational approach to physics.

Key Words: foundational approach, physics, nilpotent, quantum mechanics, Peter Rowlands.

Over the last decade or so, Peter Rowlands has developed an alternative foundational approach to physics [1-6] which he calls the "nilpotent quantum mechanics ("NQM")". Indeed, some of his ideas may go back more than 30 years [See, e.g., references in 1]. Here, "nilpotent" means a mathematical object which is the square root of zero. In NQM, not only the operator acting on the wavefunction is nilpotent but also the amplitude of the wave function itself [1-6].

NQM has its origin in Rowlands' research on the meaning of the most fundamental equation in modern physic, the Dirac equation:

$$(\gamma^\mu \partial_\mu + im)\psi = \left(\gamma^0 \frac{\partial}{\partial t} + \gamma^1 \frac{\partial}{\partial x} + \gamma^2 \frac{\partial}{\partial y} + \gamma^3 \frac{\partial}{\partial y} + im\right)\psi = 0 \quad (1)$$

By deploying the algebra formed by the commutative combination of quaternions and multivariate vectors in + and – values of eight basic units (1, i, $\boldsymbol{i}$, $\boldsymbol{j}$, $\boldsymbol{k}$, **i**, **j**, **k**), Rowloands discovered the following nilpotent form of Dirac equation:

$$\left(\mp \boldsymbol{k}\frac{\partial}{\partial t} \mp i\boldsymbol{i}\nabla + \boldsymbol{j}m\right)(\pm i\boldsymbol{k}\mathrm{E} \pm i\mathbf{p} + \boldsymbol{j}m)e^{-i(Et-\mathbf{p.r})} = 0 \quad (2)$$

where

$$(\pm i\boldsymbol{k}E \pm i\mathbf{p} + \boldsymbol{j}m)\ (\pm i\boldsymbol{k}E \pm i\mathbf{p} + \boldsymbol{j}m) = E^2 - p^2 - m^2 = 0 \quad (3)$$

Thus, NQM ultimately orginates from Einstein's energy, momentum and mass relationship as this is also the origins of Dirac equation and Gorden-Klein equation.

NQM is important because it may indeed provide an alternative foundational approach to physics both in interpretations and applications.

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For example, according to Rowlands [1-6], expression (3) has at least five independent meanings:

classical	special relativity
operator×operator	Klein-Gordon equation
operator ×wavefunction	Dirac equation
wavefunction ×wavefunction	Pauli exclusion
fermion ×vacuum	thermodynamics

Further, as the amplitude of wavefunction, each particular form of ($\pm\, i\boldsymbol{k}E \pm \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m$) has the following meaning:

$(i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$	fermion spin up
$(i\boldsymbol{k}E - \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$	fermion spin down
$(-i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$	antifermion spin down
$(-i\boldsymbol{k}E - \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$	antifermion spin up

and parity, time reversal and charge conjugation opeartions are respectivly as follows:

Parity	P	$\boldsymbol{i}\,(i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)\,\boldsymbol{i} = (i\boldsymbol{k}E - \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$
Time reversal	T	$\boldsymbol{k}\,(i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)\,\boldsymbol{k} = (-i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$
Charge conjugation	C	$-\boldsymbol{j}\,(i\boldsymbol{k}E + \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)\,\boldsymbol{j} = (-i\boldsymbol{k}E - \boldsymbol{i}\mathbf{p} + \boldsymbol{j}m)$

The above given examples are the surface of what the six papers included in this focus issue have to offer.

These six papers are arranged in chronological orders by their respective completion dates noted in the footnote on the first page of each paper. The 6th paper entitled "Physical Interpretations of Nilpotent Quantum Mechanics" completed in April 2012 is the best expression to date of NQM. The 5th paper entitled "Are There Alternatives to Our Present Theories of Physical Reality?" completed in December 2009 is also essential and form a key part of Rowland's work. Of course, the remaining four earlier papers are also crucial in the development of NQM and form the bases of what are expressed in the 5th paper and 6th paper.

For reader's convenience, I list below the title and summary of each paper in chronological order:

A Foundational Approach to Physics [1]:

A core level of basic information for physics is identified, based on an analysis of the characteristics of the parameters space, time, mass and charge. At this level, it is found that certain symmetries operate, which can be used to explain certain physical facts and even to derive new mathematical theorems. Applications are made to classical mechanics, electromagnetic theory and quantum mechanics.

The Factor 2 in Fundamental Physics [2]:

A brief history is given of the factor 2, starting in the most elementary considerations of geometry and the kinematics of uniform acceleration, and moving to relativity, quantum mechanics and particle physics. The basic argument is that in all the significant cases in which the factor 2 or ½ occurs in fundamental physics, whether classical, quantum or relativistic, the same physical operation is taking place.

Removing Redundancy in Relativistic Quantum Mechanics [3]:

It is proposed that the Dirac equation, as normally interpreted, incorporates intrinsic redundancies whose removal necessarily leads to an enormous gain in calculating power and physical interpretation. Streamlined versions of the Dirac equation can be developed which remove the redundancies and singularities from many areas of quantum physics while giving quantum representations to specific particle states.

What Is Vacuum? [4]

Vacuum can be defined with exact mathematical precision as the state which remains when a fermion, with all its special characteristics, is created out of absolutely nothing. The definition leads to a special form of relativistic quantum mechanics, which only requires the construction of a creation operator. This form of quantum mechanics is especially powerful for analytic calculation, at the same time as explaining, from first principles, many aspects of the Standard Model of particle physics. In particular, the characteristics of the weak, strong and electric interactions can be derived from the structure of the creation operator itself.

Are There Alternatives to Our Present Theories of Physical Reality? [5]

Our notions of what is physically 'real' have long been based on the idea that the real is what is immediately apprehended, that is the local or observable, the physically tangible, though there has always been an alternative philosophical notion that the 'real' is some kind of ontological structure beyond immediate apprehension, and so inaccessible through physics. However, quantum mechanics, with its intrinsic nonlocal correlations, has seemingly left us with a dilemma by showing that fundamental physical theories cannot be both real and local. Reality cannot be reconstructed as a deterministic projection from physical observations. Many people think that the problem lies with quantum mechanics, but, in fact, it is more likely to be a result of unrealistic expectations. We have assumed that fundamental physics ought to be compatible with normal (macroscopic) experience. If, however, we go beyond our current high-level physical theories to the basic elements from which they are constructed, we see that a pattern emerges that gives us a very different and much more coherent understanding of what is meant by physical 'reality'.

Physical Interpretations of Nilpotent Quantum Mechanics [6]

Nilpotent quantum mechanics provides a powerful method of making efficient calculations. More importantly, however, it provides insights into a number of fundamental physical problems through its use of a dual vector space and its explicit construction of vacuum. Physical interpretation of the nilpotent formalism is discussed with respect to boson and baryon structures, the mass-gap problem, zitterbewgung, Berry phase, renormalization, and related issues.

References

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