Physics beyond catching a mouse in the dark: From Big Science to Deep Science

Victor Christianto[1][1], *& Florentin Smarandache*[2]

[1]Malang Institute of Agriculture (IPM), Malang, Indonesia.
http://researchgate.net/profile/Victor_Christianto
Email: victorchristianto@gmail.com

[2]Dept. Mathematics and Sciences, University of New Mexico, Gallup, USA. Email: florentin.smarandache@laposte.net

Abstract
The Higgs particle has been detected a few years ago, that is what newspapers tell us. For many physicists, the Standard Model of particle physics has accomplished all the jobs. Or to put it simply: The game is over. Is it true? Then some physicists began to ask: can go beyond the Standard Model? Because the supersymmetric extension of the Standard Model has failed. If you feel that theoretical physics is becoming boring, you are not alone. Fortunately, there is good news: a new generation of physicists are doing table-top experiments in their basements. Can we expect new results later?[2] If so, what will the future of physics look like? This article discusses this question, starting with a blunt look at the relationship between mathematics and physical reality, written from the perspectives of a mathematician and a cosmologist.

"There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy."

- Hamlet (1.5.167-8), Hamlet to Horatio

Introduction: The art of catching a mouse.

Probably most of you have read Einstein's biography, perhaps out of mere curiosity or your effort to find out how to unlock the secrets of his brilliant mind. You may have read about how the young Einstein received a gift of a mathematics book from a smart medical student, who

[1] Corresponding author: Email: victorchristianto@gmail.com

[2] https://bigthink.com/robby-berman/tabletop-physics-may-be-about-to-find-answers-supercolliders-cant

gave a quite witty remark to him along with the gift:

"*Mathematics is like catching a mouse; you run after the mouse until it runs into a corner of the room. Then you get it*."

Provided that such a remark was true, it is quite understandable that Einstein's mental process was shaped more or less along that line of thought, i.e. how to seek after the eternal mouse, in the micro-world and in cosmology. Is "catching a mouse" really the correct way to think of the role of mathematics in the process of comprehending Nature?

History tells us that Einstein began his science career by writing 3 papers in the year of 1905, including an exposition on quanta of light and one on special relativity theory. Despite oppositional comments by senior physicists of the time, including Max Planck, the three papers have been regarded as the cornerstone of modern physics. Nonetheless, recent analysis by Steven Weinberg and others, show that Einstein's papers actually contain some errors.(1)
This problem leads us to ask a deeper question: "How effective is mathematics when describing physical reality?"

Beyond Platonic world

The question of effectiveness of mathematics in physical sciences has been discussed by many physicists, notably Eugene Wigner (1). And the question was brought to one of us (VC) by a senior professor of physics several years ago (see acknowledgement). As far as he can remember, he (VC) only outlined that perhaps we need to use more advanced geometry, such as fractal geometry (c.f. Benoit Mandelbrot). Yes, there are scientists who hold the view, that we can only expect new physics if we begin to explore new mathematics (Dirac's view).
But the problem may be much deeper than what it looks like at first glance. Perhaps it is true, that mathematics is "the art of catching a mouse". But most real physics problems are so delicate, that the situation may be more analogous to: "How to catch a black mouse in a dark room, when you don't even know if a mouse is in the room or not." (see "Mouse Hunt" the movie)

While most physicists believe that they can "catch the mouse" with the latest development of mathematical apparatus, there are others who think that there is problem with relying too much on such apparatus. Let us give a quote:

"Derek Abbott, Professor of Electrical and Electronics Engineering at The University of Adelaide in Australia, has written a perspective piece to be published in the Proceedings of the IEEE in which he argues that mathematical Platonism is an inaccurate view of reality. Instead, he argues for the opposing viewpoint, the non-Platonist notion that mathematics is a product of the human imagination that we tailor to describe reality.
…
So if mathematicians, engineers, and physicists can all manage to perform their work despite differences in opinion on this philosophical subject, why then does the true nature of mathematics and its relation to the physical world really matter?

The reason, Abbott says, is that when you recognise that math is just an abstract mental construct—just an approximation of reality that has its frailties and limitations, and that such abstractions will break down at some point, because perfect mathematical forms do not exist in the physical universe—then you can see how ineffective math actually is.

That is Abbott's main point (and the most controversial one): that mathematics is not exceptionally good at describing reality, and mathematics is definitely not the "miracle" that some scientists have marvelled at. Einstein, a mathematical non-Platonist, was one scientist who marvelled at the power of mathematics. He asked, "How can it be that mathematics, being after all, a product of human thought, which is independent of experience, is so admirably appropriate to the objects of reality?" (3)

Allow us to emphasise a part of the above quote:

"*just an approximation of reality that has its frailties and limitations, and that such abstractions will break down...*"

This statement gives us some clues regarding how we should think of mathematics. Yes, mathematics is useful for numerous problems, but as with human being himself, it is bound to limitations, contradictions etc. This problem of mathematical consistency has been discussed bluntly in Godel's famous incompleteness theorem.[3]

In other words, provided we accept such a non-Platonic view of mathematics, we should continue being humble. Even if sometimes our theory gives out a series of correct predictions, it does not necessarily mean that we already hit the jackpot of physical reality. But the problem is more acute, because numerous theoretical physicists (except a few), hold a position which can be expressed better than the following joke:

"An engineer considers that his/her equations approximate reality,
A theoretical physicist considers that reality approximates his/her equations,
A mathematician doesn't care about reality."

We can observe easily that so many physicists hold the mathematician's viewpoint of reality, in their stubborn adherence to mathematical models, as if the models themselves hold all the answers. This behavior happens with the so-called Standard Model of particle physics and with the Standard Model of cosmology. If there are new observational findings which contradict those standard models, they are systematically discarded, or new fancy words are created to describe the difficulties of the apparent mathematical situation, including “dark energy”, “dark matter”, and numerous “ghosts” here and there, which are forms of mental deflections, and psychological abstractions.

Such a deflecting pattern has become quite the norm in a very large industry called "Big Science," with all their bells and whistles. And there are those illustrious figures who have tried to humiliate anyone who has dared to ask questions beyond certain (unspoken)

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[3] See for instance Mark Buchanan, Nature, https://www.nature.com/articles/nphys550

“permissible limits”.

A long time ago, the late Prof. Robert M. Kiehn from Houston University wrote an email to one of us (VC), that many physicists tend to forget that what they are working with are only models, i.e. approximate and tentative descriptions of physical reality.

In retrospect, perhaps the root cause of such a strict adherence to those models can be traced back to blind acceptance of Einstein's photon model and his special relativity theory. A deeper look into those two theories will reveal that they are problematic. For example, special relativity theory rejects the notion of ether, despite some experiments showing ether wind can be observed. (Einstein later on reinstated the ether in his public lecture at the Leiden University, 1920. Subsequently various authors have tried to combine ether into a general relativity framework. Most of these attempts seem to be useless).

Therefore, perhaps now is the right time to distinguish two ways of doing science: (a) *Big Science*, emphasising anti-empiricism and operationalism, and (b) *Deep Science*, our attempts to discover the empirical hidden layers of physical reality.

Scaffold to the moon

There is another philosophical question related to Platonic view: "*Do we live in a mathematical universe?*"

Although this question appears simple, the answer is not. Beyond the Platonic and non-Platonic views, as we discussed above, there is a variety of other possible answers. To mention a few:

- Neo-Platonic view; for example the dodecahedron universe model by Prof. Luminet et al from Observatoire de Paris, Meudon.
- number theoretic model of universe (from Pythagoras: “The world is a number”.)
- set theory view
- geometric view
- string theory inspired models
- adhesion universe model
- Voronoi tessellatice model
- cellular model, e.g. Konrad Ranzan (9);
- soliton model, e.g. our recent paper on the cellular automaton KdV model (see Appendix);
- nonlinear cosmology based on Kolmogorov’s turbulence[4] or Pfaffian turbulence theories(8);

[4] For instance, in few previous papers, we reported our exploration on an early Universe model with rotation. As per our summary report submitted to J. Mathematics (MDPI), we suggest among other things:
“Questions regarding the formation of the Universe and what was there before the existence of the Early Universe have been of great interest to mankind of all times. In recent decades, the Big Bang as described by the Lambda CDM-Standard Model Cosmology has become widely accepted by the majority of physics and cosmology communities. Among other things, we can cite A.A. Grib & Pavlov who pointed to problems with assumptions of heavy particles creation out of vacuum and also launched other proposal such as *Creatio Ex-Nihilo theory* (CET).
But the philosophical problems remain, as Vaas pointed out: Did the universe have a beginning or does it exist forever, i.e. is it eternal at least in relation to the past? This fundamental question was a main topic in ancient philosophy of nature and the Middle Ages. Philosophically it was more or less banished then by Immanuel Kant’s *Critique of Pure Reason*. But it used to have and still has its revival in modern physical cosmology both in the controversy between the big bang and steady state models some decades ago and in the contemporary attempts to explain the big bang within a quantum cosmological framework.

and so on.

So, which one to choose? Our opinion is: you can start with a few assumptions which you find convenient with, and work them out seriously. But after your paper has been published, keep on being flexible, keeping in mind other possibilities.

There are a number of analogies which advise us to remain humble in our journey to decipher the hidden layers of physical reality, e.g. the story of an elephant and five blind men, which you may have heard before.

And there is also a Confucius saying: "*The wise man points his finger to the moon, but the fool only sees the finger, not the moon."*[5] The message here is striking: our given theory is only the pointing finger. Yes, the theory surely helps us to see the moon (the Universe), but we should not forget that the theory is not really the Universe. (It is worth noting here, that you are not a good physicist if you cannot distinguish the difference between a pointing finger and the Moon.)

Or perhaps you do not like Zen koans. In this case, there is another analogy (held by Murray Gell-Mann), e.g. that his theory helps him like a scaffolding, in order to describe certain physical phenomena. After the work is done, the scaffolding may be not necessary anymore.

We can develop our theories to be more and more advanced in order to explore the hidden realities of Nature. We can consider this approach as: "a scaffold to the moon." We hope that the phrase "scaffold to the moon" captures what we intend, as a method of distinguishing between Big Science and Deep Science.

(a) When your equations have been confirmed by observations and experiments, *Voila!* Yes, it is normal that the first thing that comes to your mind is to celebrate the confirmation of the equations with champagne or a bottle of vodka. An accumulation of such self-celebrating non-physical "experimental confirmations" of mathematical abstractions, leads to *Big Science*.

(b) But that is only the first in the iteration of steps up the scaffold. Perhaps one or two years later, you figure out that there were too many assumptions or there were logical flaws in your

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Interestingly, Vaas also noted that Immanuel Kant, in his *Critique of Pure Reason* (1781/1787), argued that it is possible to prove both that the world has a beginning and that it is eternal (first antinomy of pure reason, A426f/B454f). As Kant believed he could overcome this „self-contradiction of reason" („*Widerspruch der Vernunft mit ihr selbst*", A740) by what he called „*transcendental idealism*", the question whether the cosmos exists forever or not has almost vanished in philosophical discussions.
It turns out that Neutrosophic Logic is in agreement with Kant and Vaas's position, it offers a resolution to the long standing disputes between beginning and eternity of the Universe. In other words, in this respect we agree with Vaas: "how a conceptual and perhaps physical solution of the temporal aspect of Immanuel Kant's „*first antinomy of pure reason*" is possible, i.e. how our universe in some respect could have both a beginning and an eternal existence. Therefore, paradoxically, *there might have been a time before time or a beginning of time in time*."
To summarize, Neutrosophic Logic study the dynamics of neutralities. And from this viewpoint, we can understand that it is indeed a real possibility that the Universe has both *an initial start (creation) but with an eternal background*."

[5] "*When a wise man points at the moon the imbecile examines the finger."* — Confucius. url: https://www.goodreads.com/quotes/180245-when-a-wise-man-points-at-the-moon-the-imbecile

equations, and you must find a better and simpler way to figure out the hidden structure of Nature. That is *Deep Science.* Feynman once remarked something like: "the faster we find out flaws in our theory, the better, because it will lead us to move one step forward."

Deep Science is quite comparable to Deep Learning, i.e., the merging of Machine Intelligence and Big Data. This kind of merging becomes crucial in studying physical phenomena, because the amount of data involved in physical science is getting very large. One or two decades ago, a PhD student in astronomy may have needed to analyse a few Gigabytes of data, but these days the data requirements have reached Terabyte levels. In the same way, it is not enough to find the logical structures while studying cosmology. We should also learn physical patterns. After all, mathematics is not all about logic and proof building, but it is also about pattern recognition.

Two things we should keep in mind:
- physics is more than an acrobatic juxtaposition of the latest trends of theoretical jargon
- mathematics is more than a semiotic game of symbols and operators.

In other words, mathematical language is required, but that is not the goal. If you want to find the light at the end of the tunnel, you should ask different questions, and think differently.

The story of a cat tied to the pole

Probably you are an accomplished theoretician. You know all tricks of the trade. You have done all marvellous tasks: group it, geometrize it, knot it, knit it, curve it, gauge it, leave it.

But somehow deep inside your heart you know that you missed the real answer. You want to find the Holy Grail of Nature, the Ancient One. Where shall you find your answers?
Allow us to tell you a story:

"*A long time ago, a Zen teacher in a distant village was disturbed by voice of a cat in his house, so he ordered his students to tie the cat to a pole in the backyard, so he could pray, undisturbed. Decades later, long after the teacher had passed away, all his followers still hold on to their former Zen teachers' exhibited behaviours and have made it into a tradition of tying a cat to a pole in the backyard. They also publish many books discussing the spiritual advantages of praying beside a cat."*

That is an old story in a book written by Father Anthony de Mello, a wise priest from India. The lesson is simple but it has deep message: "A temporary solution for certain problem can become a cult, worshipped by future generations of ignorant followers."

You may laugh at this story, but let us give you four examples to show that the same problem actually plagues many areas of our modern life:

a. Max Planck. In a desperate move, he used a partition function in order to solve the blackbody paradox. His artificial trick was hailed as quanta of energy by Einstein in his 1905 (photoelectric paper), a development that Planck himself remained sceptical of. The photon was then traditionally accepted as real entity by later generations of physicists. In recent years, other physicists prove that Planck's blackbody law can be re-derived by assuming monochromatic waves. Earlier, Timothy Boyer derived Planck's law by applications of stochastic electrodynamics. Now we ask this question: Does the photon really exist or is it really a "cat tied to a pole" a kind of tradition?

b. Albert Einstein. Einstein developed his general relativity theory with the help of a friend, Marcell Grossmann. He was fully aware that his castle constructions assumed many things, including assumptions of continuous structures. We can argue that it is actually possible to develop various new models of cosmology starting from a discrete space, instead of the “continuous space” assumption. Ask this question: Does space-time curvature physically exist or does it exist only in your mind?

c. Murray Gell-Mann. After spending a few years learning group theory, Gell-Mann developed further Sakata's model, in order to explain certain experimental results which had arisen at the time. He called his extension of Sakata's model, “quark theory”. But Gell-Mann himself never considered “quarks” as real entities. They were only his pet name for a mathematical construction. Unfortunately, from that point, Zweig and Yuval Ne’eman developed a theory which assumed “real quarks” in the “cat tied to a pole” tradition. Later on, experimenters realised that quarks cannot be isolated. This realisation points at the fact that “quarks” are merely fictional creatures, based on unquestioned assumptions regarding “the correctness of quarks” in the “tradition” of Gell-Mann. Indeed, there is still a whole subculture in particle physics devoted to the “quark confinement” problem. What is the point of the “quark confinement” problem, if all quarks are just mathematical artefacts in the “tradition” of misunderstanding the origins of the term “quark” as “a particle”, rather than a personal term for a mathematical operation, as originally coined by Gell-Mann?

d. Abraham Maslow. He was the “father of humanist psychology” at the time, who was famous for his “hierarchy of needs”. Probably you have read that you should fulfil basic human needs first (food, clothes etc.), then begin to meet education and health needs and relationships with others, then seek actualisation of your life. Millions of people followed Maslow's hierarchy advise. (5) The story goes that. later in his life, Maslow regretted how his theory was used. Of course, if you think rather deeply, you will find out that if you follow Maslow's recipe, then by the age of 60 you will have no more energy to do actualisation, or to live meaningfully, let alone doing something good for your community. It is much better to do things the other way around: begin to seek God's purpose in your life, find His Kingdom and His truth, and you will have a purpose in your life. Then gradually God will help you to fulfil all your needs. But unfortunately only a few people can see the way. Most people only follow Maslow's hierarchy blindly, and they forget that is just a hypothesis. That is "*the road less travelled*."

Concluding remarks: Another day in Paradise

Perhaps the true purpose of doing mathematics, as well as logic, is to purify our mind. If our mind is like a mirror, then we have to remove all the dust. But minds have limitations too. As Hui Neng[6] put it: "If there is no shining mirror. …Where can dust collect?” (Put it in another

[6] Yeno (Hui-neng, 638-713), traditionally considered the Sixth Patriarch of the Zen teaching in China. url: https://www.zinzin.com/observations/2014/zen-in-action-no-tree-no-mirror-no-dust/

way: “There is no such thing as dust, *except in our mind*.")

In other words, while it is true that it takes years to get mathematical mastery in a field, may be the right answer lies somewhere else. Therefore you need to ask a variety of different questions.
Don't think “outside of the box”, either?
Box? What box? There is no box *except your mind*.
Set your mind free. Unleash and generate new ideas as much as you can. As in the title of Rod Judkins's new book: “Ideas are your only currency”. (6)

Let us close this rambling note with paraphrasing a saying of wisdom:

"*To err is human, but to generate original ideas is divine*."

Postscripts:
Allow us to add a few more words in the end of this article.

a. You may learn somewhere that to become a good scientist, you should have great ambition to dominate the entire world. You should be fast like a jaguar, strong like a gorilla, and cruel like a shark. If you follow such an advise, no wonder you gradually become a beast. And that is what they urge you to become in numerous universities. If you are a professor, you are forced to publish 25 papers and maybe more each year. They call it the "*publish or perish*" policy. Actually that is an unnatural draconian “Social Darwinism" policy, while Nature is based on Harmony, caring, and cooperation.

b. And the plan of Social Darwinism (competition and “survival of the fittest”) is to make your life miserable, like living in constant danger, in a jungle, a policy intended to curtail any real progress in the sciences. No wonder, many leading professors have no time anymore to give lectures, because they are too busy catching up their publication requirements schedule. If you follow this story in the USA, this is why scientific productivity in the USA tends to gradually decrease, as a recent article in the Economist magazine reports. See also two other articles cited below.[7]

   One of us (FS) has his own story to tell:
   "Myself, when I came to America I was advised to apply my math, so I changed from abstract algebra and number theory to neutrosophic set/logic/probability, to multispace (since our world is composed of many spaces), hybrid geometry (called Smarandache geometry) where the axioms are valid in some points and invalid in other points."

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[7] https://www.focus-economics.com/blog/why-is-productivity-growth-so-low-23-economic-experts-weigh-in; see also https://www.vox.com/new-money/2016/10/24/13327014/productivity-paradox-innovation-growth

But the truth is, you can do science in entirely different way:

c. Find the *inner peace*, feel the rhythm of your heart, know how much God love you, and begin to love your family and your neighbours. The truth is not out there, but it is inside you.

   Instead of living like an animal in a jungle, and doing cruel things to your colleagues, and having even crueller things done to you, try to listen to a soft voice of the Old Friend: "*You can walk with Me in Paradise, right now.*"

   Contrary to what most people tell you, “become a mean and cruel animal”, or “dominate the whole world”, you can ask: "What is the benefit of dominating the world, if I lose my life? How can I find purpose and happiness?"

   In the end, if you seek peace and happiness for you and your neighbours, you will find that you live not in any jungle. Instead, you will find that this day is just another day in Paradise.

   What we mean by Deep Science is:
   Deep Learning. Deep Meaning. Deep Purpose. Deep Life. Deep Spirituality.

Don't live a superficial life. Go Deep.

Hopefully you get our message.
God really loves you.

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VC & FS

(Don’t follow us either, because sometimes we got lost too, in the mental Labyrinth. Follow God only.)

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Appendix:

From Self-Dual Yang-Mills theory to Modified-KdV Equation to Soliton Cellular Automata

ABSTRACT

The present paper is a follow up of our previous title: "An outline of cellular automaton universe via cosmological KdV equation," as published last year in Prespacetime 2018, as well as our response to a new paper by S. Yu. Eremenko [10]. Besides, this paper was inspired by (a) Feynman's checkerboard solution to 1+1 dimensional Dirac equation, and (b) recent work of Prof. Gerard 't Hooft on possible reformulation of QM into classical cellular automata language. In fact, after one of us (VC) communicated our cited paper to him, he gave a short remark: "*Much more understanding of the fundamental particles is needed before one can try to imagine the CA rule(s) for our universe*." Therefore, now we hope to formulate our ideas on cellular automaton model in microworld context. While these approaches (soliton cellular automata etc) may have been known for long time in other fields of physics, their roles in understanding elementary particles have not been discussed quite often. It is our hope, that these new approaches will find their ways to experimental vindications.

Introduction

There are many literatures which discuss that Self-Dual Yang Mills (SDYM) theory reduces to Korteweg- deVries equation [4], but recently Shehata and Alzaidy have proved that SDYM reduces to modified KdV equation [2]. In a similar tone, one of these authors (VC) has obtained exact numerical solution of mKdV equation [3].

Now, in this paper we will give an outline from Self-Dual Yang Mills (SDYM) theory reduces to modified Korteweg- deVries equation, and from m-KdV to soliton cellular automata. The main purpose of this paper is to describe new possibility to describe hadron and elementary particles in cellular automata picture, beyond what has been discussed in 't Hooft's paper.[5]

From Self-Dual Yang-Mills to m-KdV equation

It has been shown since 1990s that many, and possibly all, integrable systems can be obtained by dimensional reduction of self-dual Yang Mills. Moreover, according to Schiff [4] a remarkable piece of evidence for this was produced a few years ago by Mason and Sparling, who showed how to obtain the Korteweg-de Vries (KdV) and Nonlinear Schrodinger (NLS) equations from SDYM. In this regard, it seems very interesting that A.R. Shehata and J.F. Alzaidy were able to reduce SDYM to mKdV equation in their 2011 paper.[2]

SDYM can be written in compact form as follow [2]:

$$\begin{aligned} &P_t + [P,R] = 0, \\ &R_x - Q_t - [Q,R] = 0. \end{aligned}$$

(1)

From which, Shehata and Alzaidy obtain mKdV equation as follows:

$$u_t + 6u_x u^2 + u_{xxx} = 0.$$

(2)

A numerical solution of the above mKDV system has been presented in [3]. In the next section, we will discuss how to translate mKdV equation into soliton Cellular automata.

m-KdV equation reduces to Soliton Cellular Automata

According to Tsujimoto & Hirota, there is a discrete formulation of mKdV which can be written as follows [6]:

$$\frac{\upsilon_j^{t+1}(1+\delta\upsilon_{j+1}^{t+1})}{1+a\upsilon_j^{t+1}} = \frac{\upsilon_j^{t}(1+\delta\upsilon_{j-1}^{t})}{1+a\upsilon_j^{t}}$$

Moreover, Takahashi & Makudaira are able to show that d-mKdV equation can reduce to an ultradiscrete mKdV (u-mKdV) equation under appropriate transformations of variables and limit. Then, we show that the u-mKdV equation is related to an extended version of BBS introducing a carrier of balls. And they also discuss a structure of N-soliton solutions of the system. [6]

Pawel Siwak also discusses filtrons, or discrete solitons, as the substring of a string, which exhibit soliton like properties. Then, he identifies Mealy automata that are equivalent to such models as Soliton Cellular Automata. [7] See also Kakei et al. [8].

What is more interesting to remark here, is that our microworld picture of soliton cellular automata allows us to consider quantization, beyond the standard formalism of Hilbert space.[9] This would mean a realization of ‘t Hooft’s vision to reformulate QM into CA language. We hope to explore this topic in future paper.

Concluding remarks

Summarizing, in this paper we gave an outline from Self-Dual Yang Mills (SDYM) theory reduces to modified Korteweg- deVries equation, and from m-KdV to soliton cellular automata. The main purpose of this paper is to describe new possibility to describe hadron and elementary particles in a soliton cellular automata picture, beyond what has been discussed in ‘t Hooft’s paper.

What is more interesting to remark here, is that our microworld picture of soliton cellular automata allows us to consider quantization, beyond the standard formalism of Hilbert space.[9] This would mean a realization of ‘t Hooft’s vision to reformulate QM into CA language. We hope to explore this topic in future paper.

While we admit that our model is in sketch phase, it is our hope that these new approaches can be found useful in studying mKDV/soliton cellular automata models of elementary particles by computer simulations.

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