An Autonomous, Emergent Framework for Fundamental Physics: Particles as Waves Trapped by Gravity: Supplemental Discussion

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This paper provides additional discussion of issues relating to the real-valued emergent autonomous liquid theory (REALT) framework for fundamental physics (O'Reilly, submitted). In this framework, particles emerge as stable dynamic patterns between interacting quantum wave and gravitational fields. These fields are defined over a 3-dimensional regular cubic matrix of cells, with two state values in each cell. This framework has important philosophical and cosmological implications, that are discussed in this paper.

I. INTRODUCTION

The elementary particles of nature (electrons, quarks, etc) can be created out of raw energy, and can be converted back into energy (i.e., $E = mc^2$). Particles simultaneously exhibit both wave-like and particle-like properties, and have a somewhat mysterious quantum spin property. The speed of light in a vacuum has a fixed constant value. These and other fundamental properties of physics emerge naturally from a simple computational framework called REALT (Real-valued, Emergent, Autonomous Liquid Theory; [1]). They are not assumptions of the theory, but rather emergent consequences of a simple set of assumptions regarding the propagation of two coupled fields (a quantum wave field and a gravitational field). Particles in this framework emerge as stable patterns of gravitationally trapped wave energy (i.e., miniature black holes), in contrast to the hard corpuscles envisaged by traditional particle theories. As emergent patterns, it is easy to see how such particles can be created from raw energy, and destroyed back into energy. The close fit between the emergent properties of this framework and some of the most salient qualitative aspects of our physical universe suggests that this framework is worthy of further investigation.

This paper covers some additional philosophical and cosmological issues not covered in the main technical paper [1]. Many of the philosophical motivations behind this framework are shared with earlier cellular automata (CA) approaches to physics [2–10]. In particular, CA approaches emphasize how complex physical phenomena can emerge out of simple recursively-applied equations, as is the case with REALT, where particles emerge out of interactions between two fields computed using recursively applied wave equations. Also, the emergence of elementary particles as miniature black holes (energy trapped by a sufficiently strong gravitational field of its own making) has been informally suggested by theorists (e.g., [11, 12]). A similar notion of particles as emergent structures within a uniform field (as vorticies instead of black holes) goes back to J.J. Thompson in the late 1800's (as discussed in [13]).

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*URL: `http://psych.colorado.edu/˜oreilly/realt.html`

II. COSMOLOGY

Because space and time are primary in this system (as compared to being “created” by matter as in general relativity), the natural cosmology is one of infinite space and time — boundary conditions on either tend to beg more questions than they answer. Instead of the big bang creating an expanding bubble of space that is the entirety of the universe, which is natural in the general relativity framework, one could think of the big bang as the explosion of the mother-of-all-black holes (MOAB) within a region of the infinite universe. The natural scenario that emerges is thus one of perpetual oscillation between black hole consolidation and explosion. Over time, all black holes within some region of the universe eventually merge into this MOAB, until a presumed critical point is reached where it explodes and flings energy outward, allowing galaxies and black holes to form, whereupon the process of consolidation begins anew. This dynamic avoids the problems of uniqueness of our point in time and counteracts the effects of the second law of thermodynamics; the MOAB restores order by concentrating everything into a small uniform blob of energy.

In addition, perhaps the presumption of a flat underlying space can resolve some extant cosmological puzzles, such as the need for so much dark matter, or the problems that the faster-than-light inflationary model solves?

In terms of testability, under this model, we should in principle be able to see beyond the bubble of our big bang into neighboring bubbles. The black-hole dynamics of elementary particles should in principle be similar to those of their much larger cosmological brethren in this system, so it should be possible in principle to explore their properties.

III. THE APPEAL OF MECHANISTIC FIELD THEORIES

In many ways, the present framework represents a reversion to 19th century ideas. For example, one can equate the cellular matrix of fields in the present system with the ether that dominated 19th century thinking, and as noted the idea of particles as emergent patterns in the ether was first proposed by J.J. Thompson in the late 1800’s. However, the present ether has the advantage of incorporating principles like those of general relativity, which indeed are critical in the formation of the particle attractors. The notion of pervasive fields as fundamentally real has had a tortured history [13], but it persists perhaps because it has such strong intuitive appeal.

One way to understand the intuitive appeal of field theories is in terms of the distinction between analytic, descriptive theories and mechanistic, autonomous theories. The current standard model of physics is a fundamentally analytic, descriptive framework, whereas the field theory presented here is fundamentally mechanistic and autonomous. In the analytic approach, one writes a set of equations describing a particular configuration of particles and forces, and solves them to predict the temporal evolution of such a system. The advantages of such a system include: a) it is highly compact and efficient; b) it transparently represents the measurable quantities of interest; and c) one can often easily compute predicted outcomes. However, the disadvantages include: a) it typically suffers from combinatorial explosion as the number of particles goes beyond a few (hence the pervasive difficulty in solving for “many body” configurations); b) it tends to be non-local, in that the equations describe the entire configuration, not just independent pieces of it, which often results in equations specifying action-at-a-distance, as in Newton’s theory of gravitation; and c) it tends to reify particles as discrete loci to which equations can refer, to the point that force fields are described in terms of exchanges of virtual particles in the standard model.

The mechanistic, autonomous approach focuses instead on specifying underlying mechanisms that function independently and automatically regardless of what problem is being analyzed or what situation is being described. For example, the *only* thing that differs in simulating different physical systems within the present framework is the initial state of the matrix. From that point onward, the exact same equations are applied recursively to determine the temporal evolution of the system. This autonomy is appealing in thinking about how physics really works: do we imagine that nature configures and solves different equations for each situation it encounters? Of course not. But extant analytic theories fail to provide an answer to the fundamental *mechanistic* question: how does nature actually do it? Many modern theorists eschew such questions as old-fashioned, unanswerable, and misguided, without really providing anything more than a denial that nature can be understood at this level. Given the promise of the present approach to make progress at this mechanistic level, perhaps such denials are premature.

It is interesting that the notion of mechanistic autonomy also tends to imply distributed elements with local interactions (i.e., a field theory, such as the present case). Why? Because physics happens everywhere in parallel, and the notion of one part of the system having to perform elaborate computations to coordinate with another non-local part of the system soon becomes impractically complicated. Thus, computational necessity drives one to consider parallel, distributed, local field theories.

The distinction between analytic and mechanistic approaches is blurred, however, by the fact that the analytic, descriptive theories typically presume to describe some kind of mechanistic, autonomous system that is the underlying reality. Indeed, the analytic equations for a given problem are constructed according to general principles that constitute the underlying theory. The problem is, it may not be possible to accurately capture the emergent, parallel, and distributed nature of the underlying mechanistic system using analytic abstractions. The success of the standard model of physics suggests that the analytic, descriptive approach can go very far. Nevertheless, one could argue that until the corresponding mechanistic, autonomous system can be constructed, we don't fully understand how the physics really works. We can merely describe it. Unfortunately, we have no idea whether such a mechanistic theory is possible; nature could be anything at all and placing *a priori* constraints on theories has proven notoriously limiting in the past.

A useful analogy for the above contrast comes from the attempt to understand human cognition. The "standard model" of cognition until recently has been specified in a very analytic, descriptive manner, in terms of information processing achieved through the manipulation of symbolic structures by logic and other processes (i.e., very much like a computer). In contrast, the more recent "parallel distributed processing" (PDP) models of cognition attempt to provide a more mechanistic, autonomous description of cognition in terms of the emergent phenomena produced by the collective actions of the billions of neurons in the brain (e.g., [14]). In some cases, there are nice correspondences between the different levels of analysis, but in others, the PDP framework provides very different explanations of cognitive phenomena. Unlike in physics, it is clear to almost everyone that somehow the ultimate theory of cognition must be expressed in terms of its underlying mechanistic (neural) substrate, because we have direct access to this lower level of mechanism and know that it is ultimately responsible for how the brain works. In contrast, we have no idea what the low level mechanisms of physics might be, and in this void the most successful approach to date has clearly been the analytic, descriptive approach. In the face of all these difficulties, it is hoped that the mechanistic, autonomous approach represented by REALT has some promise.

IV. DISCRETENESS

The present system discretizes space and time, but not state variables. Proponents of cellular automata (CA) models of physics argue that state variables should also be discretized, as this provides a finite underlying mechanistic basis for the theory. Somehow, real-valued state variables seem to imply the presence of a yet lower-level of mechanism that for example implements fixed-precision floating-point math using binary states. However, this kind of thinking is perhaps overly presumptuous. If nature is best described with continuous state variables, then it could just be that this is the way it is, and ultimately we just have to accept it. The fact that force fields and energy values appear to vary continuously over a huge range suggests that state variables may indeed be continuous-valued.

With this reasoning, why should one hypothesize a discretization of space and time? One very pragmatic reason is that it is impossible to simulate a truly continuous field. It also introduces problems of infinite regress: can there really be an infinity of elements within each point of space? It somehow seems more plausible to assume the finiteness of discrete space and time. This distinction may be related to the different levels of infinity represented by integers versus real numbers, for example. Furthermore, continuous space tends to result in singularities when computing the properties of point particles, which can be avoided in discretized space. There may be a more compelling argument to be made in the present situation: the emergent particles likely depend on the discretization of space and time. Achieving sufficiently energetic wave oscillations to drive stable particles seems to require neighboring cells having highly disparate oscillating values. Attempts to create larger particle structures spanning many cells have proven unsuccessful so far: the system inevitably converges on particle structures spanning only a few cells. Thus, it is not clear that these particle structures would persist in the continuum limit.

V. COMPARISON WITH STRING/BRANE THEORY

Many physicists have been pursuing the string theory framework as a means of integrating quantum mechanics and general relativity. This framework involves tiny (planck scale) oscillating string- or membrane-like elements that live in 10 or so dimensional spaces, with many of these dimensions "curled up", leaving our three-dimensional reality as the only large-scale dimensions. The primary difficulty with such theories apparently is that they can be parameterized in so many different ways that it is difficult to constrain them based on available evidence. In contrast, perhaps the primary advantage of the present framework is that it is extremely simple and has very few equations and assumptions, from which a number of prominent aspects of our physical reality follow. The single free parameter at this point is the cube length. However, the disadvantage of this framework is that if it turns out to not fit the experimental data, it may be very difficult to fix the theory; the emergent particle dynamics appear to depend critically on the exact formulation of the underlying fields.

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Particle physics experiments briefly discusses a number of past, present, and proposed experiments with particle accelerators, throughout the world. In addition, some important accelerator interactions are discussed. Also, some notable systems components are discussed, named by project.Â Brian Cox Particle Physics Lecture at CERN. Experimental Particle Physics @ IISER Pune. Quantum Physics made simple - Wave-Particle Duality Animation. Transcription. Contents. Notes, flashcards, videos and past exam questions by topic for AQA Physics A-Level Section 3 - Waves.Â Recap everything you learnt in Year 12 and fill in any gaps in your knowledge with our Physics AS-level course on 2-3 June. Notes || Flashcards || Questions by Topic. This topic is included in AS Paper 1 and Paper 2, and A Level Paper 1 for AQA Physics. Notes: Definitions. Elementary particle physics goal is to search for the remaining particles.Â Quarks are fundamental particles which interact through all four of the fundamental forces of physics: gravity, electromagnetism, weak interaction, and strong interaction. Quarks always exist in combination to form subatomic particles known as hadrons. There are six distinct types of quark: Bottom Quark. Abstract: We put forward a possible new interpretation and explanatory framework for quantum theory. The basic hypothesis underlying this new framework is that quantum particles are conceptual entities. More concretely, we propose that quantum particles interact with ordinary matter, nuclei, atoms, molecules, macroscopic material entities, measuring apparatuses, ..., in a similar way to how human concepts interact with memory structures, human minds or artificial memories. We analyze the most characteristic aspects of quantum theory, i.e. entanglement and non-locality, interference and superpo Matter waves interacting with macroscopic bodies (such as particle detectors) undergo collapse. Indeterminism: An Unsure Future. Schroedinger evolution of a matter wave is fully deterministic. That means that if we specify the present state of the matter wave, its future state is fixed completely by Schroedinger's equation.Â When quantum theory first emerged as our best theory of fundamental particles, the central role of probabilities in the theory caused much concern. The probabilities associated with the collapse of the wave packet were not of the type always formerly seen. Prior to quantum theory, the probabilities that had crept into physics could always be thought of as manifestations of our ignorance of the true state of affairs.