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CONSTRUCTING A BIT STRING UNIVERSE: a Progress Report*

H. PIERRE NOYES
Stanford Linear Accelerator Center
Stanford University, Stanford, CA 94305

MICHAEL J. MANTHEY
Department of Computer Science
University of New Mexico, Albuquerque, NM 87131

and

CHRISTOFFER GEFWERT
Academy of Finland, Helsinki
and
Stanford Linear Accelerator Center
Stanford University, Stanford, CA 94305

ABSTRACT

We present a case for a discrete, constructive physics that generates four scale constants, a connection to laboratory events and scattering theory that ties these to the dimensional constants c, h, m_p, and G, and a tentative quantum number assignment consistent with the "standard model" for leptons and quarks with three generations. Current first approximations from the theory are $\hbar c/e^2 = 137 \pm O(1/137)$, $\hbar c/Gm_p^2 = 2^{127} + 136 \simeq 1.7 \times 10^{38}[1 \pm 0(1/137)]$,and $m_p/m_e = 1836.151497...\pm$? Our understanding of "wave-particle dualism" and observational "cosmology" creates no more "experimental paradoxes" than currently accepted views — perhaps fewer.

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1. INTRODUCTION

The work presented here, although the center of serious enquiry for three decades,.,[1–9] has not achieved its final form. In particular, we have not yet seen how to construct relativistic quantum mechanics with a clear understanding of *what* results, when achieved, would terminate the program. Hence we have not yet met the requirements that one of us (CG) sees as necessary for such a program.[10] Yet this somewhat inchoate theory has suggested a model which allows us to generate a bit string universe constructively from a couple of simple operations and a few well understood symbols, - a universe that can model more simply, and in some cases more accurately than conventional physics, "facts" currently accepted by physicists. Many of those involved in this research believe we have more than that, but they have not made their case compelling either inside their current home[11] or in the broader communities we inhabit (physics, philosophy, mathematics, computer science,...?) So what this paper is about is to get any imaginative reader to think that our approach might be exciting, and fun– a strategy suggested to one of us (HPN) by Wheeler some time ago.

The fun is not far to seek once one can engage in the initial surrender of disbelief. GUTS, SUPERGRAVITY and other theories of physics with (hopefully) fewer parameters than those currently required as empirical input, yet more than the minimal three *we* need (for connection, *not* adjustment, to experiment), are avidly sought within "conventional" frameworks. Mathematics has to face the challenge of whether its theorems are "computable", if not why not – or the relevance of the question, and whether a "proof by computer" that cannot be checked step by step by humans is a "proof". Computer scientists have to ask whether the demonstrable (and practically important) uncertainties encountered in concurrent programming are more than a problem to be designed around, but might set limits to their theories, whether concurrency itself involves problems that are beyond the scope of a "universal computer" or "Turing machine" even if they could build one, whether "randomness" is a "meaningful" concept when there is no algorithm for computing a random number ,... Our approach involves all of these questions, so can be fun even where we cannot be certain of our "answers".

2. PROGRAM UNIVERSE 2

Our computer algorithm (Program Universe 2)[12] starts from nothing (in the computer, other than program and available memory) and generates a growing universe characterized by two cardinals: $SU, N \in integers$. For computer operations any element of the universe may be simulated by an ordered string of the symbols $0, 1$ containing N such symbols which we can call $U[i], i \in 1, ..., SU$. We use two operations to increase these cardinals:(1) PICK, which picks any string from the universe with probability $1/SU$ and a second string (shown to be different by discrimination - see below) with the same prior probability and generates a string by discrimination; if the new string is not already in the universe it is adjoined and SU is increased by one. If the string produced by PICK is already in the universe we invoke (2) TICK which picks a bit for each $U[i]$, randomly chosen between the two symbols $0, 1$, adjoins it at the head of the string, and hence increases N by one; the code then returns to PICK. The flow is thus $PICK \rightarrow [novel(adjoin)\ OR\ contained(TICK)] \rightarrow PICK...$.

That this seemingly trivial program can produce any interesting structure is due to the subtleties implied by the discrimination operation which (sometimes) creates new strings. For two *ordered* bit strings of length N, symbolized by $S_i = (..., x_i, ...)_N$ where $x_i \in [0,1]$, $i \in [1,N]$, *discrimination* is defined for bits by $D_N S_i S_j = (..., x_i +_2 x_j, ...)_N$, where $+_2$ is binary addition (exclusive or), or for integers by $D_N S_i S_j = (..., (x_i - x_j)^2, ...)_N$. This allows us to think of the elements of this universe, which we have sometimes called *Schnurs*, as ordered strings of bits *or* of integers from the set $[0,1]$, an ambiguity we exploit in defining conserved quantum numbers.

To get the program started we assign the first string in the universe the value R (i.e. a random choice between 0 and 1) and the second again the value R, provided only it differs from the first. We now enter the main program at PICK, and continue till doomsday. We say that each tick follows an *event*. Note that by this specification of events, and the integral ordering of the ticks (even if, outside of the computer simulation it turns out to be unknowable) we have abandoned the concept of *simultaneity*, and not just "distant simultaneity" as is customary in special relativity.

Discrimination (which we for current purposes write as +, with $a + a = 0$, and a,b linearly independent (l.i.) iff $a + b \neq 0$) creates sets which close under discrimination called discriminately closed subsets (DCsS). For example, if a and b are l.i., the set $\{a, b, a+b\}$ closes, since any two when discriminated yield the third. Similarly if c is l.i. of both a and b, we have the DCsS $\{a, b, c, a+b, b+c, c+a, a+b+c\}$. Provided we call singletons such as $\{a\}$ DCsS's as well, it is clear that from n l.i. strings we can form $2^n - 1$ DCsS, since this is simply the number of ways we can choose n distinct thing one, two,... up to n at a time.

The first construction of the hierarchy[3] started from ***discrimination*** using ordered bit strings as already defined. Starting from strings with two bits (N=2) we can form $2^2 - 1 = 3$ DCsS's, for example $\{(10)\}, \{(01)\}, \{(10), (01), (11)\}$. To preserve this information about discriminate closure we map these three sets by non-singular, linearly independent 2×2 matrices which have only the members of these sets as eigenvectors, and which are linearly independent. The non-singularity is required so that the matrices do not map onto zero. The linear independence is required so that these matrices, rearranged as strings, can form the basis for the next level. Defining the mapping by (ACDB)(xy)=(Ax+Cy,Dx+By) where A,B,C,D,x,y $\in 0, 1$, using standard binary ***multiplication***, and writing the corresponding strings as (ABCD), three strings mapping the discriminate closure at level 1 are (1110), (1101), and (1100) respectively. Clearly this rule provides us with a linearly independent set of three basis strings. Consequently these strings form a basis for $2^3 - 1 = 7$ DCsS's. Mapping these by 4x4 matrices we get 7 strings of 16 bits which form a basis for $2^7 - 1 = 127$ DCsS's. We have now organized the information content of 137 strings into 3 levels of complexity. We can repeat the process once more to obtain $2^{127} - 1 \simeq 1.7 \times 10^{38}$ DCsS's composed of strings with 256 bits, but cannot go further because there are only 256×256 linearly independent matrices available to map them, which is many to few. We have in this way generated the critical numbers $137 \simeq hc/2\pi e^2$ and $1.7 \times 10^{38} \simeq hc/2\pi G m_p^2$ and a hierarchical structure which terminates at four levels of complexity: $(2,3), (3,7), (7,127), (127, 2^{127} - 1)$. It should be clear that the hierarchy defined by these rules is ***unique***, a result achieved in a different way by John Amson[4].

In the context of program universe, since the running of the program provides us with the strings and also an intervention point (adjoin the novel string produced by discrimination from two randomly chosen strings) where we can organize them conceptually without interfering with the running of the program, we can achieve the construction of a representation of the hierarchy in a simpler way. The procedure is to construct first the basis vectors for the four levels by requiring linear independence both within the levels and between levels. Since adding random bits at the head of the string will not change the linear independence, we can do this at the time the string is created, and make a pointer to that $U[i]$ which is simply i, and which does not change as the string grows.

Once this is understood, the coding is straightforward, and has been carried through by one of us (MJM). Each time a novel string is produced by discrimination, it is a candidate for a basis vector for some level. All we need do is find out whether or not it is l.i. of the current (incomplete) basis array, and fill the levels successively. Calling the basis strings $B_\ell[m]$ where $\ell \in 1,2,3,4$ and $m \in 1,..,B[\ell]$ with $B[1]..B[4] = 2,3,7,127$, we see that the basis array will be complete once we have generated 139 l.i. strings. Since the program fills the levels successively, it is easy to prove that if we discriminate two basis strings from *different* levels we must obtain one of the basis strings in the highest level available during the construction, or level 4 when the construction is complete, i.e. $if\ i \neq j\ and\ both\ < \ell_{last}\ then\ B_i + B_j =\ some\ B_{last}$.

Once we have 139 l.i. basis strings, which will happen when the bit string length N_{139} is greater than or equal to 139, we can insure the generation of some representation of the combinatorial hierarchy by going to $TICK$. Then the only alteration of these N_{139} initial bits that can occur from then on will be the filling up, by discriminate closure, of any of the remaining elements of the hierarchy in this representation as a consequence of the continuing random discriminations. Since we keep on choosing strings at random and discriminating them, discriminate closure insures that we will eventually generate all $2^{127} + 136$ elements of the hierarchy [BUT NO MORE]. Of course there will eventually come to be many different strings with the same initial bits, N_{139}. We fix this number and call it LL for"label length"; our program automatically generates ensembles of strings labeled by some (unknown) representation of the hierarchy. The coding which provides pointers to these ensembles is again straightforward. From now on we will call the first LL bits in a string the *label*, and the remaining $(N - LL)$ bits the *address*. Finally we note that when the label array is complete we know that among the labels L_i at any one level we can find exactly B(i) l.i. strings and no more; it becomes arbitrary which of the many possible choices we make, so the "basis" becomes a structural fact and does not single out any particular strings. It follows immediately that *if* $i \neq j$ *and both* $< \ell_{last}$ *then* $L_i + L_j =$ *some* L_{last}.

3. LABELS AND QUANTUM NUMBER CONSERVATION

An event has been defined when the universe has bit-length N and (when the labels have closed at bit-length LL) at address bit-length $A = N - LL$) as the failure to produce a new string by discrimination. This can occur only when two or more discriminations happen *before* the next tick. Sequentially, the first of the two discriminations we consider resulted from picking S_1 and S_2 at random and generating a string not yet contained in the universe $S_3 = D_N S_1 S_2$. The second discrimination can lead to an event in two different ways. In the first case we pick any two of these three strings again. Since $S_1 + S_2 + S_3 = 0_N$, this second discrimination ***necessarily*** must yield a string already in the universe. Then the program takes us to TICK, and all the strings in the universe will be augmented by one random bit at the head. Clearly this can happen in three different ways, but we cannot tell without further information which one of the three occured. The second class of events generated by the program occurs when we pick two strings S_4 and S_5 both of which are different from the first three strings considered but which on discrimination yield one of the first three strings, that is $D_N S_4 S_5$ is equal to S_1 ***or*** S_2 ***or*** S_3. Again, any one of these three possibilities will lead to TICK and we cannot know which of the three occured. We can, however, calculate the ***relative*** probabilities between the two classes of events;in a subsequent paper we we will show how this enables us to calculate ***coupling constants.***

Since the levels close, they convey no ***dynamic*** information; this must come from the addresses, and the labeled address ensembles. By construction addresses are random bit strings (other than through correlation with the label). But they still have a structure we have not yet exploited, the number of zeros N^0 and the number of one's N^1 in any address string. This allows us to define for each string, or string segment, a parameter bounded by -1 and 1 $v_d = (N^1 - N^0)/(N^1 + N^0)$ which we call ***d-velocity.*** For simplicity we consider first only two bit labels for which (10) + (01) + (11) = (00), implying three possible configurations for the discriminations that occur in our definition of event:(1) $(10)v_{10} + (01)v_{01} \Longleftrightarrow (11)v_{11} \Longleftrightarrow (10)v'_{10} + (01)v'_{01}$;(2) $(10)v_{10} + (11)v_{11} \Longleftrightarrow (01)v_{01} \Longleftrightarrow (10)v'_{10} + (11)v'_{11}$;and (3) $(11)v_{11} + (01)v_{01} \Longleftrightarrow (10)v_{01} \Longleftrightarrow (11)v'_{11} + (01)v'_{01}$. To these labels we have added address strings symbolized by v whose significance we will develop below.

We can now see, in this limited environment, how quantum number conservation comes about. We call $a = (10)$ a ***particle*** label, $\bar{a} = (01)$ an ***antiparticle*** label and $q = (11)$ a ***quantum*** label. Then the three configurations can be thought of as three primitive scattering processes:(1) $a + \bar{a} \Longleftrightarrow a + \bar{a}$,(2) $q + \bar{a} \Longleftrightarrow q + \bar{a}$ and(3) $a+q \Longleftrightarrow a+q$. We see that if we represent the label as $(b_1 b_2)$ then $b_1 - b_2$ can be used to define the particle quantum number as +1,0,-1 and that the the number of particles minus the number of antiparticles is ***conserved.*** Further, if we link up tick-separated events to make more complicated diagrams, this fact will persist. Thus we have established our first discrete conservation law - so far only for level 1 labels.

If we could treat paired descriptors like (10),(01) along a string as independent quantum numbers, the interpretation given in the last section would generalize to any label with even label length; we could map onto a linear, finite Hilbert space without much effort. The hierarchical connection between levels does not allow us to do this because, for example, a label with string length 4 allows 16 symbols, four of which are linearly independent, while the hierarchy requires us to use only (any l.i. choice of) three of these and hence only seven non-null strings. Nevertheless, at level 2, it is possible to define conserved quantum numbers for two in – two out processes. Since the demonstration is by exhibition, and not by an elegant proof, we omit it here. Using an appropriate connection between the particle, antiparticle dichotomy and velocity direction, level 2 label event structure allows two conservation laws. One implementation allows these to be the difference between the number of particles and antiparticles; for a string (b_1, b_2, b_3, b_4) this is $d = b_1 - b_2 + b_3 - b_4$. The second quantum number in this pair takes twice the component of spin along the velocity direction to be

$2s_z = b_1 + b_2 - b_3 - b_4$. Then, as can be seen from the first two columns of Table I,

Table I

Two interpretations for level 2 quantum numbers

	$(b_1b_2b_3b_4)$	d	$2s_z$ or $2I_z$	$2U_z$	$2V_z = 2(I_z + U_z)]$
STRING:	1110	+1	+1	+1	+2
	0010	+1	-1	+2	+1
	1100	0	+2	-1	+1
	1111	0	0	0	0
	0000	0	0	0	0
	0011	0	-2	+1	-1
	1101	-1	+1	-2	-1
	0001	-1	-1	-1	-2

$d = b_1 - b_2 + b_3 - b_4; 2s_z = b_1 + b_2 - b_3 - b_4$

$2I_z = b_1 + b_2 - b_3 - b_4; 2U_z = -2b_1 + b_2 + 2b_3 - b_4; 2V_z = -b_1 + 2b_2 + b_3 - 2b_4$

We have two fermions and two antifermions, two helicity 1 quanta, and an $s_z = 0$ interaction with no "antiparticle". The natural interpretation is the electron-positron-gamma-coulomb system. Alternatively, we could identify the second of these quantum numbers with twice the "z component" of isospin. Then we define $2U_z = -2b_1 + b_2 + 2b_3 - b_4$, and find, consistent with the usual definition $V_z = I_z + U_z$, that we have seven of the eight quantum numbers of the basic SU_3 octet. Our scheme even becomes an octet when we add the label (0000) which is degenerate as to these quantum numbers with (1111) [and which will eventually be generated in this position by the continuing discriminations]; of course in our context this label is meaningful only when it is part of a longer string.

Mapping level 2 to level 3 produces four bits which can take on all 16 independent possibilities and additional parts of the string which have only three independent basis vectors, like level 2, giving $8 \times 16 = 128$ possibilities from which we must subtract the null string to leave 127. It is therefore natural to take the octet as the color octet and the 16 states as what we can get from two different spin 1/2 fermions with their antiparticles, – the up and the down quark? If this works out in detail, level 1,2, and 3 then give the first generation of the standard model (two component electron neutrinos; electrons, positrons and vector quanta with a long range scalar interaction; colored up and down quarks with their antiparticles)

Turning to level 4, we note that we can obtain a level 4 basis string by putting together three basis strings from different lower levels providing us immediately with $2 \times 3 \times 7 = 42$ basis vectors, and by repeating this structure three times in longer strings end up with with 126 of the 127 basis vectors for level 4. Since each of these has, internally, the same quantum number structure, this looks suspiciously like the three generations which have been found experimentally (electron, up, down; muon, charm, strange; tau, truth, beauty). The 127th basis vector is needed for cross-generational interactions. Once we understand it in terms of our dynamics, we will have our own constructive candidate for "grand unification". The one string which couples everything in the same way, and which occurs with a prior probability of $1/(2^{127} + 136)$, then represents the Newtonian gravitational interaction, and the starting point for our theory of "supergravity".

But to make that development possible we must first connect our scheme to space time.

4. RECONSTRUCTION OF RELATIVISTIC QUANTUM MECHANICS

To go from quantum number conserving label-specified scattering events to a quantum scattering theory we assume that the bits added to a particular labeled ensemble between two scattering events (separated by $b = N^1 + N^0$ ticks) conserving that label define a random walk ensemble[5] with $p =< N^1/b >$ the probability of a step in the + direction. Then the step in the opposite direction has probability $q = 1 - p =< N^0/b >$ and (for fixed step length and time interval) the most probable position moves with velocity $v = p - q$, which coincides with our definition of "d-velocity". We further assume that we can attribute a mass m_L (or mass distribution) to each label. Then we can *define* two digital quantities scaled by m_L by $E_d^L = m_L c^2 \times (N^1 + N^0)/2(N^1 N^0)^{1/2}$ and $p_d^L = m_L c \times (N^1 - N^0)/2(N^1 N^0)^{1/2}$ Then $E^2 - p^2c^2 = m_L^2 c^4$ independent of our digital definition of v_d for any label L. However $p_d c/E_d = v_d = c(N^1 - N^0)/(N^1 + N^0)$ consistent with our original definition.

So far our random walks, and energy-momenta are in 1+1 Minkowski space. However, thanks to our postulated (later to be articulated) connection between masses and labels, we have a *metric* space. Further, we have only four basic types of event (involving the four levels of the hierarchy) so can construct a 3+1 space which is rotationally invariant (no way to pick a reference direction). We think this is obvious, and find detailed justification unilluminating.

So far we have, dimensionally speaking, only $[M]$ relative to an arbitrary finite mass and $[L/T]$ limited by c; the theory is still scale invariant. To introduce a unit of length we take the step length in our random walk to be $\ell = hc/E$, which in the unique zero velocity frame (for any otherwise undistinguished bit string segment $< N^1 >=< N^0 >$ and hence $< v = 0 >$ by construction) reduces to h/mc. Clearly our Lorentz invariance requires h to be a universal constant. We now can (once we have made the appropriate connecting links) "measure" the distance between events starting from some reference event. But, in contrast to the unique zero velocity frame given by our theory, there is no way to single out one reference event, or origin in space. Consequently our theory has Poincaré invariance, not just Lorentz invariance, and at least at large distance must have momentum conservation. Thus our theory has the usual free particle relativistic kinematics – the starting point for an S-matrix theory. Since we are developing elsewhere a relativistic finite particle number quantum mechanical scattering theory,[13–17] . we will not pursue that construction further here. What remains is to establish the usual quantum mechanical interference phenomena in space.

The laboratory paradigm we start with is two "counters" with volumes $\Delta x \Delta y \Delta z$ whose geometrical dimensions are measured by standard macroscopic techniques and a time resolution Δt measured by standard clocks. When two counters separated by a macroscopic space and time interval larger than the volumes and time resolutions of the counters have fired, some random walk connecting those two volumes has occured. The connection to the bit string universe is the understanding that what we have called an *event*, and connected constructively to relativistic quantum scattering theory, initiates the chain of happenings that end in the firing of a counter or equivalent natural "event"[7,9]. But we do not know within those macroscopic volumes where this random walk started and ended.

To meet this problem, we construct an ensemble of "objects"(i.e labeled ensembles with a specified ***d-velocity***) all characterized by the same vector velocity $\vec{v}$ and the same label (or mass) chosen in such a way that, after k steps, each of length $\ell = (h/mc)[1-(v/c)^2]^{1/2} = hc/E$, the peak of the random walk distribution will have moved a distance ℓ in the direction of $\vec{v}$. Our basic "quantization condition" is $E = hc/\ell$, which defines a second length by $p = h/\lambda$. We take as our unit of time the time to take one step, $\delta t = \ell/c$. Once "time" is understood in this digital sense, the velocity of the peak of each subensemble in this coherent ensemble has a velocity c/k. We call this ***coherent*** ensemble of ensembles a ***free quantum particle*** of mass m, velocity $\vec{v}$, and momentum $\vec{p} = m\vec{v}/[1-(v/c)^2]^{1/2}$. There is a second "velocity" associated with this ensemble of ensembles, namely that with which "something" moves at each step always in the direction $\vec{v}$. We call this v_{ph}; clearly $v_{ph} = kc$, and $vv_{ph} = c^2$. Since this velocity exceeds the limiting velocity it cannot support any direct physical interpretation, and in particular any which would allow the supraluminal transmission of information; of course it can provide for the supraluminal correlations experimentally demonstrated in EPR experiments. Associated with each of the two velocities and the label (or mass) there are two characteristic lengths $\lambda_{ph} = \ell = hc/E; \lambda = k\ell = h/p$.

Now we consider two basis states for a spin 1/2 fermion which we write as $(10)\vec{p}$ and $(01)\vec{p}$ where $\vec{p}$ stands for an address ensemble triple. We have seen that such a "particle" can scatter from another and lead to a final state in a different direction. But there are only two possible states in the new direction. To preserve the (asymptotic) rotational invariance of our theory therefore requires that the new state be expressable as a ***coherent*** sum of the two states referring to the new direction. Then Lorentz invariance leads directly to the usual spin 1/2 formalism using two-component spinors and Wigner rotations. The operational consequences can be followed through and lead to the usual density matrix formulation with all the "interference" phenomena reduced to probability statements[9]. The key to this is that our ***asymptotic*** definition of momentum, plus coherence between spin label states and the momentum ***direction*** - which is ***also*** an asymptotically measureable quantity - allows us to ***understand*** coherent superposition, the amplitude squared rule, and therefore the wave-particle dualism within the framework of the bit string universe.

5. UNDERSTANDING THE MASS SCALE AND MASS UNIT

To understand the mass scale we make use of the original hierarchy identification $\hbar c/Gm_p^2 = 2^{127} + 136 \simeq 1.7 \times 10^{38}[1 \pm 0(1/137)]$, which differs from experiment only to order 1/137. Hence we have the choice of taking the accepted proton mass as our mass unit and correcting the gravitational constant, or visa versa. Until our dynamics is further developed, we cannot do either. For the electromagnetic coupling we have as our first result $\hbar c/e^2 = 137 \pm 0(1/137)$. Since we must calculate in the physical "gauge" we can reasonably state that this is the value for electrostatic interactions. Then we can calculate finite "renormalization" corrections due to spin dependence as order 1/137 corrections to the fine structure constant. For this the finite particle number relativistic quantum scattering theory should suffice, not only to get definite results but even to kill this theory if it is wrong.

Meanwhile, we are justified in using this theoretical number without correction to calculate the rest energy of the electron from its electrostatic energy $m_e c^2 = < q^2 >< 1/r >$. Since this calculation, initially achieved by Parker-Rhodes[6], has been published several times[4,6,7,9], we are brief here. The minimal meaningful distance in a zero velocity system with spherical symmetry is the Compton radius $h/2m_p c$; r must start from this value, and scales a random variable y greater than or equal to one. Similarly, since charge is conserved, $< q^2 >= (hc/2\pi \times 137) < x(1-x) >$. Hence $m_p/m_e = 137\pi / < x(1-x) >< 1/y >$. Since we have now established our space as necessarily three-dimensional, the discrete steps in y must each be weighted by (1/y) with three degrees of freedom. Hence $< 1/y >= [\int_1^\infty (1/y)^4 dy/y^2]/[\int_1^\infty (1/y)^3 dy/y^2] = 4/5$. Since the charge must both separate and come together with a probability proportional to $x(1-x)$ at each vertex, the other weighting factor we require is $x^2(1-x)^2$. For one degree of freedom this would give $< x(1-x) >= [\int_0^1 x^3(1-x)^3 dx]/[\int_0^1 x^2(1-x)^2 dx] = 3/14$. Once the charge has separated into two lumps each with charge squared proportional to x^2 or $(1-x)^2$ respectively, we can then write a recursion relation[4,6,7,9] $K_n = [\int_0^1 [x^3(1-x)^3 + K_{n-1} x^2(1-x)^4] dx]/[\int_0^1 x^2(1-x)^2 dx]$ and hence $K_n = 3/14 + (2/7)K_{n-1} = (3/14)\Sigma_{i=0}^{n-1}(2/7)^i$ Therefore, invoking again the three degrees of freedom, we must take $< x(1-x) >= K_3$ and we obtain the Parker-Rhodes result $m_p/m_e = 137\pi/[(3/14)[1 + (2/7) + (2/7)^2](4/5)] = 1836.151497...$ Since the electron and proton are stable for at least 10^{31} years we identify this ratio with m_p/m_e in agreement with the experimental value 1836.1515 ± 0.0005; thus we claim to calculate the basic mass ratio scale for the theory. Whether this mass ratio calculation remains unchanged when we go on to level 4 and we must show how to calculate the masses of *unstable* baryons and bosons from our dynamical theory is under investigation.

We believe that so far as QED, and more generally quantum field theory, goes our finite particle number scattering equations will either succeed or fail in a few years. So far as we can see at this stage they contain the same physics for finite processes as the conventional approach, and have the advantage of being automatically unitary. Gravitation differs from QED and related theories modeled on it in that the field itself is a source of the field. In the weak field limit the spin 2 theory of gravitation has the right characteristics, as has been known for some time[18]. But Noyes understands from Chris Isham[19] that the passage from this microtheory to the macroscopic Einstein theory is plagued with infinities. It should be clear by now that if our scheme works this will not be our problem. It is primarily for that reason that we are calling our work to your attention at this conference.

6. SUMMARY

We start from the symbols 0,1, binary addition, *sequence* represented by the integers, and a random operator R which gives us either 0 or 1 with equal prior probability. From these we construct the discrimination operation for ordered bit strings and the strings themselves employing *Program Universe 2.* We expect that when this program is fully evaluated it will provide an algorithmic definition of *events* sequentially ordered by the integers but accessible for purposes of interpretation only by statistical arguments. We use the *combinatorial hierarchy* to organize the information content of the early stages of the construction into four *levels* characterized by the cumulative cardinals 3,10,137 and $2^{127}+136$.

When the information carrying capacity of this construction is exhausted, we use these elements as *labels* to organize the growing universe of strings into *labeled ensembles* of *addresses.*

Accepting this growing universe of labeled bit strings as adequately constructed, we use the concept of *d-velocity* to *order* the connections between tick-separated events. We show that the labels support an interpretation as the conceptual carriers of conserved quantum numbers between events. By assigning a mass to each label (to be calculated at a later stage) we show that we can define *d-energy* and *d-momentum* in such a way that our definition of *d-velocity* can be identified formally with a limiting velocity and the masses as invariants. We construct a 3+1 dimensional momentum-energy space which, for large bit string segments, is approximately continuous and Lorentz invariant. Using this basis we construct a momentum space scattering theory with conserved quantum numbers and 3-momentum conservation.

Granted 3-momentum conservation, either as deriveable or as an additional postulate, we claim to have connected our bit string universe to laboratory practice by our counter paradigm and to have conventional relativistic particle kinematics available to us. The random walk paradigm then provides us with the basic Einstein-deBroglie quantization condition. We extend this to a wave theory by noting that at any level we will have somewhere in the label string the independent pair (10), (01) which can be used as a dichotomous variable refering to a conserved quantum number. But the algebraic sign of this quantum number is then correlated with the algebraic sign of the *d-velocity* in the address string. We claim that our construction of a three $3+1$ asymptotic space with rotational and Lorentz invariance, plus our scattering theory, then lead to the usual directional properties of spin. Having uncovered a directional (algebraically signed) internal quantity we then have all that is needed for the understanding of quantum interference phenomena, even though our basic theory is discrete. We therefore claim to have arrived at an *understanding* of the wave-particle dualism in our context.

If it be granted that we have successfully established an understanding of "free particle" deBroglie waves and correctly identified the source of the quantization condition in terms of random walks, we claim that we have a firm basis for constructing a relativistic quantum scattering theory for any finite number of "particles". The "coupling constants" which give the probabilities of scattering events relative to the "free particle" basis then can be assigned, because they are based on the random elements in *Program Universe 2*, as the prior probability assignments of these events relative to the "free particle" basis. This, we claim, justifies Bastin's original identification of the hierarchy cardinals as the "scale constants" of physics, Parker-Rhodes' calculation of the proton-electron mass ratio, and the hierarchy connection between the gravitational constant and the unit of mass required by the theory.

Once this task is accomplished, we will be able to go on to establishing our own route to "grand unification" and "supergravity". Here we are, up to a point, playing a currently fashionable game. The main difference is that most contemporary approaches take the space-time continuum and quantum field theory as the framework within which to pose the problem. Any intuited or postulated or "derived" structure for the interaction Lagrangian which is not in conflict with the conventional connection to experiment is fair. In contrast, since we have a specific connection between our quantum numbers, the wave-particle dualism, constructed "space-time" and a rigid *exoskeleton* set by the combinatorial hierarchy, ted. We therefore can hope to discover in a finite time whether our theory is ***necessarily*** in conflict with experiment, or not.

Our final point is that by making ***velocity*** basic, rather than space and time, we believe we have the correct fundamental starting point for unifying macroscopic quasi-continuous measurement with a digital model. Further, our ticking universe allows us to fuse the special relativistic concept of ***event*** with the unique and indivisible events of quantum mechanics, ***and*** with the events which complimentaryly limit our understanding of cosmology. Whatever else survives from this attempt to construct a digital model for the universe, we are convinced that this is the correct place to connect relativity with quantum mechanics in a fundamental way. We close by remarking that the cosmological implications of the model are not in obvious conflict with experience.

REFERENCES

1. E.W.Bastin and C.W.Kilmister, *Proc. Roy. Soc., A 212*, 559 (1952).
2. –*Proc.Camb.Phil.Soc., 50*, 254, 278 (1954), *51*, 454 (1955);*53*, 462 (1957); *55*, 66 (1959).
3. T.Bastin, *Studia Philosophica Gandensia, 4*, 77 (1966).
4. T.Bastin, H.P.Noyes, J.Amson and C.W.Kilmister, *Int'l J.Theor.Phys., 18*, 455-488 (1979).
5. I.Stein, Seminar at Stanford, 1978, and papers at the 2nd and 3rd annual meetings of the Alternative Natural Philosophy Association, Cambridge 1980, 1981.
6. A.F.Parker-Rhodes, *The Theory of Indistinguishables*, Synthese Library, *150*, Reidel, Dordrecht, 1981.
7. H.P.Noyes, in *The Wave-Particle Dualism* S.Diner, et.al., (eds), Reidel, Dordrecht, 1984, pp. 537-556.
8. M.J.Manthey and B.M.E.Moret, Communications of the ACM, *26*, 137-145, 1983.
9. H.P.Noyes, C.Gefwert and M.J.Manthey, in *Proc. 7th Int'l Cong. on Logic, Methodology and Philosophy of Science.* Salzburg, 1983 (in press) for a much more detailed version see – "Toward a Constructive Physics", SLAC-PUB-3116 (rev. September 1983).
10. C.Gefwert, *A Participator: the Metaphysical Subject*, SLAC-PUB-3277 (December, 1983) and *The Proposition-as-Rules Idea*, SLAC-PUB-3303, (March 1944), to be submitted to *Synthese*; *On The Logical Form of Primitive Recursive Functions*, S LAC-PUB-3334 (May 1984) and *On The Logical Form*

of Mathematical Language, SLAC-PUB-3344 (May 1984), to be submitted to the *Journal of Philosophical Logic*.

11. The Alternative Natural Philosophy Association, founded 1979; for information contact the ANPA Secretary-Treasurer, 15905 Bear Creek Road, Boulder Creek, CA 95006, USA.

12. For *Program Universe 1* see Ref 9; *Program Universe 2* has also been coded by M.J.Manthey in *Pascal* with concurrency, an effort which made this paper possible.

13. J.V.Lindesay, PhD Thesis, Stanford, 1981, available as SLAC Report No. 243.

14. H.P.Noyes, *Phys Rev C 26*, 1858 (1982).

15. H.P.Noyes and J.V.Lindesay, *Australian J. Phys., 36*, 601 (1983).

16. H.P.Noyes and G.Pastrana, *Proc. Few Body X*, Karlsruhe, 1983.

17. J.V.Lindesay and A.Markevich, *Proc. Few Body X*, Karlsruhe, 1983.

18. S.Weinberg, *Gravitation and Cosmology*, Wiley, New York, 1972,pp 285-289.

19. Conversation with C.Isham, September, 1983.