Emptiness and relativity

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1 Relativity and interactivity

The Buddhist principle that all is empty is understood by some as the principle that all is relative [Thurman (1993)]. This universal relativity principle is more embracing though less structured than Einstein's general relativity principle, which still admits many absolutes. It is worth considering seriously. A philosophical argument for a universal relativity could be a useful guide for future physics. The major changes in physics in this century have been extensions of relativity at one level or another, and I think a further extension is due, at an even deeper level of physics than the previous. Philosophical inquiry has aided such extensions before, and it could do so again. I consider here whether such a universal relativity principle can be meaningful and perhaps even work in physics.

For a physical theory one must be more specific about the nature of the relation that is mentioned but not specified in the broad term “relativity.” The relation that special relativity refers to, for example, is that between observers in relative motion, and one studies the effect of this relation upon the basic relation of being in communication, for example by exchanging signals.

The relativity underlying quantum theory, however, is that between observers of complementary quantities. Different experimenters choose fundamentally different interactions with the system and experience different aspects of its activity. Interaction is a lower-level concept than communication, in that every communication is made up of interactions. The relativity of quantum physics is deeper than those of space-time physics.

Therefore in what follows I often specialize “relative” to “interactive” and relativity to interactivity.

Is it indeed possible that all is interactive? How far have we already gone in that direction? What absolutes remain?

My main tool here is an analysis of classical relativity by Inönü and Wigner (1952), derived from a still deeper study of Segal (1951), which shows us by example how to detect possible false absolutes and relativize them.

The main absolute of physics today that we will discuss is the dynamical law, also called the law of nature, describing how the system develops in time. I consider the possibility that we should relativize dynamical law much as Einstein relativized geometric law in general relativity; and even take it as the sole variable under study, as Einstein did for geometric law in his unified field theory. Such a more relativistic space-time-matter-dynamics unity might embrace general relativity and the standard model and reach beyond them.

2 Idols

Let me indicate how I use three terms basic to this discussion. *Relativity* is the part of any physical theory that concerns how appearance — the phenomenon — depends on the observer. An *absolute* property or entity — a noumenon — is one whose presence or absence all experimenters are supposed to agree on, though they may name it differently. *Reification* is imagining an absolute entity where there is none. An *idol*, in the language of Francis Bacon (1620), is a false absolute resulting from reification. “Idols of the tribe” are those common to a whole community, such as those resulting from innate propensities to reify. “Idols of the theater” are those erected within a particular theory. I find it necessary to regard idols as an inevitable and useful product of the same theory-making process that breaks them. It is naive to imagine that this process of idoloclasty can ever be completed.

Relativity came to the foreground in the mechanical physical theories of projectiles and planets, where one must relate observers in relative motion.

For example, Johannes Kepler wrote an entire relativistic science-fiction novel, *Somnium*, just to relate the views of people on the Moon to those of people on Earth, to oppose the common sense that the Earth was at absolute rest with the equally common sense of Lunarians that the Moon is at rest. On the grounds of his relativistic manuscript Kepler's mother was charged with witchcraft and exposed to the instruments of torture. Bruno was burned at the stake and Galileo was confined to house arrest for their similar relativisms. Einstein, on the other hand, was rewarded for an even greater relativism. The intellectual climate is clearly changing.

Nevertheless physics once again runs into idols that block its development.

We can spot these idols using a detection system that Segal (1951) and Inönü and Wigner (1952) formulated and applied to classical mechanics and other physical theories. I describe it first and then apply it to present physical theory.

One looks for partially but incompletely fused constructs. The mathematical term for these is *non-semisimple*. For euphony I call them *compound*. I count as a construct an entity of any kind that everyone in a community can experience, such as an electron, or the Moon, or the time of day, as opposed to chimerae or optical illusions. A construct is called *simple* in this context if it includes no other construct (except the trivial ones: itself and constants). It is called *semi-simple* if it is simple or equivalent to a collection of simple constructs. It is called *compound* if it is not semi-simple.

A compound construct results when one simple construct has subordinated another without fully integrating it. A compound construct looks like a snake that has just swallowed a pig. A strong attachment has been formed but full integration has yet to come. A compound construct is a sign of an impending revolution.

Inönü and Wigner applied their criterion only to classical mechanics, where the diagnosis could be checked against the already known outcome. This tested the test more than the theory. The I-W (Inönü-Wigner) test passed its test, by "predicting" the evolution of the relativity of Galileo into special relativity.

The compound construct of classical mechanics that they studied is space/time.

The solidus in "space/time" indicates a compound composite, not a quotient. Simple fusions like Einsteinian "space-time" are marked with a hyphen.

The Galilean compound space/time forms from the Aristotelian simple time and simple space when time "swallows" space. That is, in Galilean thought there is no space separate from time; we cannot recognize the same place at a different time, and to speak of it has no meaning; but there is still time within space-time, and still a unique space at each time, a time-slice of the tree of history. Galileo has absolute time and space/time but no absolute space.

Space/time is therefore not a composite of two simples, space and time. Yet it contains the simple time. Space/time is therefore compound.

To put it differently, Inönü and Wigner look for a one-way coupling between constructs. The snake swallows the pig and not the pig the snake. In transforming from one observer to another in relative motion, Galileo couples time into space but not conversely. Another way to say that space/time is compound, then, is to say that there is this one-way space/time coupling under transformations from one observer to another.

This could have hinted to Galileo or a contemporary that there is likely a missing physical constant coupling space back to time; a speed c, therefore. The speed c would have to be so large that the effect of this coupling from space to time, an effect which must vary as $1/c$, could elude physicists in Galileo's low-speed day. But if it were not too large, it could become important later, when experimenters develop greater relative velocities and more sensitive instruments. The coupling constant c "predicted" by the I-W test is the speed of light.

Such one-way coupling generally indicates a compound and is circumstantial evidence that the unresponsive partner in the coupling is an idol. The guiding heuristic principle underlying the I-W test is that actual couplings are always mutual. This mutuality principle is not Newton's physical principle of action and reaction but might be its philosophical grandmother. I find it plausible enough to explore its implications here and elsewhere, leaving experiment as the court of last appeal.

The more evolved construct, the space-time point of Einstein and Minkowski, is simple, with no non-trivial parts. This is the evolution of Galileo's space/time "predicted" by the I-W test in retrospect. Galileo had shown that space was an invalid reification. Einstein's development showed that time was too. Aristotle's two uncoupled absolutes, space|time, had evolved through the compound space/time of Galileo into the one absolute space-time of Einstein.

The I-W test can show us a possible idol and it can suggest the kind of reverse coupling to look for experimentally, but it gives no indication of how strong this coupling might be, except that it must be weak enough to have been overlooked so far. The actual size of the new coupling coefficient must be learned from experiments that invalidate the theory containing the idol under study.

It sometimes happens that one relativistic evolution compounds previous simples, and then another later evolution simplifies that compound, but creates other complications at the same time. Galilean space/time is the transitional phase between Aristotelian space|time, the semisimple conjunction of two separate simple space and time entities, and Einstein space-time. Einstein space-time preserves other complications that I mention below.

It took thousands of years to lower the gang-plank in space|time half way down, making space/time, and only two centuries more to drop it completely to form space-time. The pace picks up, with prior relativizations helping each next one. To develop skill and confidence with our idol test I will apply it to three more relativizations that occurred in the first three decades of the twentieth century before tackling one of the next millenium. I omit some important relativizations that are not crucial for the story.

3 General relativity

Newtonian physics has a compound absolute that special relativity inherited: not absolute rest, but absolute coasting, non-acceleration rather than non-motion. Newton believed that while there is no standard of absolute non-motion there is a standard of absolute non-acceleration. For example, a droplet is spherical if it is not spinning and ellipsoidal if it spins. (Newton used a water bucket for this test but in free fall droplets work as well or better.) In the spinning droplet each part is accelerated toward the center of the droplet. In the non-spinning droplet each part follows a geodesic.

What provides the standard of non-acceleration is today identified with a local structure in space-time called the metric (field). It is reckoned as part of the structure of space-time.

Through its metric, space-time acts on the rotating droplet or other matter, but in Newtonian physics and special relativity the matter, even if it be the size of the Sun, does not act on the space-time. There is therefore a compound matter/space-time. One simplification of this compound was carried out by Einstein in his theory of general relativity, a successor to special relativity, bringing us closer to a matter-space-time unity [Weyl (1922)].

In general relativity the dynamical evolution couples matter to metric as well as metric to matter.

The resulting variations in the metric account for gravity, which is locally indistinguishable from the effect of an accelerated observer. The coupling coefficient that corresponds to c for this evolution of physics is usually taken to be G (Newton's constant), henceforth the hallmark of general relativity. It may equivalently be taken to be a small time T_P formed from G, h, and c called the Planck time, whose value is about 10^{-43} seconds. Again the "prediction" of our idol-test agrees with the outcome that we knew in advance.

The relativization from special to general relativity was more dramatic than the previous ones because it introduced a richer new physical construct, the metric field, where before had been a frozen constant, and because both relativizations took place in one mind within one decade. The G relativization has been enormously fruitful. The current standard model of the nuclear forces was modeled on it, with several other local standards playing the role of the standard of coasting.

4 Quantum relativity

The simplicity of quantum theory emerges from another complication of classical theory by another relativization and idoloclasty.

To take this conceptual quantum jump, Bohr emphasized, we must first change epistemologies. One formulation of this change is that we stop defining entities by their states ("ontically") and define them by our actions upon them ("praxically" [Finkelstein (1996)]). In an action-based (or "praxic") semantics, any property of the system is defined by actions of preparation, selection or registration carried out upon the system by the experimenter. I think of this change as replacing reality by actuality. It helps us empty a concept of essence by making us more aware of how our knowledge of the concept arises from our own actions.

First we point out a complication of the classical epistemology.

In classical physics since Descartes, the distinction between physical system and mathematical model was intentionally minimized. Some claimed the two were isomorphic and identified them. Transformations between observers were considered to be of a rather shallow kind, mathematical changes of description amounting to a word-for-word literal translation from the language of one to the other. They were regarded as relating different but complete views of the same object.

Physicists took for granted that there was a special construct of the system called its *state* (of being, implicitly), independent of the experimenter, and completely describing the system. The state is thus a complete description of a system by itself, determining all other properties. In classical particle mechanics the state is the specification of the positions and velocities of all the particles at one instant. Each determination of a classical system by an ideal experimenter simply fixes its state. Each action on the system simply transfers it from one state to another. Classical thought thus builds in an absolute distinction between knowing (fixing the state) and doing (changing the state). A classical relativity theory need merely specify how different experimenters represent these same absolute states in order to determine how they represent the same action.

When an ideal experimenter determines the state, the state couples to the experimenter, who learns something, but the experimenter does not couple to the state, which is fixed. Here the state is the absolute, like the time of Galileo or the space-time of special relativity. As a result any classical construct — say a pendulum of theoretical mechanics — is compound.

To see this complication most clearly one studies the most elementary actions that define the construct. In classical thought, each such action can be represented by an arrow, starting with one state and ending with another. The collection of such arrow transformations is "closed." This means that doing two arrow transformations in sequence is again an arrow transformation if it is defined at all.

The key point is that within the collection of these arrow transformations lies another closed collection consisting of those arrows that start and end at the same state, loops, representing acts of selection or knowing. So the collection is not simple.

But the entire collection cannot be made by combining all the arrows of this closed subcollection with all those of another. So the collection is compound.

[Brackets like this are side-remarks to the trained physicist, indicating the mathematics behind the words. In mathematicians' argot: The arrow semigroup of a classical object is not semisimple but a category. The corresponding semigroup of a quantum object is not a category but simple, being the projective semigroup of a vector space.]

By focusing on actions rather than states in this pragmatic way, we can discern the classical compound doing/knowing. The quantum relativization then fuses the two into one simple concept of operation or action. All classical theories have this absolute, the state, and quantum theory relativizes it.

In quantum physics there is no complete dscriotion. Learning (something about the system) and doing (something to the system) are no longer fantasized as fundamentally different kinds of action. The act of determining a property is an interaction between experimenter and system that now has significant consequences for both. This mutuality of coupling was generally expected on philosophical grounds long before experimentation at the photon level made it precise.

The way the game actually played out is surprising, however, and unforeseen. The future value of any one variable may still be prepared long in advance, in principle, but not those of any two. For example, if the system is a particle, I may determine its future position in space at some time, or you may determine its future momentum at that time, but we cannot do both at once. Such complementarity between variables was not imagined before quantum mechanics. It is as alien to wave theory as to particle theory. A quantum acts like neither a wave nor a particle.

Rather than renounce the absolute state of being, some quantum physicists seize a quantum concept that should be and sometimes is called "mode", as in "mode of action", and call it "state." They thus violate the correspondence principle which relates classical and quantum concepts so that the two languages are mutually consistent where they both apply.

[The quantum Hamiltonian corresponds to the classical Hamiltonian, for example. But it is well known that a quantum mode corresponds to a classical construct called a Hamilton-Jacobi function, characterizing a flow of infinitely many possible systems and simply related to the classical concept called action; and not to a classical state at all.]

Sometimes we still talk of "sunrise," "points of time" and "states" as if Copernicus, Einstein and Heisenberg had never worked here. These locutions still work if taken relativistically. One really means, "sunrise (or point of time, or state) relative to my (or some other specified) frame of reference." In the present more philosophical context such implicit agreements cannot be taken for granted and I avoid them here.

Experimentally fixing a property is now only a special case of an action on the system, and changing the property is another of the same kind. Now we no longer separate them but unite them in Heisenberg's one simple concept of operation without object.

The idea of visualizing anything completely and exactly, a goal of some mental practices, is renounced by Bohr and is alien to quantum mechanics. Since illuminating the system disturbs it unpredictably, completely visualizing anything "as it is" is self-contradictory. "As it is" means without external intervention, in which case the system is sitting alone in the dark, unperceived.

A quantum entity is simple because among our actions on it, there are no longer privileged acts of selection that are not also acts of transformation. There is no “is” here, just a “does.”

The coupling coefficient that corresponds to $1/c$ and G for this relativization is h (Planck's constant), the hallmark of quantum theory. Again our idol test works, in that the diagnosis agrees with the outcome that was known in advance.

The quantum theory is so much simpler, more unified and better-working than its ancestor that I am sure that we shall never go back to classical thought. We must therefore go forward.

In physical theories so far there have always been absolutes, vestiges of being, essences. Indeed, Einstein first called his brain-child a theory of invariants, not of relativity. What remains now that is absolute? What must we empty next?

As we have seen, we cannot always detect important absolutes easily from within a theory. By never moving, idols tend to become invisible. We must step outside the theory and examine both what physicists say and what they do, and especially to the connection between these two modes of action, the semantics of the theory, to discover what absolutes are tacitly assumed.

Let us apply the idol test to some parts of present physics and predict their evolutions. Now these are genuine predictions. They may even be wrong.

5 Logic without negation

The existing quantum theory still has an absolute concept of predicate, defined by selective actions as distinguished from more general actions, though the resultant of two selective acts in sequence is generally not a selective act. And it still has an absolute negation, relating each predicate P to a unique predicate NOT P. The absolute NOT of present quantum physics is too conspicuous to omit from our bestiary of absolutes, especially since Indian logicians considered logics without negation many centuries ago.

According to present quantum theory, some physical processes respect negation. This means that when predicates evolve under these processes, the negation of the evolute of a predicate is the evolute of the negation of that predicate.

[In quantum theory these are the processes called unitary.]

Almost all quantum processes do not respect negation; these may be called negation-violating. For example, quantum interventions such as input, selection, and outtake violate negation.

In classical, pre-quantum, physics all system processes, even interventions, respect negation.

[Otherwise put: In classical theory the intersections of two disjoint sets with any third set are still disjoint, so selection respects negation; but in quantum theory, projections of orthogonal mode vectors are generally no longer orthogonal, so selection does not generally respect negation.]

In this sense we may say that negation is inviolate in classical physics but not in quantum physics. Nevertheless quantum logic should not be called a logic *without* negation. It has a fixed negation concept that all dynamical evolutions of isolated systems are supposed to respect between our interventions.

Present quantum theory also mentions processes that are not necessarily interventions, yet do not respect negation, such as the creation and annihilation of an individual quantum. For isolated systems these are not supposed to occur separately, however, but only in combinations that respect negation. The evolution of a closed quantum system between our interventions is assumed to respect negation.

This story is not finished yet, however. When a quantum falls into a black hole, for example, it is possible that a negation-violating process occurs, much as though the quantum were annihilated. We still do not know how to deal with black holes systematically within a quantum theory.

6 Interactive space-time

General relativity simplifies matter-space-time, but at the same time it creates new complications and new one-way couplings that re-activate the idol alarm. Another relativization is due, and long overdue at that. I expect it to introduce another small physical constant having the dimensions of a time, for the following reasons.

The one-way coupling that enters now is between field and space-time. It suffices to consider just the case where the field is defined by a vector at each point, like the flow velocity of the universal fluids of Kelvin, Descartes or the Stoics. In a transformation from one frame of reference to another with relative acceleration, or to curvilinear coordinates, we must know the point in order to transform the field, but not conversely. The space-time coordinates of a field/space-time point couple into its field, but its field-value does not couple into its space-time coordinates.

This field/space-time non-mutuality is like the space/time non-mutuality in Galileo's relativity. In field theory the absolute is space-time; for Galileo it was time. [These are bundle bases. In string theory the complication and base is the string manifold, and the space-time coordinate space becomes the fiber.]

Today space-time is as absolute as time was in the seventeenth century, and subordinates the field as time then subordinated space. A fiber/base compound occurs in any theory that makes an absolute distinction between base coordinates and fiber variables, including general relativity, the standard model, and modern string and membrane theories.

Closer inspection reveals where this complication sets in. It is not present in a discrete skeletal or network model of space-time, composed of atoms of space-time, where field vectors are analyzed into chords or arrows, pairs of points themselves, representing elementary displacements of the atoms of space-time themselves. Points being simple, classical point pairs or arrows are semisimple. The coupling between two points in a pair is symmetric, not one-way.

The vector/space-time compound emerges from such a polygonal structure only in the continuum limit $\Delta t \to 0$, where the chord joining two points becomes a tangent vector asymmetrically assigned to one of the points. This is the limit where the differential calculus works. The small physical constant that is neglected in the old physics and which will be the insignia of the new, if this prediction comes true, is a cut-off value for the limit $\Delta t \to 0$ and is therefore probably a small time. I infer that the physics of differential equations is a transient phase, and that it will evolve into a purely algebraic physics. Einstein (1936) considered this possibility without committing himself to it.

I call this ultimately small time ת (*tav*), other forms of T having been preempted. Tav derives from the Canaanite-Phoenician symbol for a musical note or a tally mark, appropriately enough, and lies at the opposite end of the Hebrew alphabet from the letter ℵ that the mathematician Cantor chose for the ultimately large.

Some have suggested that ת must be the Planck time T_P, the time that can be made from the constants c, h, G. But the magnitude of ת cannot be set from within the theory where ת $\to 0$, any more than classical mechanics can suggest the values of h and c. To fix ת requires physical data incompatible with the degenerate theory with ת $= 0$. T_P is a coupling coefficient from matter to metric, while ת is a cell size and a coupling coefficient from velocity to position. The fact that two coefficients have the same dimensions in the MKS system of units does not mean that they are even approximately equal. There are only three independent units in the MKS system, and there are more than three couplings going on, so inevitably some coupling coefficients with quite different meanings will have similar dimensions.

Quantum and gravitational theory can be played off against each other to show that due to black-hole formation field theory has an infrared or long-time limit as well as an ultraviolet or short-time one, and that the short-time limit ת exceeds the Planck time by as many orders of magnitude as the large-time limit exceeds ת [Finkelstein (1999)]. The ratio in question might be about 10^{10} or more.

The simple quantum entity replacing the compound tangent vector, the atomic unit of dynamics-space-time that bears the scale-size ת, I call the *chronon*. The hunting of the chronon has gone on for some time. For example, Aristotle (1984) discussed and rejected extended "indivisible lines" evidently proposed by his contemporaries, and the Mādhyamika tradition of Buddhism includes space atoms [Dalai Lama (1997)].

The tangent vector might be replaced by a chord, a point pair, in the network model mentioned earlier. A point pair is not simple but semisimple. Then the underlying simple entity would correspond to one point of space-time, one end of an arrow.

I do not think that is what happens. In the examples of relativization we considered earlier, a complication evolved into a simple, not a semisimple, under relativization. Synthesis occurs, not analysis. Points do not have dynamical evolutions but tangent vectors do. Probably therefore the chronon does not correspond to a space-time point, with four coordinates, but to a tangent vector, with eight. Since a tangent vector can be regarded as an operator connecting a point to an infinitesimally nearby point, this chronon also fits better into the historic pattern of replacing states of being by modes of action.

It has taken me some time to take this possibility seriously because in classical thought a tangent vector is compound. But quantum theory simplifies it by introducing complementarity relations between its two classical components.

Now the separation of the matter-space-time network into field and space-time, inhabitant and habitat, becomes a local and relative one, like the division of space-time into space and time.

Moreover, the locality principle basic to Einstein is alien to quantum theory, though tolerated in our present hodge-podge relativistic quantum physics. From the algebraic point of view that is supposed to dominate quantum theory, there is no absolute difference between position and momentum, for example, One transforms from position-fixing modes to momentum-fixing modes with a harmonic (or spectral, or Fourier) synthesizer, an application of the superposition principle.

But locality refers specifically to position, not momentum. For a local interaction to occur between objects, their positions in space must agree at some time, but they can be far apart in their momenta.

Therefore the synthesis of quantum theory and relativity probably will relativize the locality of general relativity, replacing absolute locality by a process of localization carried out by an experimenter, one equal among many.

To indicate how little we have progressed in this direction, I mention that the programs of quantum gravity, supergravity, grand unified theory, string theory, superstring theory, and the standard model, all incorporate absolute concepts of locality and space-time. My quantum relativity [Finkelstein (1996)], which indeed relativizes these concepts, is still in an immature formative phase.

Renouncing such a successful common-sense absolute as the point-event in space-time leaves an emptiness which can be experienced either as empowerment and liberation or anomy and nausea, depending mainly on one's prior practice in coping with emptiness and relativity.

7 Interactive law

Another persistent absolute element of physical theory is the dynamical law, or briefly the *dynamics*. [This is the information usually imparted in the action function.] In present physics the dynamics influences the system, but the system does not influence the dynamics. The dynamics thus actuates our idol detector as directly as the metric did.

The inference is that the separation between matter-space-time and dynamics is another transitory one and will dissolve in the evolution of physics. The compound matter-space-time/dynamics will become a semisimple matter-space-time-dynamics unity.

This process has begun. The relation between dynamical and geometrical law is more than an analogy. The geometrical law ultimately rests operationally on experiments with light, which is governed by a principle of stationary path-time: The path-time for the actual path of a light pulse is the same as for all infinitesimally nearby paths, to the first order of approximation. The dynamics tells us how light and all other signals actually propagate, by giving us the quantum phase for various histories. The geometrical law is merely the dynamical one viewed under coarse resolution and restricted to the special case of light signals.

Therefore the metric and the dynamics cannot be chosen independently of each other. The quantity that is stationary in the geometrical law is actually the quantum phase of the dynamics, a dimensionless quantity. One converts it to the classical action using Planck's constant h, according to quantum theory, and to the path time using the mass of the signal and the speed of light, according to general relativity. When the dynamics governs the geometry, it governs only an aspect of itself. This reflexivity is at present a plausible inference from the actual operations of the physicist, but has not been established, or even given a fitting mathematical formulation.

As a beginning teacher I would tell beginning students, "Physics is the search for the laws of nature." After I read more of Einstein, this became, "Physics is the search for the Law of Nature." Now I wonder what kind of creature such an absolute Law could be. Where could it exist? How could we perceive it if we cannot change it? After all, perceiving any entity is operationally inseparable from changing the entity.

Now I am sure that only an atavistic vestige of the common-sense split between space and time inclines us to think still of dynamics as absolute, fixed by nature. The dynamics represents what goes on inside the system while we wait outside. In present theories, the kinematics — the theory of the descriptions of the system — and the dynamics are separate, and the distinction between them is absolute. But the coupling asymmetry between the two parts of the matter-space-time/dynamics compound implies that a further fusion into matter-space-time-dynamics is in the offing.

8 Trying to breathe in empty space

My group at Georgia Tech is attempting a more relativistic theory of the matter-space-time-dynamics unity discussed here, built on causal connection and complementarity, the cornerstones of general relativity and quantum theory respectively.

The sole variable is now the dynamical law connecting past to future. When we describe it we are also specifying the space-time occupied and its material occupant relative to each frame of reference. The vicinity of an event consists of the other events immediately connected with it by the dynamical law.

In a fully quantum theory, any sharp kinematic description gives a probability amplitude for any other, and that is what a dynamical law is supposed to do.

The coupling coefficient from matter-space-time to the geometric law, the metric, is already known from general relativity. It is the very small Planck time T_P, which I have suggested above is smaller than [illegible] by many orders of magnitude. There is therefore a large number to account for with no units at all, the ratio [illegible]$/T_P \sim 10^{10}$.

Several absolutes would still remain in such a physics, perhaps to be relativized in some later evolution, if the appropriate couplings ever become accessible to experiment. One is the universe; another is the system. Also, each theory we make today has itself as an absolute. The principle of universal relativity – like that of semisimplicity — seems incompatible with a fixed theory of any kind, and in particular with the goal of a final theory, which seems to me to be another idol that we must break in order to pass beyond.

Leibniz conceived of a theory as having three parts, a combinatorics, a characteristic(s) and a ratiocinatorics, which today can been called its syntax, semantics, and logistics respectively. He imagined at least one of these parts, the semantics, as generative and open-ended, able to express new meanings as new experiences required. Only such an open-ended theory could incorporate a universal relativity.

One may think of any whole theory as a view, as etymology suggests. A view is a view from a position, which is then an idol of that theory. it seems that the process of making a theory inevitably introduces idols that can only be corrected by a later theory, and so will never be completed.

Extrapolating the evolution of physics has led us to some hypotheses that resemble tenets of ancient Indian philosophies especially where they depart from the Cartesian world system. The Einstein energy-mass equation suggests the Atman-Brahman equation to many people, and Bohr complementarity seems to sharpen the reservations about language expressed as the beginning of the Tao Te Ching, for example.

Given the number of different philosophical positions, some such agreements with contemporary physics must be expected by chance, which has its own beauty. On the other hand, different people sometimes come up with similar ideas because they have independently figured out what is actually going on; as different animal species independently solve the problem of vision by evolving startlingly similar eyes out of quite different body parts. The strange-seeming physics of today evolved by dint of much physical experiment and mathematical theory, drawing its inferences from reproducible external experimentation, physical induction, and mathematical formulation and deduction. Buddhist conclusions seem to derive from life experience, meditative practice, and scholastic debate. There are some well-known harmonies between their conclusions [Stcherbatsky (1930)], especially where they both differ from Descartes:

- The empirical revisability of logic.
- The representation of the world as a pattern of acts of termination and dependent reorigination.
- The atomicity of time and space.
- The indecomposability of the world.
- The incompleteness of any representation of the world.

Rather than coincidences or borrowings, these agreements might simply be due to the fact that both work, and in domains where Cartesian rationalism doesn't: the inner world and the microworld.

When the I-W analysis, and other considerations that I omit only for brevity, led to the extreme relativistic surmise that the matter-space-time-dynamics is one unity, I vacillated for some without committing myself fully to that hypothesis. I found such a unity frighteningly non-intuitive, but that is no indication that it is wrong. Intuition is a lazy, docile ox, that has to be trained to carry us where is best for us and it, or it wanders into dead ends and pitfalls. The main problem was that there seemed to be too many possibilities. Exploring even one wrong path could devour valuable years. While Newton proposed that the dynamical law is variable, and many have agreed with him, I have not encountered a development where it merges with the system it has swallowed, as time has with space. The closest precedent is Einstein's suggestion that the metric, which defines the dynamical law of a test planet, be the sole variable of a unified field theory. Even then, Einstein wrote a separate higher-level dynamical law to govern the evolution of the metric, once again splitting the variable governed from the governing law. Lacking a mathematical model of such an autonomous dynamic, I have no reason to suppose that such a unification can even be self-consistent, let alone consistent with experiment.

Atoms of space or time and changing laws are discussed in Buddhist treatises of the previous millenium. I have already mentioned their far-reaching relativism. The basic heuristic principle at the root of the I-W criterion, mutual coupling, is hardly new. Relativistic contemplation could have led to a similar unification of the governed with the governing law long ago. I wondered whether this specific relativization and simplification had already been explored.

For five days in 1997, five physicists (Arthur Greenberg, Piet Hut, Arthur Zajonc, Anton Zeilinger, and I) discussed traditional Buddhist physics and modern physics with the fourteenth Dalai Lama, not as a national or religious leader but as a Buddhist monk versed in the Mādhyamika tradition and interested in science. Two bilingual and bicultural hermeneuts, Thubten Jinpa and B. Alan Wallace, bridged our linguistic and conceptual differences. The discussions are recorded elsewhere. We found that we held several basic positions in common from the start.

For example, we would not invoke faith or divine revelation as the source of our knowledge, but rely upon experiment. Most of the physicists agreed with the Dalai Lama that knowledge, even of the rules of logic, comes from experience and is revised by experience. Here was a school of thought as systematically relativistic as I had hoped. Among many other things, we touched on the questions I have raised here. The Dalai Lama had thought about space atoms, and was aware of the modern intuitionistic logics that suspend the law of the excluded middle. He propounded his belief that science must be rooted in compassion. This seems to agree with Sakharov's Equation,

$$\sqrt{\text{Truth}} = \text{Love},$$

the root of truth is love.

When the question arose whether concepts like a variable matter-space-time-law unity had ever been expressed, Nagarjuna's verses on the Mādhyamika (the Middle Way) were cited. From a recent translation of a translation [Nagarjuna (1995)], it seems that they can indeed be read as saying that space, time, matter and causation are relative, with no permanent essence, and that this is inferred from the very fact that we perceive them.

Critical steps in the evolution of physics have required us both to break prior idols and to form appropriate new ones. The Mādhyamika appears to focus on the first part of this process, the emptying of concepts, and not on the formation of new idols, which are among the concepts called conventions in the translation of Garfield [Nagarjuna (1995)].

Some great scientists like Laplace and Einstein have believed in the existence of an absolute law and taken it as the supreme goal of physics. But many Western scientists and philosophers, including Newton, Mach and Whitehead, like many Buddhist and Hindu philosophers, explicitly propose that there is no fixed absolute law of nature, and that it makes sense to speak of a varying law. Bohm's (1965) expression of this philosophy especially influenced me. He views a scientific theory as a specialized extension of normal human discourse. A theory is something that we tell one another. A final all-inclusive theory is as likely as a final all-inclusive remark. Again, Smolin (1997) attempts to account for many details of our present law of nature by a Darwinian evolution of that law.

The I-W test for idols suggests that the dynamics too, with its one-way coupling to the system, is an idol within a compound system/dynamic; that the variable dynamics and the variable system are both aspects of one deeper quantum variable; and that there must be a coupling from system to dynamic through a small physical coefficient that is implicitly treated as 0 in present physics. Combined with the other relativizations we have discussed, this fusion means that what goes on in nature is a semi-simple quantum space-time-matter-dynamics unity. Perhaps the process that goes on may be represented as law-changing. It is moot whether we would describe such an evolution of physics as the end or the true beginning of the dominion of law.

I have argued for the relativity of the dynamic previously [Finkelstein and Rodriguez (1984)], but the traditional goal of the one fixed absolute law still marred my effort to marry space-time and quantum theory as late as 1996 [Finkelstein (1996), section 16.8.3]. Now a promising algebraic setting for the operations of a matter-space-matter-dynamics has presented itself [Finkelstein *et al.* (1999)] and I have been able to replace the search for an absolute dynamic by the study of relative ones and their average properties. This work is still too speculative and far from experiment to merit more space here.

When Einstein (1936) considered applying Heisenberg's "purely algebraic method" to space-time, he likened it to "trying to breathe in empty space." Now emptiness has acquired another meaning for me and his simile seems even more apt. The space-time of Einstein and of physics today is still absolute, full of essence. It seems likely that we must cross at least one more relativistic bridge, marked on my map, to reach enough emptiness for the next major revolution of physics to transpire.

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