MATHEMATICAL ALCHEMY IN PHYSICS

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Preamble

There is in physics a sentiment and trust that the more perfect logical structure of mathematics can save the day for some of the not so logical conceptual leaps of modern physics. This investigation aims at a better logical balance between the two, wherever this is possible. The present account emerged in part from experiences in crystal physics, which long ago required a closer relation between physics and its mathematical description. For crystals the demands go well beyond standard needs in physics, in fact they end up gibing with those needed in differential geometry.

Physics and mathematics are so close, because the language of modern physics is primarily one of mathematics. As a result physics has developed near-magic confidence in a never ending potential of some contemporary procedures for bringing in new harvests of results. Even after diminishing returns, more magic is attempted, yet oddly, "magic" handwritings on the wall warning about overreaching goals are not always heeded. As a result man feels as if Nature has been leading him astray. Since no proof exists of Nature taking delight in intentionally misleading its students, it may well be closer to the truth if students of Nature were to admit to misleading one another.

So, the following has become an unearthing of clues about marginal situations between physics and mathematics. Since this is not a pursuit of a specific physics problem with lengthy calculations, ***no equations are displayed in this paper***. They are mentioned by name instead, which is more than adequate, because all of them are well known items in contemporary physics.

Without equations and long extended deductions, more attention can be given to conceptual aspects. Since equations referred to here all have reputations of great effectiveness in modern physics, one would be reluctant to see them change. The hard earned experiences of numerous workers in past and present plead against undue tinkering with the intrinsic structure of well established tools. Yet everything else, specifically what exactly the tools stand for, is open to further probing. Let it be said, though, intrinsic structure may manifest itself better in suitable mathematical garb revealing its virtues.

So, while leaving the tools intact, definition domains and realms of applicability are due for major reassessments. Readers drawn to a romantic sentiment in modern physics with its pronounced element of nonclassical mystique may well be in for an anticlimactic experience. The conceptual reassessment, as here delineated, largely does away with the many nonclassical metaphors of contemporary physics. After all, let us face the reality of life, the task of physics always was one of resolving mysteries, not adding to them.

1. From Physics to Groups and from Groups to Physics

When in the course of the 19th century group theory began to give precious insight into crystal symmetry and structure, the stage was set for a chapter of beautiful physics where theory and praxis went hand in hand. Yet, except for spotty references, discussions of these matters are strangely missing from the contemporary textbook literature of general physics. Only special texts discuss these matters.

The discrete groups of crystal symmetry were physically significant subgroups of the group of rotations and mirror operations. The discovery of the Lorentz group was a major physical event in subsequent developments, followed by the conformal group and the general spacetime Diffeo-4 transformation of the general theory of relativity. All earlier Galilean as well as special relativity views of nature could now be classified as subcategories of the Diffeo-4 procedures of the general theory of relativity.

All of the above related directly to geometry- and physics-based explorations of the spacetime domain. Quantum theory would literally add a multitude of dimensions to these earlier four-dimensional experiences. The configuration spaces associated with quantum mechanics opened op an entirely new world. From the orthogonal invariance groups in space and spacetime, physics found itself confronted with multi-dimensional unitary and simplectic groups of invariance in configuration space.

The dimension of configuration space could not only go to infinity, its individual dimension became two-dimensional domains of complex numbers. If complex numbers did not suffice, hypercomplex numbers became possible tools in physical theory.

The emergence of spinor groups is a case in point not to disregard out of hand these esoteric possibilities. The configuration space structures were believed to be, at least in part, generated by an already familiar space-time group structure. This led to the development of what is known as group-representation theory. Apart from being a legitimate mathematical endeavor, physics' pursuit of representation theory was also motivated by a hunch that these complex superstructures held information that the more down to earth groups of real transformation could not reveal.

If the just depicted realm of mathematical diversity may have dazzled outsiders, who express an interest in the well-being of physics, let it be clear that it equally dazzles, or even more so, those who have inside knowledge of the subject. Imagine how young students are affected who have chosen this field of academic activity. Here is this amazing garden of mathematics with its even more amazing though erratic interconnections to physical reality. How many youngsters are just dying to search this ambiance and make their mark as explorers by picking orchids from that magic garden. From orchids in the wild, to cultivating and breeding their perfection is the natural follow-up of early discovery.

Physics, as it appeared in the early Thirties, had been an ideal environment for young people with the right intellectual acumen and imagination to make promising interconnections. The era became known as the period of "Knaben Physik" (boy's physics). It meant almost everything goes as long as the mathematics is correct. Once certain work recipes yield spectacular success, try it again and again, as the French say: *à tous et travers!*

In this abstract group approach to physics, the individual symmetry operations were much less visible as in crystal physics. It was considered clean and irrefutable, because it was not based on model metaphors that could be misleading. Copenhagen's axiom of an ever present quantum uncertainty discouraged blind pursuit of models with identifiable symmetry operations in the micro-domain. Groups offered a conceptually cleaner chance of interrelating the particle zoo of high energy physics to mathematical paradigms.

This game of adapting known groups to an unwieldy world of high energy observation was the challenge of the day. Long ago Lie groups and Lie algebras had enhanced understanding of continuous groups. They were now called upon to understand the special unitary groups SU(2) for rotations and spinors, the eight generators of SU(3) for the quarks, SU(4) added flavor, SU(5) added helicity, and finally an encompassing SU(6) that "might" have everything.

The eight-fold way is the most prevalent example of interrelating regularities of particle properties. Yet while the quark successfully mediated in structure regularities, efforts at directly substantiating the quark's physical reality failed. Compared to the old group description of crystals, the situation with quarks had been sort of reversed. In crystals realistic physical structure invited the group ordering, whereas in the eight-fold way group ordering was a way of getting to know the potential building blocks.

All of this illustrates differences between direct approaches as in crystals, whenever they are possible, and situations taking freely (sometimes too freely) recourse to trial and error in the hope some ontic propositions can be covered under an umbrella of a more encompassing epistemic virtue. However, if that promise is not met, it may be a sign of too much trial and too little error assessment leaving us with too many unpromising situations.

Once there are diminishing returns, decisions need to be made whether the time for hitting jackpots is gone. A more enhanced conceptual input and coherence become points of primary consideration.

The second part of the Twentieth century indeed reveals a sequence of diminishing relevance. Quantum Electro Dynamics QED gave precise answers, yet its methods were contingent on an awkward technique of manipulating infinities. Quantum Chromo Dynamics QCD manifests a measure of physical relevance with the help of mathematically less questionable procedures. Yet it lacks the beauty of physical-mathematical synthesis of the crystallographic edifice.

Finally String theory has marked the last quartile of the 20th century. After many years of undaunted activity of its originators and aficionados, it has not as yet established a contact with an epistemic or even an ontic reality in the physical realm. Those who claim knowledge in this realm praise its mathematical beauty. So far, this beauty has been exclusively in the eyes of the circle of beholders. Yet it has failed to convince outsiders that mathematical beauty is a sufficient condition that at sometime, somewhere, some manifestation of physical relevance should be forthcoming. At this time no such hoped for interface with reality has materialized.

2. Comparing the 19th and 20th Centuries

In the perspective of the 19th century relation between mathematics and physics, a measure of looseness with that subject in the 20th century dealings can hardly be denied. The previous century started out with the Hamilton-Jacobi theory of mechanics, the Faraday-Maxwell conceptions of the electromagnetic field and last but not least the Fedorow-Schönflies classification of crystal structure. All three of these development are impressive edifices that testify to a tight relation between physical concepts and mathematics. It shows how such discipline can improve and widen the insight into physical fundamentals.

In the 20th century the *relativities* and quantum mechanics became prime movers of conceptual thought in physics. While both disciplines opened tremendous perspectives, they also added an element of mystery as not seen before. Perhaps the most challenging mystery was an only partial compatibility between the two in the form of the Dirac theory. Somehow the two failed to blend together in a more complete way when it was attempted to meet the full requirements of the general theory of relativity.

The efforts of the Thirties to make quantum mechanics compatible with the premises of the general theory did not lead to a successful and constructive conclusion. In the course of time, this failing became a source of frustration. Whose fault was it? Quantum Mechanics' interaction with everyday physics tipped the scale of interest as compared to the cosmology oriented implications of the General Theory. Yet the hurdle preventing logical harmony turned out to be mostly a deficiency of quantum mechanical interpretations.

3. A Principal Weakness of the "Knaben Physik"

Let us search for causes where and when the relation between physics and mathematics failed to meet requirements of sound epistemology. Deviations from the path of truth must have either occurred in the General Theory of Relativity or in the theory of Quanta. In fact, something in both can be pinpointed as preventing conceptual harmony. An omission in the general theory and an erroneous step of quantum interpretation are the center pieces of this assessment. Let us focus here first on the wrong quantum decision, because revising that decision casts light on the nature of omissions in the general theory of relativity.

When the Heisenberg and Schrödinger methodology became available, it was just taken as a foregone conclusion that these matrices and wave equations were describing a single quantum system. Yet, there was no experimental evidence whatsoever backing up that conclusion. In fact, all experimental evidence available at that time suggested otherwise. The body of spectroscopic observations was quantum mechanics' major cross-check with experimental reality. They indicate presence and joint responses of many identical single systems. The observation of responses from an isolated single atomic systems are experimentally very difficult and so rare that they could not have played a role in Copenhagen's single system axiom.

It seemed much closer to experimental reality to assume that the spectral observations, commonly cited as confirming theory findings, are really the result of an ensemble response not a single system response. It is not clear at all for what reason, the Schrödinger equation was taken to be a tool that would be describing single systems.

Publications of that time reflect a preconceived sentiment of having obtained an exact tool; perhaps because it gave more information about transitions between states than the earlier methods of Bohr-Sommerfeld. On the other hand, by the same token, an ensemble presence could be argued as instrumental in transitions. Anyway, for whatever reasons, not obvious to us now, it was taken as a foregone conclusion that this new 1925-26 quantum mechanics had to be a single system tool.

To make a long story short, let it be said, there is an extensive body of evidence pleading in favor of the ensemble alternative. An array of interlocking arguments supports this point of view and has been elaborately stated elsewhere, yet for unclear reasons they have not become common good in physics circles.

Let it suffice here that Schrödinger's own recipe for obtaining his wave equation lends a dramatic support to the ensemble, not the single system.* The suggested change of venue for the wave equation's realm of operation elevates the Schrödinger recipe to an honest derivation of an ensemble tool. Yet, in doing so it has to vacate the unsuited single system pedestal. Going through the details, mutual phase and orientation of the ensemble elements are revealed as parameters of a perfectly classical statistics, taking the place of the nonclassical textbook statistics. It makes sense that assessing Schrödinger's recipe, instead of relegating it to a recipe realm not susceptible to further analysis, has a message for physics.

This change of venue from single system to ensemble obviates the need for most nonclassical textbook talk, because the ensemble returns to the nonclassical statistics its rightful *universe of discourse*, which Copenhagen's single system thesis had so rudely removed.

It further follows from this change of venue that the zero-point energy is no longer a single system attribute, but a lowest ensemble average as introduced by Planck. He introduced the notion of zero-point energy as early as 1914, yet his results have been viewed

* The recipe extremizes a volume integral with an integrand, which is a converted Hamilton-Jacobi equation. The latter is the equivalent of its collective of solutions. The H-J constants of integration can be shown to relate to mutual phase and orientation, thus identifying a phase-orientation random ensemble, and not a single system! The latter correspond to a solution manifold contrac-ted to a point, which is not part of Schroedinger's recipe. Copenhagen's single system is so relegated to wishful thoughts about having obtained an **exact** tool.

with reservation, because there were two versions of his “Theory of Heat Radiation.” The second edition cites a calculation of a phase random ensemble of single systems. Optimizing the ensemble probability gives the zero-point energy average of ¡ø/2 per system.

The reader should note that Schroedinger’s recipe in actual fact averages a solution manifold of the Hamilton-Jacobi equation, with each of its solutions quantized in pre-1925 fashion. The variational process optimizes this solution manifold and so produces the Schroedinger equation. The latter assigns eigenvalue extrema to its solutions as effective quantum numbers of the initial Hamilton-Jacobi solution manifold. This sketchy perspective brings us just about as close as one can get to Planck’s 1914 averaging process.

Heisenberg, “der Knabe,” presumably unaware of Planck’s earlier work, obtained the expression ¡ø/2 in 1925 and so did Schrödinger in 1926. Without explanations, both were convinced of having identified a universal single system property, yet Schrödinger, the senior “Knabe”, mentions Planck’s earlier work. Neither he, nor anybody else at that time, followed up with a more thorough comparison.

The problem with accepting the Heisenber-Schrödinger single system (sub)assumption is that every individual electromagnetic harmonic oscillator of free-space would have to be equipped with an always present zero-point energy. This leads to QED vacuum infinities. On the other hand, accepting Planck’s version, harmonic oscillators are allowed to have zero energy states. This improves chances of living without infinities, yet some folks may complain of having been bereaved of an inexhaustible source of energy!

4. Quanta as Probes of a Discrete Micro-Structure

Since quantum mechanics, as presently known, has inadvertently been sailing under the misleading flag of single systems, this same quantum mechanics must now give up its erstwhile fundamental status. So, if Schrödinger-Dirac equations are not primary tools of quantum mechanics, what are the primary tools?

The answer to this question may for many be anticlimactic, because those primary tools have been around in an early form for many decades, predating the Heisenberg-Schroedinger methodology. Their new perspectives were in part discovered through the Schroedinger equation. Unfortunately, that very fact also gave them second rate standing, because Schroedinger’s equation had been taken to be exact. The primary tools to be considered are a set of cyclic integrals going back to the early 19th century. In the course of time, though, they underwent an evolution enhancing their status.

I The one-dimensional cyclic integral of (London)-Aharo-nov-Bohm becomes a counter of flux units for an appropriate class of integration loops.

II The two-dimensional cyclic integral of Ampère-Gauss-Maxwell was long ago known as Gauss’ law counting net elementary electric charges at rest or in motion for appropriate integration cycles.

III In the Seventies a pioneer of this methodology identified an “exterior product” integral of I and II as a counter of action units. Using integral II for a single charge, one so retrieves the Bohr-Sommerfeld integral of earlier quantum methods of before 1925.

The (Ampère)-Gauss-(Maxwell) integral had already graduated as a quanta counter of net electric charge, after Faraday's 1831 experiments with electrolytes had established the existence of a universal quantum of charge; confirmed by Millikan many years later.

While not usually recognized as a quanta counter, the extended Ampère-Gauss-Maxwell integral II is a basic element of perhaps the most fundamental of all physical theories to date: *i.e.*, the theory of Maxwell. By virtue of this exclusive origin, its quanta counting ability is hereby also taken to assume an exact status.

Now, taking a good look at the London-Aharonov-Bohm integral I, it also is a perfectly basic element of Maxwell's theory. Yet contemporary views about the exactness of the Schrödinger equation relegate integral I to an asymptotic place. However, section 4 now has changed that situation, because an inference of inexactness of integral I on the grounds of it asymptotic relation to an inexact Schroedinger equation is no longer valid. Hence integral I can now join integral II as an exact quanta counter. Its quanta counting potential, was first suggested by London in the Thirties and confirmed by experiment in the Sixties. Its asymptotic relation to Schrödinger's process now ensues from single system-ensemble *physical* asymptotics.

As **quanta counters integrals I, II and III should be invariant under arbitrary changes of spacetime coordinates, including metric changes of length and time,** because honest counting could not possibly be affected by coordinates! In fact a mathematical proof of that invariance was implicit in papers published by Kottler and Cartan. in the early Twenties. At the time this metric-free aspect of physics was considered as too esoteric to be of practical use. In witness of the pre-metric features of topology, let it be said that integrals I, II, III are beginning to assume the form of a complete spacetime set in the sense of de Rham's cohomology; a method of topology description developed in the Thirties.

5. The Unexpected Realm of Metric-Free Physics

Since the integrals I, II, III have been around for some time, it can now be seen why they remained down on a level of relevance, way below their station of potentiality in physics. The conjunction of neglecting esoteric mathematics and the premature identification of the Schrödinger-Dirac method as exact prevented a natural evolution of insights about the integrals I,II,III as quanta counters.

In the wake of the general theory of relativity, the early Twenties and Thirties saw a number of papers on the subject of metric-independent general invariant aspects of specific parts of Maxwell theory. At the time, they were causing some upheaval in the world of physics, however, when no physical specifics could be tied to this mathematical phenomenon, the interest in these relations began to wane and by now they may be all but forgotten.

However, now after changing venue for the primary quantum laws from Schroedinger-Dirac to the integrals I, II, III, it can now be seen how this measure suddenly resolves a decades-old problem of compatibility between quantum theory and the general theory of relativity. The quanta counters I,II,III meet all requirements of the general theory of relativity and just a "little more." This "little more" shows the quantization here considered to be a topology specification of microstructures, which is totally independent of metrtic structure. Since the metric is the mediator of gravity, this ought to affect contemporary discussions of *quantum gravity.*

The desperate attempts of the thirties trying to define a generally covariant rendition of the spinors in the Dirac equations testify to the fact that almost everything could be given a covariant form if competent people set their mind to it. There is no guarantee, though, that an indiscriminately imposing of covariance yields goods.

The metric, as it is now known, has a dual role: **A passive role** in giving criteria for length and time interval, thus providing distinctions between macro and micro-physics, **plus an active role** given by the general theory of relativity by providing a measure for an absolute gravity potential, say mc^2, with a gradient profile giving the forces of gravity.

6. From Local to Global and vice versa

Ever since Newton opened up physics to the tool of calculus, the tradition has been one of freely going back and forth between local and global methods. By local is meant a situation characterized say by a differential equation, with a definition domain for which the local statement remains valid. A global statement, by example, is the inverse square law of gravity. A century or so after its inception it became known that this global law was a solution of the Poisson differential equation. Hence solutions of local differential equations so became regarded as global in nature

The differential equations of planetary motion are based on an input mixture of local and global information. Yet, final solutions end up as all global results. By contrast, the Poisson equations of gravity is a completely local statement, its solutions are meant to have an all global character. The same holds for the Einstein field equations of gravity. Of course, the global features of Poisson equation solutions differ from those of the Einstein field equations. Theorizing in physics so becomes a matter of good judgment in choosing and weighing local and or global starting points, prior to getting into solutions.

The Maxwell equations of the electromagnetic field are all local in nature, yet they were obtained from a set of global integral relations that were the result of experimental observation. They are known as the integral statements of conservation of flux and of electric charge. With the help of the Stokes and Gauss integral theorems those integrals are converted into differential equations, now known as the Maxwell field equations. Many practical concerns in electromagnetism are local for which the differential form is indispensable.

The theorems of Stokes and Gauss have been faithful standbys of physics in going back and forth between local and global situations. Towards the end of the last century and beginning 20th century, mathematics has been looking for dimensional generalizations that have now become known under the name of Stokes generalized theorem. This generalized theorem has become instrumental in topological investigations that have found expression in the earlier mentioned work of de Rham. These mathematical developments are here mentioned in anticipation of parallel development in physics.

Even for information coming to us in global form, say conservation, those concerned with the mathematical description of physics have had a preference for casting laws in the form of differential equations from which solutions are obtained to be readapted to special global boundary conditions. Here is a little secret why physicists can anticipate solutions, where mathematicians are at a loss, because they may not be privy to related physics information.*

A theorem by de Rham casts light on how conservation statements of flux and charge lead to the residue counting laws I, II of section 4. Identical quanta makes this esoteric theorem quite transparent.

The conservation of flux, given by a cyclic 2-dimensional integral vanishing for all 2-cycles, it creates for the LAB integral I the possibility of counting flux units linked by 1-dimensional cycles.

Similarly conservation of electric charge, as expressed by a 3-dimensional cyclic integral vanishing for all 3-cycles, similarly begets integral II enclosing charges at rest or linking charges in motion.

The preceding two paragraphs convey in a nutshell an essence of de Rham's method of *cohomology*. The interplay between vanishing and nonvanishing cyclic integrals carries information about the topology of field structure and their sources. In corresponding mathematical language, conserved fields (differential forms) are called **exact**, and those that have residues are called **closed**.

All told it is not surprising that Maxwell theory has been a source of inspiration in the development of de Rham's general theory of cohomology, which has now become a general procedure for assessing the topology of field configurations in mathematics.

For physical applications it is important that the residue integrals I, II, III are metric-independent. Since the metric is the one and only reference that makes the macro-micro distinction possible. Hence de Rham's methods remain applicable in atomic and particle domains.

De Rham theory gives a better balance between local and global through the topological delineation required by global description. So, the quanta counting integrals I,II,III were available to us all along as a global superstructure on traditional Maxwell theory.

7. Thoughts about Avoiding Alchemist Anarchy

Almost half a century ago mathematicians (Haefliger and Milnor) have shown the SU(2) doubly covering spin representations of rotations to be an expression of properties of manifold orientability. No impact of these findings on the mathematical policies in physics have come to pass. Spin formalism have been flourishing as if those orientability connections had never been made.

Let us recall, it was the SU(2) spin formalism that presented the biggest hurdle in the ill-fated covariant transcriptions of the Dirac equations in the Thirties. Only rotations and Lorentz transformation permit manageable spin representations. Their associated orthogonal frames can not be extended in an integrable fashion in the Riemann-type manifolds of relativity. It means those transcriptions invoke anholonomic reference systems, the complexity of which is more than enough to cause anybody severe bouts with headaches.

Mindful of the spin-orientability relation, questions need to be asked whether space-time descriptions, that properly accommodate improper transformations associated with orientability changes, might do the same as spinors or perhaps better. It would at least lift this chance restrictions to Lorentz and rotation groups.

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* There is a famous example of Hilbert and Einstein simultaneously finding the field equations of gravity. Einstein immediately had a physically relevant solution, whereas Hilbert did admit to Felix Klein having wrongly concluded from these equations a general validity of energy conservation!

When spinors first entered the realm of physics with the Dirac equations, there was indeed concern among theorists. The arsenal of description had vectors and tensors, why were spinors suddenly needed that live in an unphysical two-dimensional complex manifold (Ehrenfest)? Since spinors entered the physics stage in somewhat of a chance fashion, inquiries are justified whether they are the most effective entities to give expression to orientability features of the spacetime manifold and the objects therein.

It is the very physical geometric notion of orientability that begot the mathematical alternative of spin, not the other way around. Not only the rotation group manifests the double covering called spinorization, also the orientation preserving linear group exhibits spinorization. Yet, in the latter case there are too many parameters for a simple unitary representation, such as available for the rotations.

This triggers questions about a chance quality in the earlier mentioned sequence of unitary groups of QCD: SU(2)‘SU(6). It is strange logic to first exclude improper spacetime transformations[*] and then invite them back in again with the help of spinors. **Why?**

In the past only crystal physics dealt with the phenomenon of enantiomorphic (*i.e.*, mirror) pairing in those crystals that have no mirror symmetries in their group characterization. That problem was confronted directly by carefully defining behavior of vector- and tensor-species under improper transformations. No general textbook of physics can be found which systematically covers that aspect. Only specialized books on crystal physics confront those requirements, but those stop short of elsewhere needed Riemannian generalizations.

In the mathematics of differential forms, de Rham first went out of his way defining *pair* and *impair* forms. This provision may well have been due to physical sources that initially guided his cohomology characterization. However, perhaps due to lack of consistent follow-ups in the physics literature, he later did not explore this aspect in his development of cohomology. Those seeking applications of de Rham theory in physics do well reminding themselves about pair-impair omissions in the subsequent mathematical literature.

Let us recapitulate: Copenhagen’s single system axiom places undue emphasis on Schrödinger-Dirac methodology as a primary procedure, which in turn gives undue emphasis to primary functions of configuration spaces and the unitary sequence SU(2) all the way to SU(6), invoking an indirect coverage of spacetime orientability.

The alternative puts three quanta counting integrals in a primary law position for single systems. The quanta of action and charge change sign under an orientation change, the flux quantum does not. Since the Schroedinger-Dirac methodology assumes hereby a derived secondary position, describing ensemble behavior of single systems, this change of venue detracts from the primary roles previously assigned to configuration spaces and their tentative sequence of groups SU(1), SU(2), SU(3), SU(4), SU(5), SU(6).

The last two paragraphs delineate a critical situation, because so much of contemporary theorizing is riding on the unjustifiable single system thesis of the Copenhagen school. It shows the roles between physics and groups sort of reversed. In the early days of crystals, physics determined the groups that could do the job. Now groups look for the physics

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[*] It is necessary to be reminded that vector analysis, the major vehicle of mathematical communication in physics is based on an identification of vectors and bivectors. This only works for an orientation preserving group. It used to add to the confusion that in the French literature the identification was made for left-handed frames whereas others made it for right-handed frames!

in randomized ensembles of single systems, not isolated single systems. It seems information conveyed by the unitary sequence must be, part single system, part ensemble based.

8. Conclusion

How can one possibly verbalize an appropriate good bye and a fitting sent-off to an almost three quarter century odyssey of basically misguided nonclassical metaphors? Let it be a solace that history has known longer and far worse periods of collective misguidance in the realm of religion.

So, after having been told how science should stand for truth, it seemed tragic that physics could not have escaped a time span of misguidance by a more critical introspection. Frustrations in contemporary theorizing go back to what seems an unopposed deification of the Schroedinger-Dirac process. Even Schrödinger, although opposed to the Copenhagen school, shared a common opinion that the wave equation process would be describing one single system at a time.

In retrospect, it seems almost unbelievable that the alternative of an ensemble was hardly considered. A small group, pioneered by Popper, held out for an ensemble, even so they were willing to inherit much of the nonclassical lore started by Copenhagen.

Somehow, the times of the Twenties embraced religion that had gone more scientific and science that had gone more religious. The idea of an absolute quantum uncertainty limiting human knowledge appeared a welcome alternative to earlier arrogant claims of a science that knew no limitations.

Even so, religious sentiment was no justification for ignoring a glaring logical incompleteness of the Copenhagen interpretation. The latter became sanctified in the wake of the higher mathematics of eigenvalue procedures and orthogonal expansions invoked by the Schrödinger process. It seemed inconceivable that such a showcase of tight mathematical logic could have been harboring a logically defective physical interpretation. Higher mathematics had unintentionally legalized faulty physical procedures.

When Schrödinger's equation was followed by the Dirac equation, the magic of spinors, just fitted the mystique of that time. Those who had their doubts were afraid of being painted in a corner of doubters unable to keep up with the new trends. In fact, Einstein and even Schroedinger himself, the very creator of this eigenvalue process in physics, became suspect of belonging to a past generation. Such are the graces and favors of a world with a short memory.

The magic and mysticism of the 1925 quantum revolution had created a measure of gullibility as had not been known since the days of alchemy. Most were afraid to say so, as long as a good harvest was coming in. Others were too lazy to think it through; let good enough alone as long as it serves the intended purpose. Heartless expediency became the hallmark of good physics.

Now, in retrospect, one wonders how vast majorities of teachers and students succumbed to such an uncritical acceptance of Copenhagen's single system premise. The small minority at that time objecting to this premise, had been free in wording their opinions. Today such opposition is much less tolerated, which goes to show how **an uncritically accepted single system premise has, in the course of time, acquired the strength of a dogma.**

It is this dogma that led to the acceptance of vacuum infinities and an unrelenting ever-present quantum uncertainty. This sacrifice of reasoning avenues, initially believed to serve progress, did not stop here. There is the blind acceptance of spin and SU type formalims as substitutes for a seemingly unrelated spacetime orientability. Particle classifications sought by QCD, are bound to be affected by ensemble connotations of the SU sequence of groups.

By contrast, since quanta counters generate cohomology groups H^0, H^1, H^2, H^3 for particles, their group elements directly relate to charge, spin, flux and magnetic moment properties as elementary particle observables. One so achieves a return to the direct process of assessing crystal symmetries.

In the realm of mathematics, the current state of cohomology theory is, however, restricted to so-called pair forms. For physics application it will be essential to extend de Rham theory to cover the impair differential forms. Historically, Gauss established the first residue integral, as the integral of an impair form! While mathematics focuses on manifold structure, physics in addition has to focus on the wealth of objects embedded in that manifold. Hence not everything in this new conceptual environment is ready made for use in physics, it means much more work is needed for smooth adaptations.

Now summarizing the principal sticking points in a nearly three quarter century old status quo there is foremost: Copenhagen's unproven single system premise for the object of description of the method of Schrödinger-Dirac. From it follows the whole array of nonclassical paradigms, which can now all be avoided by replacing the single system by an ensemble. Here is no space for compromise!

Note that none of the above is a sacrifice of method, it is at best a sacrifice of misguided applications unsuited for the Schrödinger-Dirac process. Hence all acquired virtuosity in dealing with eigenvalue procedures remains intact and ready for use under the ensemble umbrella.

In the realm of the general theory of relativity, it is essential not to ignore metric-independent (*i.e.*, gravity-independent) aspects of that theory, because they provide a long awaited bridge to the theory of quanta and its micro-physical applications.

A fuller account of orientability of spacetime and the physical objects embedded therein is necessary in rising above the restrictions of current spin descriptions. The latter have been forcing a use of frames of description fitting the **Special** theory, not the **General** theory. Einstein's own expressed objective was to view the special theory from the angle of the general theory.

The contemporary way of looking at the General theory from the position of the Special theory goes against the grain of common sense as well as against Einstein's own views on that matter**.** In many ways modern cosmology with its big bang preoccupation reflects an undelineated mixture of Riemannian-Euclidian metaphors that seem an aftermath of looking at the **General** from the angle of the **Special.**

Literature

While it would have been possible to give explicit references to the many authors on whose work this reassessment rests, in the process of looking up references, physics oriented readers are known to get turned off by the frequently purely mathematical context and verbiage in which some relevant subjects are presented. My experiences have amply confirmed that simple references to mile-stone mathematical events are inadequate if one expects or hopes to see them register in an appropriate physical context. By the same token, experienced mathematicians, presently offering help in contributing to physics, run a serious risk of being misled about the assumed center(s) of *gravity* of contemporary physical concerns.

To alleviate difficulties arising from the just mentioned hurdles, most topics here presented have been earlier collected and documented in a more physical context, with many detailed references to originators of key concepts. This has been attempted in a book put together by the present author. It is entitled**:** ***Quantum Reprogramming*** (Kluwer, Dordrecht, Boston, 1995).

I am sorry to say, though, also these earlier attempts, at making collective insights on needed revisions available, have not succeeded in reaching out across the borders of the contemporary community of establishment-oriented physics. Therefore, the present journalistic account is meant as help to snap out of sundry vicious circles of specialist myopia and misguided expediency. Those who, for whatever reason, are still interested in added background are invited to consult the just cited text; which at this point in time has neither been officially rejected nor officially accepted by establishment authorities. So, let us say**: try it! All you stand to lose is some magic-based prejudices that really are no longer needed.**