From the desk of Pierre Beaudry

LOUIS DE BROGLIE : THE WAVE AND PARTICLE PARADOX

by Pierre Beaudry, 7/11/2010

"Humanity is going to need a substantially new way of thinking if it is to survive!"
Albert Einstein.

"Having much more the state of mind of a pure theoretician than that of an experimenter or engineer, loving especially the general and philosophical view, I was drawn towards the problems of atomic physics."
Louis de Broglie.

"In principle, a physical event is inseparable from the measuring instrument or the organ of sense that perceives it; and similarly, a science cannot be separated in principle from the investigators who pursue it."
Max Planck.

"You, who presume to move this way,
Get a *good lantern* lest you stray…
Destiny pulls the willing, the unwilling drags."
Francois Rabelais.

INTRODUCTION: REVIVING THE LEAST ACTION PRINCIPLE OF F

In 1924, Louis de Broglie (1892-1987), tackled one of the most difficult scientific problems that no scientist had been able to solve before him. The mission he undertook was to solve the wave and particle paradox. Fortunately, it was as a historian, and not as an experimental physicist, that de Broglie took-up that challenge, because he knew that this problem could only be solved from the standpoint of the history of ideas and not with the use of mathematics, or from observations in a laboratory.

What de Broglie discovered was a principle that solved a problem representing, at least, three interacting degrees of knowledge. At the first and highest level of epistemology, the problem involved solving the crisis between the Platonic and Aristotelian methods of considering the universe; that is, either what is real in the universe is coherent with the anti-entropic processes of the human mind, or what is real is the self-evident object of sense certainty. At the second level of scientific knowledge, the problem involved the discovery of a solution to the profound historical division between two principles of dynamics and of mechanics, that is, the disparity of a typical Leibniz-Newton incompatibility between the Optics of Pierre de Fermat and the Mechanics of Pierre Louis Maupertuis. At the third and lower experimental level, the problem to be solved involved two anomalous but parallel conceptions of energy and matter, the paradoxical state of affairs between wave and particle in the process of radiation. De Broglie's explicit commitment was to solve this triple layered problem as a matter of principle, by reestablishing the least action principle of Pierre de Fermat and by applying the principle's congruence of phase with Plank's Theory of Quanta and Einstein's Theory of Relativity. This is how de Broglie formulated his objective in the introduction of his Doctoral Dissertation of 1924:

> "Guided by the idea of a general relationship between the notions of frequency and of energy, we acknowledge in the present study the existence of a periodical phenomenon related to a piece of energy whose nature remains to be clarified as to its proper mass, and in accordance with the Plank-Einstein equation. The Theory of Relativity has taught us to associate with any uniform motion of a material point the propagation of a certain wave whose phase travels in space faster than light. (Ch. I.)
>
> In order to generalize that result in the case of a non-uniform motion, we are made to admit proportionality between the Impulsion of the Universe vector of a material point with the characteristic vector of an associated wave propagation whose time component is established by its frequency. The principle of Fermat applied to the wave, therefore, becomes identical with the principle of least action applied to a moving body. The rays of the wave are identical to the possible trajectories of the moving body." (Louis de Broglie, *Recherches sur la Théorie des Quanta*, Annales de la fondation Louis de Broglie, Vol. 17-N0. 1, 2007, p. 3.) http://tel.archives-ouvertes.fr/docs/00/04/70/78/PDF/tel-00006807.pdf

As I will show in this report, De Broglie identified the principle of least action as the final causality principle designed to orient change in all processes of physical spacetime, including the generation of singularities. De Broglie went back to Fermat's idea which defined least action as Leibniz and Bernoulli had done, that is to say, as the pathway of final causality representing the easiest and most efficient of all possible pathways that nature chooses to achieve its end. De Broglie called this principle of proportionality the ***"harmony of phases"*** between the wave and the particle, and he identified this process as the most important discovery of his life.

Finally, de Broglie's treatment of Fermat's principle of least action can also be considered as a method of ***bootstrap self-generation*** that is congruent with the principle of irony in Classical artistic composition. In other words, the discovery of de Broglie includes a forth degree of knowledge. As I will demonstrate in the last segment of this report, the particle has within itself a harmonic ordering principle by means of which its wave overtakes it in harmonically determined places inside of the atom. This process of phase change is analogous to the phase change process that is generated in the well-tempered musical system of Johann Sebastian Bach. As a result of such a process of self-generation, de Broglie was able to develop a conception of radiation in which the phase of the wave travels faster that the speed of the electron particle, therefore, discovering within the atom a singularity of what can only be qualified as a "quantum leap." Thus, like a voice register shift in Classical singing composition, the ***harmony of phases*** of the wave and particle paradox works like a poetical irony simply because this is the way the universe is lawfully organized for the mind as well as for matter.

1- SOLVING THE WAVE AND PARTICLE PARADOX

Louis de Broglie was 19 years old when he first began to investigate the necessity of a wave theory for radiation and for the quanta when he attended the First Solvay Congress of 1911 on *The Theory of Radiation and the Quanta*. This is where he started to work in collaboration with the French physicist Paul Langevin who had been a student of Pierre Curie and who rapidly became the most prominent French representative of Einstein's Theory of Relativity. At that time, de Broglie began to consider the design of "unifying the particle and wave points of view and deepening the true meaning of the quanta." (De Broglie, Op. Cit., p. 11.)

The first conceptual problem that de Broglie had to solve was how to establish a workable concept of action to replace the notion of energy. This was not simply a question of language or of mathematical formula, but a question of principle. The issue was to reestablish in physics the authority of the lost universal physical principle of least action of Fermat as a fundamental principle of nature. De Broglie knew he could not restitute this idea without launching a major war that he might lose at the onset. So, he first had to prepare the axiomatic terrain where a harmonically ordered notion of wave action was going to eventually replace the fallacious notion of energy based on the sense-perception of particles. De Broglie noted that on several occasions, during the early developments of the theory of Quanta, there had been attempts to establish a notion of "mechanical action," but all cases lacked the truthful dynamics that were required. As he wrote:

> "On several occasions there were attempts at giving to the quantum relation an enunciation that would involve action as opposed to energy. Assuredly, the (Planck) constant *h* has the dimensionality of an action, that is, ML^2T^{-1}, and this is not due to chance, because the Theory of Relativity teaches us to classify action as one of the main

"invariants" of physics. However, action is a magnitude of a very abstract character and, following numerous meditations on the quanta of light and the photoelectrical effect, we have been forced to return to the use of energy as a basic notion, until the day we can explain why action plays such an important role into so many questions." (De Broglie, Op. Cit., p. 14)

Although de Broglie had to accept a momentary set back, he nonetheless established his fundamental hypothesis for the least action principle, conditionally, as follows:

"We can therefore conceive that in accordance with a great Law of Nature, for each piece of proper mass of energy m_0 there is related a periodical phenomenon of frequency v_o such that we have:

$$hv_0 = m_o c^2$$

v_o being measured, of course, within the system related to the piece of energy. This hypothesis is the foundation of our system: it is worth what any hypothesis is worth, the value of the consequences that can be deduced from it." (De Broglie, Op. Cit., p. 14)

This is how de Broglie restored the Fermat principle of least action in its modern scientific form, but with the provision that he could later change the concept of energy for the more appropriate concept of action. That was de Broglie's way of applying the principle of least action in a very unique form of harmony, as I will show below. Thus, de Broglie developed his hypothesis from the Planck-Einstein equation $W = hv$ where W is the energy, h is the Planck constant, and v is the frequency of the wave.

Then, de Broglie ironically introduced the two opponents of the least action debate, Pierre de Fermat and Pierre Louis Maupertuis, as a way of reflecting the very ambiguity of the issue of wave and particle. Historically, de Broglie dealt with the question as a matter of proportionality in which Fermat was to the wave as Maupertuis was to the particle. De Broglie wrote:

"The principle of Fermat applied to the phase wave is identical with the principle that Maupertuis applied to a moving body; all of the possible dynamic trajectories of a moving body are identical to those of possible wave rays. We believe that this idea of equivalence between the two great principles of Optical Geometry and of Dynamics could be a precious guide for affecting the synthesis between waves and quanta." (Louis de Broglie, *Recherches sur la Théorie des Quanta*, Annales de la fondation Louis de Broglie, Vol. 17-N0. 1, 2007, p. 37.) http://tel.archives-ouvertes.fr/docs/00/04/70/78/PDF/tel-00006807.pdf

The point is that although de Broglie had made the courageous choice of attempting to solve the wave and particle paradox, undoubtedly the most difficult paradox of contemporary science, according to Einstein, he knew the price he had to pay for telling the truth. He also knew that the preferred pathway to take with liberals is on the level of principles. In other words, the only way to come to terms with ambiguities in the domain of physics, as de Broglie did, is to reflect them as ironies of the domain of artistic composition. The poetic necessity in the domain of science is to always choose experiments that reflect the ambiguity of both science and art as a product of the same creative process of the mind. It was from this sort of timereversal historical ambiguity that he was able to draw the following conclusion, three years later on the day he received the 1929 Nobel Prize for Physics. De Broglie drew the following conclusion:

> "When I started to ponder these difficulties, two things struck me in the main. Firstly, the light quantum theory cannot be regarded as satisfactory since it defines the energy of a light corpuscle by the relation $W = hv$ which contains a frequency v. Now, a purely corpuscular theory does not contain any element permitting the definition of a frequency. This reason alone renders it necessary in the case of light to introduce simultaneously the corpuscle concept and the concept of periodicity.
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> On the other hand, the determination of the stable motions of the electrons in the atom involves whole numbers, and so far the only phenomena in which whole numbers were involved in physics were those of interference and of eigenvibrations. That suggested the idea to me that electrons themselves could not be represented as simple corpuscles either, but that a periodicity had also to be assigned to them.
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> I thus arrived at the following overall concept which guided my studies: for both matter and radiation, light in particular, it is necessary to introduce the corpuscle concept and the wave concept at the same time. In other words, the existence of corpuscles accompanied by waves has to be assumed in all cases. However, since corpuscles and waves cannot be independent because, according to Bohr's expression, they constitute two complementary forces of reality, it must be possible to establish a certain parallelism between the motion of a corpuscle and the propagation of the associated wave. The first objective to achieve had, therefore, to be to establish this correspondence." (Louis de Broglie*, The Wave Nature of the Electron*, Nobel Lectures, December 12, 1929.)

Thus, if a particle such as an electron could behave as a wave, then, a wave also had to behave as a particle. Therefore, since the electron had to behave like a wave, de Broglie used Einstein's photoelectrical effect to demonstrate that the wavelength associated with the electron had a ratio of the Plank constant h divided by the momentum of the particle v; that is, h/v. Also, when you speak of periodicity, you speak of whole numbers, but when you speak of periodicity of the particle, which is also a wave, you are speaking not just physically, but also poetically: Note, especially, that de Broglie introduced the function of the Plank constant h for the purpose of establishing proportionality between the energy of a particle and the frequency of its electromagnetic wave. That is where the true poetical ambiguity of the corpuscular and wave structure resides. What is left of the particle is no longer a thing in itself but a harmonic ordering process of change. But, de Broglie took the proportionality a step further.

What de Broglie called parallelism was, in reality, an effort at understanding the physical universe from the standpoint of psychophysical parallelism, that is, the relationship between the judging powers of seeing and hearing, the proportionality between what his vision could no longer see, but that his musical understanding could hear in the form of harmonically ordered waves in his mind. This is the way Einstein understood de Broglie's effort:

> “To arrive at results consistent with the relevant experiments, radiation of a given frequency had to be treated as though it consisted of energy atoms of the individual energy *hv* where *h* is Plank’s universal constant. During the years following it was shown that light was everywhere produced and absorbed in such energy quanta. In particular Niels Bohr was able largely to understand the structure of the atom, on the assumption that atoms can have only discrete energy values, and that the discontinuous transitions between them are connected with emission or absorption of such an energy quantum. This threw some light on the fact that in their gaseous state elements and their compounds radiate and absorb only light of certain sharply defined frequencies. All this was quite inexplicable within the frame of the hitherto existing theories. It was clear that at least in the field of atomistic phenomena the character of everything that happens is determined by discrete states and by apparently discontinuous transitions between them, Plank’s constant *h* playing a decisive role.
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> The next step was taken by de Broglie. He asked himself how the discrete states could be understood by the aid of current concepts, and hit on a parallel with stationary waves, as for instance in the case of proper frequencies of organ pipes and strings in acoustics. True, wave actions of the kind here required were unknown; but they could be constructed, and their mathematical laws formulated, employing Plank’s constant *h*. De Broglie conceived an electron revolving about the atomic nucleus as being connected with such a hypothetical wave train, and made intelligible to some extent the discrete character of Bohr’s “permitted” paths by the stationary character of the corresponding waves.” (Albert Einstein**,** *The Einstein Reader***,** CITADEL PRESS BOOKS**,** Kensington Publishing Corp., New York, 1956*,* p. 96.)

Thus, the wave-particle paradox was posed and began to be resolved in the minds of Plank, Einstein, and De Broglie, but it remained an enigmatic puzzle for most of the other scientists, because they did not understand the subject matter from the level of principles. Those were, for all intent and purposes, the only scientists who understood that the universe was based on universal physical principles, while the fictitious universe of the positivists and empiricists was based on sense perception, as determined by the probability of statistics.

What liberal empiricists did not understand was the poetic principle of irony, the ambiguous nature of the phenomenon of wave and particle as a unified conception. For example, the most important idea that de Broglie had discovered was not the wavelength of the electron as most people were made to believe. His most important discovery was the **“*accordance of phases*”** between the two fundamental aspects of the electron. De Broglie hypothesized that there existed between the wave and the particle a **“*harmony of phases*”** which reflected the presence of an internal clock inside of the particle, as he defined it in the first chapter of his 1924 Thesis. The singularity that was expressed by the frequency of the internal clock of the particle lay in the fact that it was the same as the frequency of the wave, but slower than the wave. The slower phase of the particle was in synchronization with the faster frequency of the wave by a margin of discrepancy that was always harmonically organized in a manner similar to the well-tempered musical system of Bach; as if it were an analog of the human voice tuned at C-256 cycles per seconds. As a result, de Broglie established the **“*law of accordance (harmony) of phases*”** which stated:

> ***"For any Galilean observer, the phase of the "internal clock" of the particle is, at each instant equal to the value of the phase of the wave calculated at the same point at which the particle lies."*** (Louis de Broglie, *The Wave-particle dualism: a tribute to Louis de Broglie on his 90th Birthday*, edited by Simon Diner, Kluwer Academic Publishers, 1982, p. 4)

The point to be made is that de Broglie's discovery was not dualism in the sense of Neils Bohr, who believed that under a certain circumstance you get a wave, and under a different circumstance you get a particle. The idea is rather that of a permanent coexistence between waves and particles. Contrary to Bohr's conception, de Broglie hypothesized that there was a true ambiguity, a unity of ambiguity whereby particles are waves at the same time, and that the wave motion is what determines all the properties of the particles. In other words, the particle and its wave phase are not two different realities. It is the **"*harmony of phases*"** which represents the crucial idea of a stable proportionality between particle and wave. When some form of dissonance breaks that harmony, a singularity is generated that changes the system. You get a quantum leap. The best understanding of what the underlying "unity of phases" represents was described by physicist George Lochak who wrote:

> "The wave-length became famous after the discovery of the diffraction of material corpuscles and thanks to the preeminent role played by Schrodinger's equation. But in fact, the forgotten law of phase harmony, which is no longer quoted in textbooks, constitutes the basis of the whole problem of wave-particle dualism and contains, in the opinion of de Broglie, the deep mystery which has to be solved in the first place if one is to understand quantum mechanics. De Broglie never considered that, in stating this law, he had given any explanation of wave-particle dualism: he only found an important formula which follows from the laws of relativity. But the question is: what property is hidden behind this formula? What is this mysterious balance between corpuscle and wave (similar to the balance between a surf-rider and the sea wave), which is expressed in the formula?" (George Lochak, in Louis de Broglie, *The Wave-particle dualism: a tribute to Louis de Broglie on his 90th Birthday*, edited by Simon Diner, Kluwer Academic Publishers, 1982, p. 4)

Lochak did not answer that fundamental question probably because it required going outside of mathematics into classical artistic composition. Indeed, think of this process as being harmonically ordered musically. Look at how the wave and particle of the electron are organized like the musical ordering between intervals and notes in a classical composition. Once you begin to think of music in terms of intervals of action as opposed to what the notes represent as particles, you are on your way to understand the mystery that lies behind or between the notes. Therefore, you must imagine that Mother Nature is playing some great symphonic composition between the particles. That is where the answer lies. So first, go back to the thought experiment that de Broglie related to in his Thesis:

> "Take a horizontal circular disk with a very large radius and append to that disk a number of identical systems formed by a spiral spring to which a weight is attached. Consider that the number of such suspended systems per unity of surface of the plate

decrease in density very rapidly as you move away from the center and in a manner such that there is a condensation of those systems around the center. All of the weight-spring systems are identical and they all have the same periodicity. If you make them oscillate with the same amplitude and the same phase, the surface going through the center of gravity of all of those weights will represent a plane that goes up and down in an alternating motion. This whole process represents a very rough analogy with the piece of isolated energy, as I have conceived of it." (Louis de Broglie, Op. Cit., p. 17.)

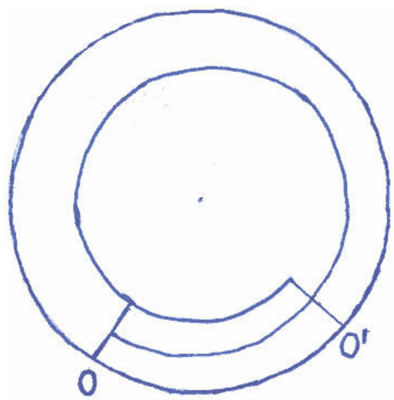


Figure 1. ***Harmony of phases*** between the particle and the wave. From the time it takes for the particle to go through the trajectory from 0 to 0^1 along the circular pathway, it is overtaken by its own wave by a full rotation of the circle, because the wave is moving along the spiral pathway at a greater velocity than the particle. (Figure by George Lochak in Louis de Broglie, *The Wave-particle dualism: a tribute to Louis de Broglie on his 90th Birthday*, edited by Simon Diner, Kluwer Academic Publishers, 1982, p. 5.)

By comparison with figure 1, do an *analysis situs* construction of a ***harmony of phases*** between particles and waves using the octave values pertaining to C-256 going through a torus. As in Figure 2, imagine that regular integers express particles and the intervals between them express waves. The internal clocks of the particles are measured by regular arithmetic intervals of one integer at a time, like 1, 2,3,4,5, etc., but the waves are measured by growing intervals which are (0)1, (1)2, (12)3, (123)4, (1234)5, etc. Arrange the two types of oscillations of the particles and the waves in such ***harmony of phases*** that all of the wave phases always end up coinciding with the particle motions, and thus, end up covering all of the empty spaces where the particles should be in a series totaling 136 waves. That is the sort of bootstrap self-propelling principle that de Broglie imagined existed inside of the atomic structure.

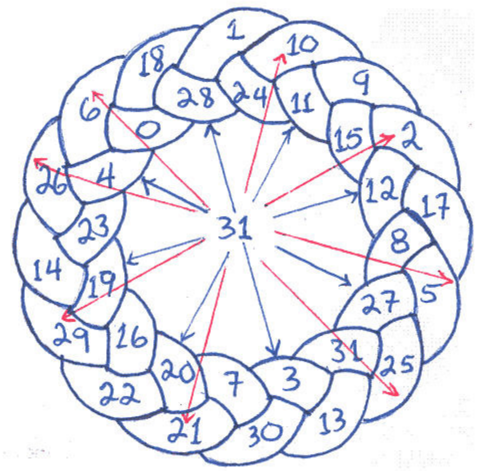


Figure 2. ***Harmony of phases*** in a torus with a Poloidal/Toroidal ratio of 3/16.

Figure 2 is not a model for de Broglie's atom. This is a heuristic device showing that by investigating a process, you can sometimes discover something else that wasn't there. And, it might turn out that what wasn't there reveals the most important aspect of the principle that underlies that process. So, how can we answer Lochak's question: "What property is hidden behind this formula? What is this mysterious balance between corpuscle and wave?" In the above example, the distribution of the waves and particles of 5 octaves shows that they are hiding a reciprocity function with the constant total of 31, and in which all of the particles are distributed into sixteen doublets of P/2 waves between each pair of reciprocals. If you rotate the entire system clockwise, you find that the following two series of reciprocities are perfectly balanced between the Outer and the Inner rims:

Inner rim	Outer rim.
0 + 31 = 31	13 + 18 = 31
28 + 3 = 31	30 + 1 = 31
24 + 7 = 31	21 + 10 = 31
11 + 20 = 31	22 + 9 = 31
15 + 16 = 31	29 + 2 = 31
12 + 19 = 31	14 + 17 = 31
8 + 23 = 31	26 + 5 = 31
27 + 4 = 31	6 + 25 = 31

2- THE FERMAT LEAST ACTION PRINCIPLE

The idea of understanding shadows is not for the purpose of enjoying entertaining sound or visual effects, but for the purpose of selecting those moments of reality that reflect ironies in a manner that the shadows reveal the presence of a universal physical principle. Then, you must identify the principle that casts such a shadow. For instance, look at the shadow of the tear that is shed by the son of Ivan the Terrible in the famous painting of Ilya Repin. What is the principle involved? The same sort of ironical process can be identified with the shadow of the particle in the wave and particle paradox of de Broglie.

With that in mind, look at the manner in which de Broglie twists and turns the question of the least action principle of Fermat in no less than seven different ways in his 1924 Doctoral Dissertation. The point that he keeps making in his 109 pages thesis (at pages 3, 18, 25, 34, 37, 61, and 107) is that the mechanical application that Maupertuis made of the least action principle is nothing but a weak shadow of the dynamics of "***phase concordance***" that Fermat had developed in his least action principle of light propagation.

The point to be made is that Maupertuis had subverted the principle of least action of Fermat, Leibniz, and Bernoulli and, instead of applying it to dynamics, he applied it to mechanics. In his discrete fashion, de Broglie generalized the principle and restored it to the dynamics of quanta and relativity. He boldly showed that the application that Maupertuis had concocted was a shadow of Fermat's principle that had so enraged Descartes and the Cartesians on the issue of the moral purpose of final causality. The Cartesians could not understand that light was following a design that God had built into it so that it "knew" what direction to take during its propagation.

I remind briefly the reader of the famous state of perplexity where Claude Clerselier, the official delegated champion of Descartes, found himself when he was confronted with the "intentionality" of the Fermat principle of light propagation. Clerselier wrote to Fermat:

> "The principle that serves as foundation for your demonstration, namely that nature always acts by way of the shortest and simplest paths, is but a moral principle, and not at all physical, which is not and could not be the cause of any effect of nature. […]
>
> This same principle must put nature in an unresolved state, not knowing what to do when she must pass a ray of light from a rarified body into a denser one. Because, I ask you, if it is true that nature must always act by the shortest and simplest pathways, since the straight line is undoubtedly both the shortest and the simplest of all, when a ray of light has to travel from a point in a rarified medium to a point in a dense medium, is it not the case that nature must hesitate, if you wish her to act by the principle of following a straight line immediately after the break, since, if the latter is the shortest in time, the other is shorter and simple in measure? Who will decide, then, and who will pronounce himself on this matter?" (*Letter of Clerselier to Fermat*, May 6, 1662.)

Thus, Clerselier could not fathom the idea that light propagation was governed by an "intention" that gave directionality to light propagation. The positivists of the early part of the twentieth century similarly could not understand that there was a built-in "phase concordance," as de Broglie called it, inside of the atom, and tried to show the difference that existed between the Fermat principle of optics and the Maupertuis mechanics. Therefore, de Broglie did the same as Fermat did by demonstrating in the concluding part of his thesis that the particle was merely the sense perception shadow of the wave function of the least action principle. As he wrote:

> "Obviously, this idea that the motion of a material point always dissimulates the propagation of a wave would require a more complete study, but, if we succeeded in giving it an entirely satisfactory form, it would represent the synthesis of a great rational beauty." (Louis de Broglie, Op. Cit., p. 107)

In de Broglie's mind, least action essentially meant the pathway of a process, or of history of a conceptual development, that must always relate reality to some principle that could not be perceived by sense perception. The action that was measured in physics was the change between the so-called energy multiplied by time, which was calculated in Joule-Seconds (J.S.), as in the case of the Planck's constant *h* representing the quantum of action. The idea to be stressed, however, is not the "quantum" in itself, but the nature of the "action." The key point being that the pathway of the action is what is being defined as the easiest, and best of all possible pathways, as Leibniz and Bernoulli had established with the discovery of the Brachistrochrone. That was an expression of the most natural and effective pathway of change in the universe.

Thus, the least action pathway had been established as a universal measure of change that mathematicians could not understand. As mathematicians tend to reduce everything to zero, the least action principle represented an insoluble paradox from the corrosion of which least action was immediately subverted and became, as Maupertuis put it, the minimum form of change as expressed by the paradoxical idea of "stationary action." Maupertuis actually designed a whole series of equations demonstrating his own failure to cope with the dynamics of real physical processes.

3- MAUPERTUIS AND THE SABOTAGE OF THE LEAST ACTION PRINCIPLE

As the foremost Newtonian in France, Pierre Louis Maupertuis (1698-1759) made several stabs at the principle of least action in a design to kill its significance and magnitude. It was the idea of final causality that Maupertuis hated the most about the principle. The reason is not difficult to understand, as Maupertuis did not believe in the anti-entropic nature of the universe. Instead, he believed in the blind hereditary nature of eugenics. He was one of the early advocates of genetic predestination and of the survival of the fittest.

The problem that de Broglie had to confront was the accommodating popularity of Maupertuis in French academic life. From about 1740 to about 1750, Maupertuis had devised a whole series of contradictory definitions for the least action principle. For example in 1741, Maupertuis defined the principle of least action as "potential energy." By 1744, a new definition of least action as "kinetic energy" was devised as an attack on Leibniz. By 1750, Maupertuis had concocted a hybrid function of least action in which he attempted to apply the principle to hard balls colliding with each other. However, in his 1744 definition, Maupertuis had established his fallacy of composition for a so-called notion of least time. He did not like the idea of light having to choose between the shortest distance and the shortest time, so, he decided to trick the least action pathway of light by having it choose a third way: the pathway of "minimum action." Here is how he argued his case against Fermat and Leibniz, that is, against light itself:

> "After meditating deeply on this topic, it occurred to me that light, upon passing from one medium to another, has to make a choice, whether to follow the path of shortest distance (the straight line) or the path of least time. But why should it prefer time over space? Light cannot travel both paths at once, yet how does it decide to take one path over another? Rather than taking either of these paths *per se*, light takes the path that offers a real advantage: *light takes the path that minimizes its action.* […]
>
> "I know the distaste that many mathematicians have for *final causes* applied to physics, a distaste that I share up to some point. I admit it is risky to introduce such elements; their use is dangerous, as shown by the errors made by Fermat and Leibniz in following them. Nevertheless, it is perhaps not the principle that is dangerous, but rather the hastiness in taking as a basic principle that which is merely a *consequence* of a basic principle.
>
> "One cannot doubt that everything is governed by a supreme Being who has imposed forces on material objects, forces that show his power, just as he has fated those objects to execute actions that demonstrate his wisdom. The harmony between these two attributes is so perfect, that undoubtedly all the effects of Nature could be derived from each one taken separately. A blind and deterministic mechanics follows the plans of a perfectly clear and free Intellect. If our spirits were sufficiently vast, we would also see the causes of all physical effects, either by studying the properties of material bodies or by studying what would most suitable for them to do." (Pierre Louis Maupertuis, *Accord between different laws of Nature that seemed incompatible,* **http://en.wikisource.org/wiki/Accord_between_different_laws_of_Nature_that_seemed_incompatible**

This not only shows Maupertuis' crass ignorance of principles, but it also demonstrates how he inspired Adam Smith in writing about the destiny of man in his *Theory of Moral Sentiments*. Smith agreed with Maupertuis that man should stay within the purview of his instincts and not get involved in the domain of final causality. Here, Maupertuis identified least action with the minimum amount of change the action of light propagation requires as the product of the mass, velocity and distance of an object in motion. While for Fermat the principle of least action was a way for nature to optimize its ability to change, it became a minimum form of action for Maupertuis. It is this minimization that led Maupertuis to believe in the paradox that the best of all possible action was finally no action at all. Later, the Maupertuis principle of least action became known as the principle of "stationary action" of LaGrange.

4-THE DIALOGUE AMONG PLANCK, EINSTEIN, AND DE BROGLIE.

Don't forget that Planck had reservations about the interpretation of "quanta" as being the natural condition of radiation. Planck did not believe that quanta were the natural state of light when it propagated, but only when it was absorbed by an object, or when it was emitted in a reflection or refraction from such objects. As Planck said, "quanta were features only of how radiation was emitted and absorbed by a surface rather than a feature of the actual light wave as it is propagated through space." (Quoted by Walter Isaacson, *Einstein: His Life and Universe, Simon & Schuster Paperbacks,* N. Y., 2007, p. 156) In other words, the quanta are the apparent moment of a kinetic clash with a wall, similar to the clash of egos in the stock market of Wall Street.

Also, as early as 1909, during his Salzburg lectures, Einstein indicated his agreement with Plank on this question, and especially on the complementarities between wave and particle. As he said: "These two structural properties simultaneously displayed by radiation should not be considered as mutually incompatible." (Albert Einstein, *On the Development of Our Views Concerning Nature and Constitution of Radiation*, Lecture in Salzburg, September 21, 1909.) De Broglie reported that this was the first time that a community of "Our Views" was publicly acknowledged between Planck's Theory of Quanta and Einstein's Theory of Relativity. However, neither Planck nor Einstein were able to solve the wave and particle paradox, and the ambiguity of the phenomenon of light remained unresolved until de Broglie tackled the difficulty after the first Solvay conference of 1911.

Interestingly, it was the assistant of Planck, Max Laue, who, in 1906, had approached Einstein and had corrected Einstein's first view of radiation. Laue told Einstein that he was wrong in considering radiation as quanta. As Laue correctly wrote to him: "This is not a characteristic of electromagnetic processes in a vacuum, but rather of the emitting or absorbing matter, and hence, radiation does not consist of light quanta as it says in section six of your first paper." (Isaacson, Op. Cit., p. 141) In fact, Einstein had made the mistake of saying that radiation "behaves thermodynamically as if it consisted of mutually independent energy quanta." (Isaacson, Op. Cit., p. 142) Lyn made the point quite clearly on this question of radiation, when he said:

> "And how do we understand cosmic radiation? Well, as a point of reference today, we refer to the de Broglie discovery and his elaboration of that: That there are no particles in the Periodic Table. There are only singularities. Are they efficient? Of course, they're efficient! But they're not efficient in the sense of atomic. They're as a product, as a reflection of the way in which the universe is organized. And you are organized; you are a particle, in a sense, even your own existence which is efficient with respect to the past of mankind in the universe, and the future of the universe. And you have to find yourself there." (Lyndon LaRouche, *National Leadership Meeting*, Saturday, June 19, 2010.)

What de Broglie had discovered was, in effect, that atomic particles were a special effect of wave dynamics that he demonstrated in collaboration of his brother Maurice through the photoelectrical effect of X rays and the corpuscular spectra of the elements. He was able to provide a synthesis of the works of Plank and Einstein in developing a notion of wave-particle duality in the sense that for every particle, there was a corresponding wave. But why was that the case? What was the causal explanation of the phenomena in opposition to probability? De Broglie wrote:

> "Having much more the state of mind of a pure theoretician than that of an experimenter or engineer, loving especially the general and philosophical view, I was drawn towards the problems of atomic physics…It was the conceptual difficulties which these problems raised; it was the mystery which surrounded that famous Planck's constant, *h,* which measures the quantum of action; it was the disturbing and badly-defined character of the dualism of waves and corpuscles, which appeared to assert itself more and more in the realms of physics…" (Louis de Broglie, http://www.vigyanprasar.gov.in/scientists/ldbroglie.htm)

The important point to understand, here, is that the quantum of action pertains to the dual nature of the metaphorical process as much as to the process of physical spacetime. It was not the particle, in and of itself, that needed to be focused on, but the dual nature of the measure of change, the singularity, that is embodied in the wave-particle behavior and of its action of being pulled by the future.

Einstein was right, of course, as some of his friends like Banesh Hoffmann who attested that all of the empiricists were destabilized by the debate that put into question the hegemonic function of little hard balls of light. As Hoffmann reported later: "They could but make the best of it, and went around with woebegone faces sadly complaining that on Mondays, Wednesdays, and Fridays, they must look upon light as a wave; on Tuesdays, Thursdays, and Saturdays, as a particle. On Sundays, they simply prayed." (Isaacson, Idem., p. 586)

What the empiricists could not understand was that the issue was one of thought experiment as inferential knowledge. So, beware of simplifications about space, or about time, because the point is not merely to replace particles by waves, or replace light and matter by wave and particle respectively, as amateur scientists like do. Here the illusion of Ockham's razor for simpletons does not cut the mustard. When you do such simplistic substitutions, you are merely reintroducing Newtonian fallacies under a new disguise. Einstein made the point when he said:

> "When forced to summarize the general theory of relativity in one sentence: Time and space and gravitation have no separate existence from matter**.** ... Physical objects are not in space, but these objects are spatially extended. In this way the concept 'empty space' loses its meaning. ... The field thus becomes an irreducible element of physical description, irreducible in the same sense as the concept of matter (particles) in the theory of Newton. ... The physical reality of space is represented by a field whose components are continuous functions of four independent variables - the co-ordinates of space and time. Since the theory of general relativity implies the representation of physical reality by a continuous field, the concept of particles or material points cannot play a fundamental part, nor can the concept of motion. The particle can only appear as a limited region in space in which the field strength or the energy density is particularly

high." (Albert Einstein, *1950*. *http://www.spaceandmotion.com/Most-Simple-Scientific-Theory-Reality.htm*)

And he corrected himself four years later by stating:

> "All these fifty years of conscious brooding have brought me no nearer to the answer to the question, 'What are light quanta?' Nowadays every Tom, Dick and Harry thinks he knows it, but he is mistaken. … I consider it quite possible that physics cannot be based on the field concept, i.e., on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics." (Albert Einstein, 1954. *http://www.spaceandmotion.com/Most-Simple-Scientific-Theory-Reality.htm*)

So, the issue is not to substitute "real wave motions of a continuously connected space of spherical standing waves" of sense-perception for Einstein's "continuous fields in physical spacetime." Beware of amateur scientists. The number one issue in physics today is not particle, wave, or field, but the role of the human mind and its relationship with historical wave motions. That is what Newtonians cannot grasp. Erwin Schrödinger also had the right approach to the subject:

> "What we observe as material bodies and forces are nothing but shapes and variations in the structure of space. Particles are just schaumkommen (appearances). ... The world is given to me only once, not one existing and one perceived. Subject and object are only one. The barrier between them cannot be said to have broken down as a result of recent experience in the physical sciences, for this barrier does not exist. ... Let me say at the outset, that in this discourse, I am opposing not a few special statements of quantum physics held today (1950s), I am opposing as it were the whole of it, I am opposing its basic views that have been shaped 25 years ago, when Max Born put forward his probability interpretation, which was accepted by almost everybody. I don't like it, and I'm sorry I ever had anything to do with it. (Erwin Schrödinger, The Interpretation of Quantum Physics, 1954. (http://www.spaceandmotion.com/Most-Simple-Scientific-Theory-Reality.htm)

The idea that a wave structure of matter could be reduced to a matter of mathematical deductions is not merely ludicrous, but outright perverse. The issue is not to explain the relationship between the ideas of mass increase in Einstein's theory of Relativity with the de Broglie wavelength as the wave property of matter, and then suddenly, pouf: $E = MC^2$.

In December of 1924, Einstein had gotten a copy of de Broglie's thesis from Langevin. He might have also read a de Broglie article on the same subject in the spring of that year. Einstein wrote to Lorenz about the discovery of de Broglie: "A younger brother of (Maurice) de Broglie has undertaken a very interesting attempt to interpret the Bohr-Summerfeld quantum rules (Paris dissertation 1924). I believe it is a first feeble ray of light on this worst of our physics enigmas. I, too, have found something which speaks for his construction." (Letter of Einstein to Lorenz, December 1924, quoted from Abraham Pais, *Subtle is the Lord: The Science and Life of Albert Einstein*, Oxford University Press, 1982, p. 348.) Then, later the following year Einstein wrote to Langevin: “Louis de Broglie’s work has greatly impressed me. He has lifted a corner of the great veil. In my work I obtain results which seem to confirm his. If you see him, please tell him how much esteem and sympathy I have for him.”

The common ground between Einstein and de Broglie was that for both physicists, matter was energy and energy was matter. As de Broglie wrote: “After long reflection in solitude and meditation, I suddenly had the idea, during the year 1923, that the discovery made by Einstein in 1905 should be generalized by extending it to all material particles and notably to electrons.” But the issue was not only the relationship of “matter to energy.” There was a more fundamental issue at hand that had to be settled once and for all, and that was the issue of indeterminacy that Bohr and Heisenberg had raised at the Solvay Congress of 1927. De Broglie agreed with Planck and Einstein that there had to be determinacy and causality in the domain of quantum mechanics, not statistical interpretations. However, the bad habit of reducing science to observations as the Bohr-Heisenberg group did, gained ascendancy at the congress over the objections of Einstein, Planck, and de Broglie.

For de Broglie also, there was no such a thing as empty space. Space was filled with radiation. As he put it in 1945 recalling his original discovery:

> “Thirty years ago, physics was divided into two camps: … physics of matter, based on the concepts of particles and atoms which were supposed to obey the laws of classical Newtonian mechanics, and the physics of radiation, based on the idea of wave propagation in a hypothetical continuous medium, the luminous and electromagnetic ether. But these two systems of physics could not remain detached from each other: they had to be united by the formation of a theory of exchanges of energy between matter and radiation …the intervention of quanta and of Planck’s constant *h*, as much in the theory of photons as in that of the quantization of the electronic movements, seemed to me to show clearly that the link between the two terms of the wave-corpuscle dualism took place through the intermediary of the quantum of action, and must in consequence be expressed mathematically with formulas in which the constant *h* would appear. This was already the case for the relations which, in the theory of the photon, expressed the energy and momentum of the corpuscle of light as a function of the frequency and of wavelength of the luminous wave, and the form of these relations gave an indication of the interaction that had to be established in the general case of any corpuscle whatever.” (http://www-groups.dcs.st-and.ac.uk/~history/Biographies/Broglie.html)

Throughout his entire carrier, de Broglie worked toward developing a causal understanding of wave dynamics in opposition to the probabilistic models that had dominated science since the Solvay conference of 1927. However, because of the tremendous opposition against him in the scientific community, he never succeeded in completing his project. The task remains unfinished and it is our responsibility to finish it, today.

<Note> De Broglie’s most important publications are: Waves and Motions (1926), Wave Mechanics (1928), Non-linear Wave Mechanics: A Causal Interpretation (1960), Introduction to the Vigier Theory of Elementary Particles (1963), and The Current Interpretation of Wave Mechanics: A Critical Study (1964). In addition to his strictly scientific work De Broglie wrote

on popular aspects of physics, and philosophy of science including the value of modern scientific discoveries. Among his popular books on physics included Matter and Light: The New Physics (1939); The Revolution in Physics (1953), Physics and Microphysics (1960) and New Perspectives in Physics (1962).

5- WHY ARTISTIC COMPOSITION MUST SUPERCEDE MATHEMATICS.

When Lyn answered the last question of his webcast on June 26, 2010, he made the crucial point of reconfirming the necessity of what he had developed years ago in answering the question: "*Why Poetry Must Supercede Mathematics in Physics*." He stated:

> "But, to understand what underlies music, you're touching on the deeper part of the human mind, not the sense-certainty organized part. That's why it's so difficult to have a formal, algebraic, or mathematical type or something like that, a formal demonstration – it's the communication of an idea. And, this is an idea that can properly only be recognized, in those characteristics of the human mind, which are not corresponding to sense-certainties. There's no sense-certainty explanation which will give you a real insight into the music, Classical music, in the Bach tradition. It's something you acquire by developing your mind, so that in this matter, you have a special kind of sensitivity." (Lyndon LaRouche, *Change is a 'comin'*, LaRouche Webcast, June 26, 2010.)

What is the point here? The point is that mathematics destroys sensitivity in science, and that is the most urgent problem to solve in scientific thinking today. We must replace mathematical equations with proportional relationships as elaborated in Nicholas of Cusa's *Docta Ignorantia*, change from mechanics to dynamics, take care of sense-perception as the clinical cripple that it is, and restore the patient to the domain of mind. So, if you take the case of de Broglie and apply his method of scientific investigation to classical artistic composition, what do you get?

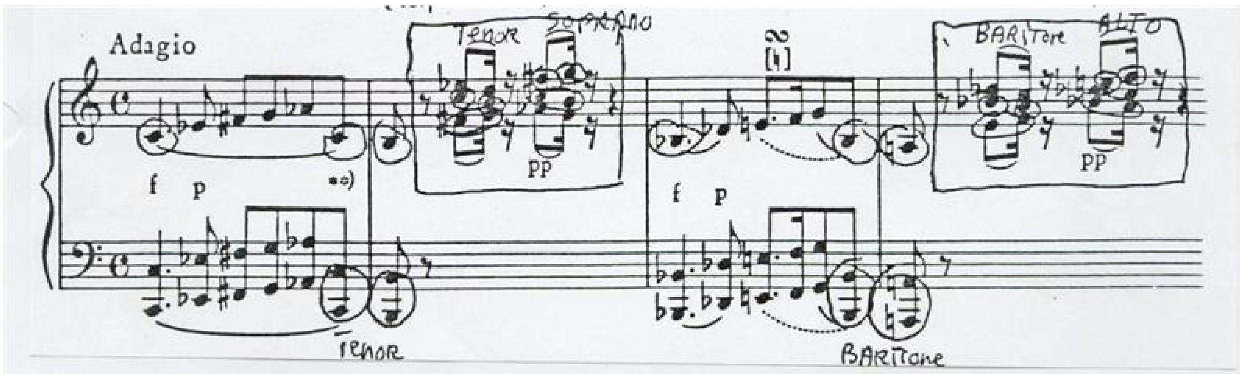
The problem that de Broglie tried to resolve was not merely the wave and particle paradox. That was the surface of the problem. That was his pretext. The underlying problem that de Broglie and other scientists had to resolve was to eliminate the difference between dynamics and mechanics. De Broglie knew that the so-called "science of mechanics" was unable to deal with the physical nature of light, and especially with the characteristic of light that wasn't there, that is, none visible X-rays or Gamma rays, for example. He knew that he could not make use of sense-perception to solve the problem he was tackling. He also knew he had to effectively use the inferential device of the metaphorical process, that is to say, the poetic principle of irony in order to solve the problem of sense-perception. What did he do? With his brother Maurice, he used the irony of the black body problem in the study of X-rays. In other words, he had to ask himself: "How else could you solve the paradox of sense perception in science if not by using the issue of blindness? How do you make people see how the mind is working while you are making a discovery of black light?"

The black body problem was a well-chosen pedagogical device, because it was a thought experiment in which a box absorbed radiation that fell upon its walls, and since no visible light was reflected, the object of reflection had the non-appearance of being black when it was cold, and when it was hot, it had the non-visible appearance of emitting heat radiation. Therefore, the experiment depended essentially on the factor of temperature to display a black body spectrum, a heat spectrum. This is what became known as Planck's Spectrum.

So, the question became: "How do you use such creative discontinuities in nature in a way that wrenches the bad habits of scientists who rely almost exclusively on sense-perception? How do you stop reducing science to the kinetic activity of self-evident little hard balls? How do you create a bridge between two invisible things: the particle and the wave?" Those were the questions that were racing through de Broglie's mind faster than the speed of light. And, the problem is the same as when a higher level of culture comes into contact with a lower level of culture. You can't solve the problem with a mathematical equation, but only with a social process such as an artistic proportionality. That's the passing tone of the new register shift that science has to execute if it wishes to survive.

Today, we have come to a turning point in science as well as in artistic composition. Both are dead. So, how do you revive them? One has to become inspiration for the other. This is where scientific experiments or discoveries must no longer be primarily demonstrated by mathematical equations, but by demonstrable proportions of classical artistic composition. The point of this shift of emphasis should be obvious to anyone who is not a mathematician. It is the creative experiment of the mind, as in musical classical composition, which must prevail in the scientific development from now on. The problem that mathematics has posed to scientific development is that it cannot show how the mind works. As a matter of fact, mathematics show how the mind fails to communicate fundamental conceptions regarding man and nature. That is the only usefulness of mathematics today, to show humility. That is the only role that mathematics should play in science today: show how the construction of equations fails to explain scientific principles.

Take the musical example that Lyn often refers to, that is, the J. S. Bach Ricercare theme of his *Musical Offering*, and use that as a compositional demonstration of the process of discovery that de Broglie made with his idea of ***harmony of phases*** between the wave and the particle. Forget number theory! Forget mathematical equations! Think only of proportionality between old friends who created new variations on the theme of Bach, such as Mozart, Beethoven, and Brahms, and compare that series of creative advances with the wave and particle paradox of de Broglie. Think of the dialogue of de Broglie with Plank and Einstein, and look at the task they all had of recreating, each in their own ways, the least action principle of Fermat for modern science. Historically speaking, you have a transformation which beckons a comparison between a phase change that occurs inside of an atom and a phase change which occurs inside of a classical artistic composition. What do they have in common?



FIRST 4 MEASURES OF MOZART 'S FANTASY IN C- 475
FIGURE 25.

MEASURES 161 – 164 OF MOZART'S FANTASY SONATA - 475.

Figure 3. Mozart Fantasy Sonata K. 475. The measures reflecting the three underlying Lydian spiral actions of the six human voices.

Play on the piano the measures of the Mozart Fantasy Sonata K. 475 that I have identified in Figure 2, and listen closely for the occurrence of dissonant singularities. In those eight measures, you hear an echo of the Bach Musical Offering in a form that identifies three underlying spiral action going up and down, one for Tenor and Soprano voices and the other for Baritone and Alto voices and a third for the Contralto and the Base voices. Note that measure 1 begins with middle C and ends with the same middle C. This would sound normal, if the intention of C were to resolve itself back to C, but it does not. The process results in a change that introduces dissonant intervals between each of the two measures1-2, 3-4, 161-162, and 163-164. These are the dissonant singularities of all of the six voices taken two by two. The dissonances of those four singularities are resolved in measures 2, 4, 62 and 64. Thus, Mozart identified the Lydian modality of change as an echo of Bach for resolving singularities in an interchange among all six human voices, a sort of musical road map for register changes among all of the six human voices.

Therefore, you must think of the Mozart Sonata as a compositional dialogue with Bach's mind based on the idea of change expressed by the intention of all of the six human voices taken two by two, and as occurring not in the notes as particles, but in the intervals of musical action overtaking the notes as spiral waves overtake particles in De Broglie's ***harmony of phases***. What is developed is a self-generating process in which the particles are overtaken by their own waves pulling them toward a future resolution, like the waves that pulled Columbus toward America in the pursuit of happiness. They are the same type of proportional self-generating motion.

Those measures show the thematic creative material that Mozart transformed from the Ricercare theme of the Bach *Musical Offering.* They indicate how only three types of spiral actions cover the entire range of the well-tempered system, the six human voices, and the 24 key signatures. I have identified in Figures 3, 4, and 5, those three spiral actions. Each spiral shows how the Mozart ***harmony of phases*** is based on the underlying Lydian divisions of the octaves by half, and by half of the half, again, generating all minor thirds. When you listen to them in a variety of combinations, those divisions cause dissonances that require a resolution.

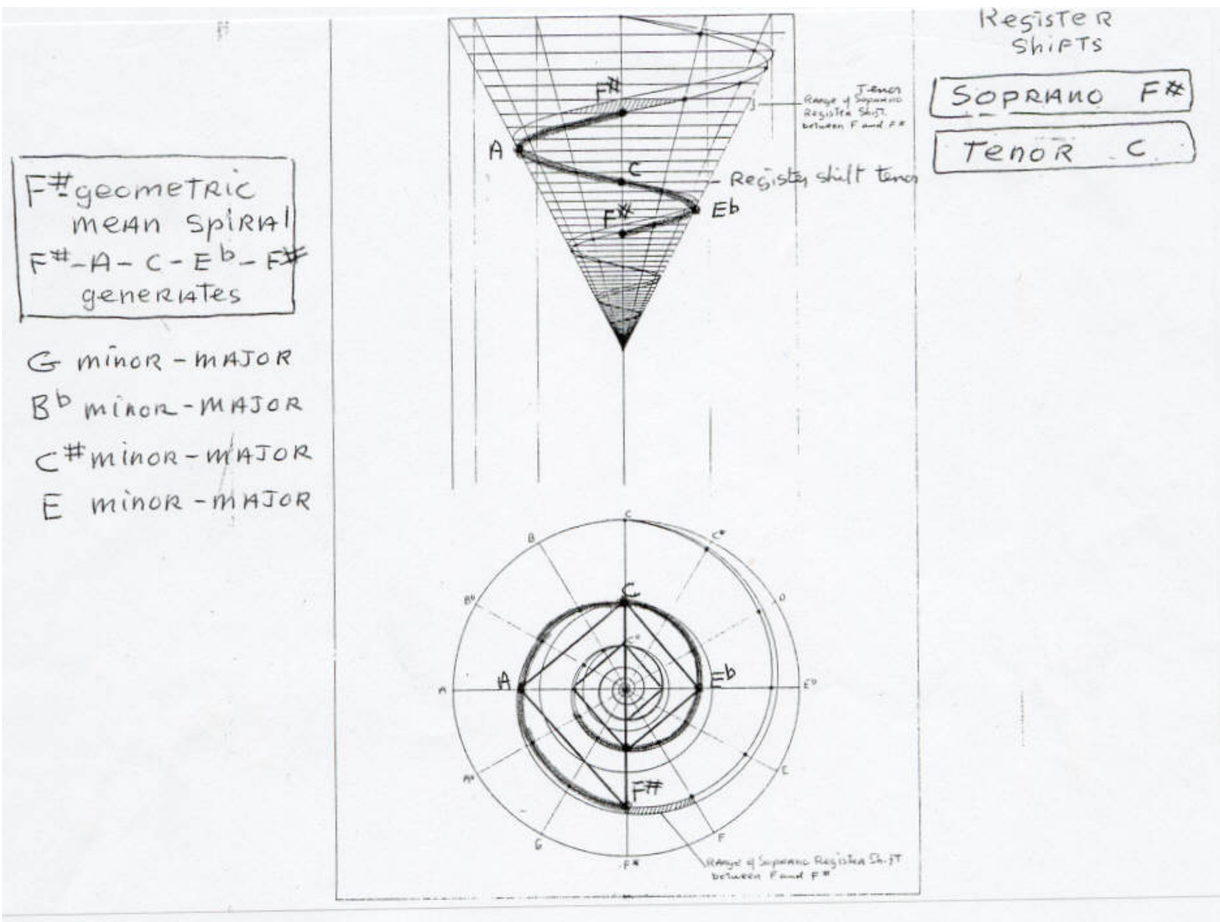


FIGURE 22. GEOMETRIC MEAN SPIRAL OF F #

Figure 4. The Lydian spiral action of four intervals between F#, A, C, E flat, F#.

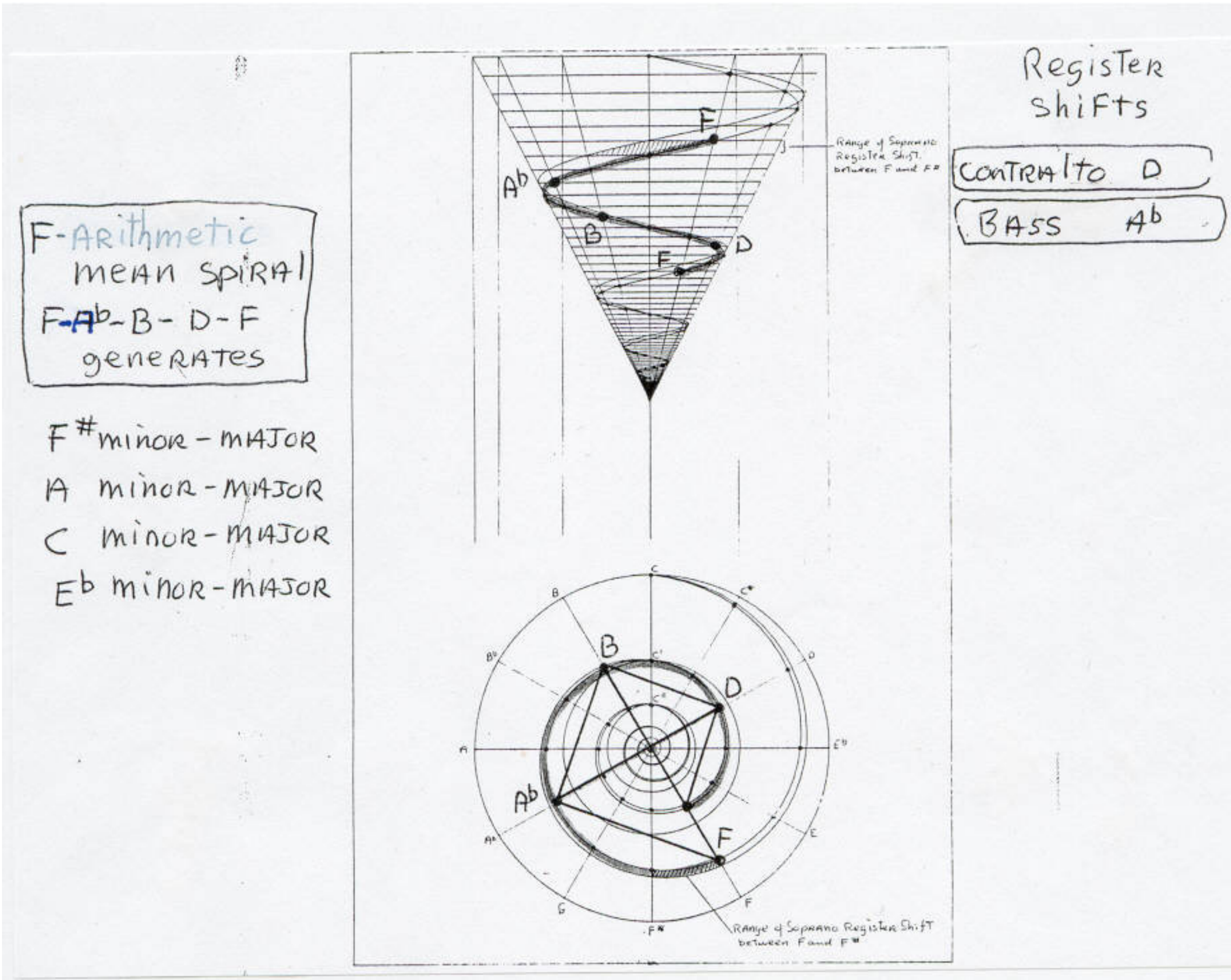


FIGURE 23. THE HARMONIC MEAN SPIRAL OF F.

Figure 5. The Lydian spiral action of four intervals between F, A flat, B, D, F.

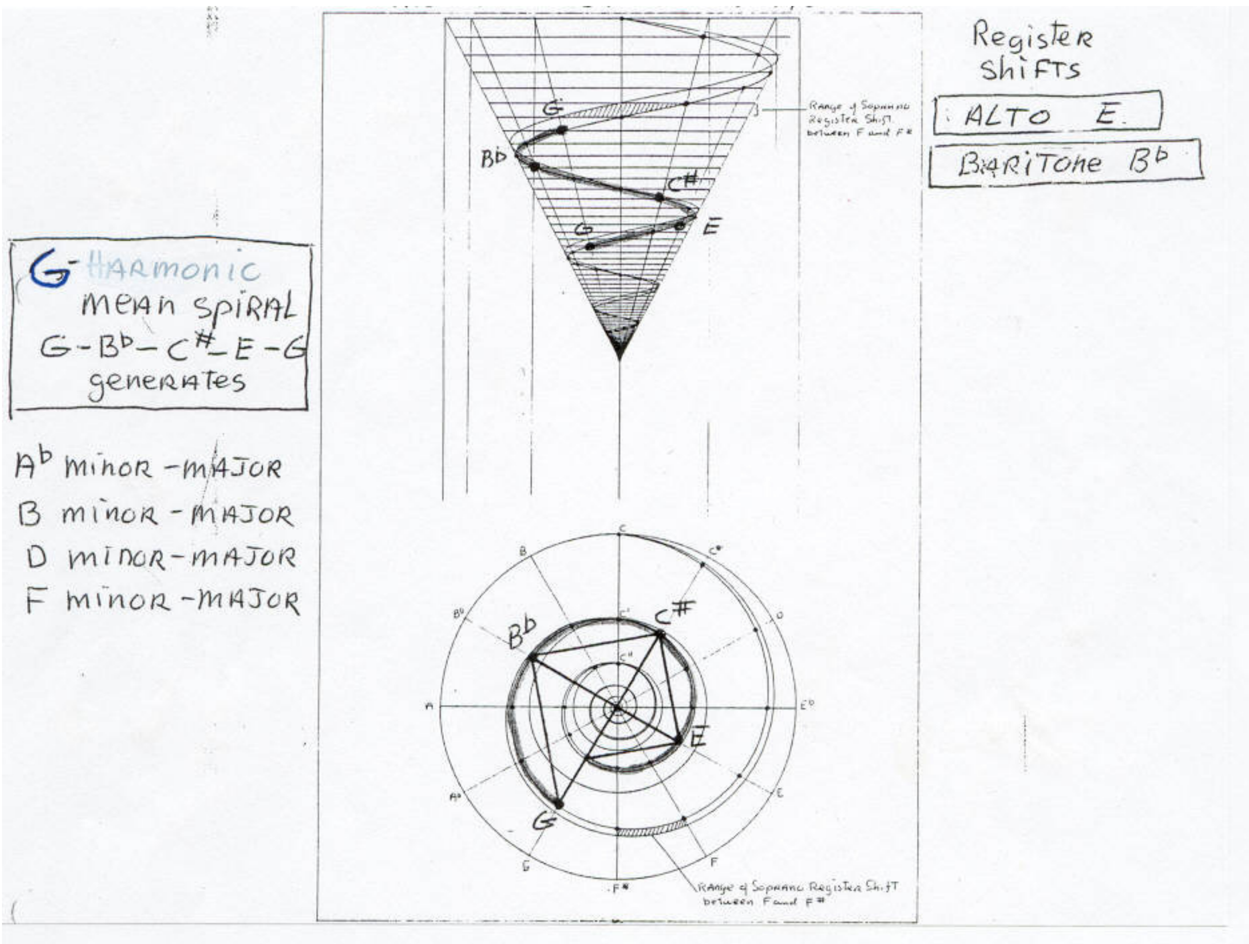


FIGURE 24.THE ARITHMETIC MEAN SPIRAL OF G.

Figure 6. The Lydian spiral action of four intervals between G, B flat, C#, E, G.

These three Lydian minor third spiral actions represent the augmented or diminished intervals that Mozart used for key changes and voice register changes inside of his Fantasy Sonata. By identifying those Lydian intervals, Mozart was showing how the process of change occurred in his own mind as if lawfully from in between the notes. Those three sets of minor third mean actions represent the fundamental underlying process of proportionality developing all of the minor and major keys of the well-tempered musical system. Those Mozart phase changes are similar to the changes in the ***harmony of phases*** that de Broglie discovered as a solution to the wave and particle paradox. They are the sort of ***harmony of phases*** that bring congruence between science and classical artistic composition. That is the reason why, whatever falls intside of this ordering of Lydian causal determination must be considered as the only legitimate form of classical artistic combination, just like the proper frequencies that Einstein had identified in the stationary waves of de Broglie were the only "permitted" pathways of the atomic nucleus wave train.

However, the visual appearance of the spiral action doesn't tell you anything about the dissonances in the harmony of changes, and what their intentions are. Here, vision is of no help whatsoever without the benefit of hearing. Moreover, you must listen to this action with the inner ear of your mind. And, the more you familiarize your mind with hearing the action of these three spirals, and only those three and their variations, the more you will be able to compose singularities of the Lydian modality, in science as well as in artistic composition, but only if and when a dissonance of the wave action pulls your mind forward into a higher resolution.

CONCLUSION

In conclusion, it becomes clear that the true meaning of the least action principle of Fermat, as restored to modern physics by de Broglie, is that it truly expresses a universal concordance in the ***harmony of phases*** between wave and particle by unifying both the Theory of Quanta and the Theory of Relativity. In that sense, the harmonic ordering of de Broglie is in tune with Kepler's *Harmony of the World,* and with Cusa's sense of proportionality that he developed in *Learned Ignorance*. From that historical perspective, de Broglie represents a major step forward for human knowledge as a whole. The tragedy, however, is that the empiricists have imposed their statistical agenda on science since the end of the Solvay Conferences; and from that moment on, the axiomatic significance of the ***harmony of phases*** and the idea that it was a product of physical ***spacetimereversal*** were lost to humanity. Therefore, this crucial de Broglie idea must be recovered urgently, because there won't be any future without it.

The problem of this momentary slowdown was essentially caused by a lack of courage on the part of the scientists themselves. Science has been misdirected after the Solvay Conferences because scientists were unable, or unwilling, to define mankind's intention of mastering the universe. It was that very moral intention that Clerselier and Maupertuis objected to regarding Fermat's principle of least action. Both of them rejected the idea that the intention of nature applied universally. The light of that intention began to shine again in modern science with the first investigations into cosmic radiation by Mendeleev and Vernadsky, and then it grew brighter with Plank, Einstein and de Broglie. But, again, the intention was killed because it was objected to, essentially, by British liberalism and positivism.

The point that must now be made is that unless the intention of where mankind wants to go is everywhere clearly stated and defended, that is to say, unless you have a "mission-intention" oriented toward a future objective, as in the case of the Moon-Mars mission, you will not be pulled by the future. As is the case of a Soprano intending to break through the voice register barrier for the purpose of mastering the interval of action that leads to a high C, so it is for the internal dynamics of an electron that is being pulled from the future by its own wave. The same process applies to all dynamic processes in the universe. It was the very nature of this intention that underlied the challenge of de Broglie in his discovery of ***harmony of phases*** in the domain of cosmic radiation, and that is why Lyn had ironically and poetically identified the process as the process of the "wavicle."

FIN