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## SECOND SCIENTIFIC REVOLUTION

### Aether and dogmatic thinking

In Newton's Model Physics found a rigorous representation of Gravity, which ruled unchallenged for centuries and even currently continues to be the most pertinent approximation for low speeds and weak Field areas.

Optics, on the contrary, lacked a consistent theory and accumulated without cease new problems and difficulties. As we said above ("FIRST SCIENTIFIC REVOLUTION"), physicists abandoned the corpuscular theory of light replacing it with wave theory, without, unfortunately, renouncing the dogma of mechanistic cosmos. Following this dogma, they founded Optics in a supreme noumenal crutch, in a hypothetical corpuscular "substance" called Aether. It has been conceived by analogy with well known wave phenomena such as sound whose propagation is supported by discrete media, by oscillating particles of corpuscular fluids - gases or liquids.

Light manifesting however, essentially different behavior than sound, like propagating through vacuum, the theory started with severe problems whose apparent solutions created other, still more complex ones, reaching the apogee after the discovery of electro-magnetic field by Maxwell. The complexity of mathematics trying obstinately to save the purely a priori noumenal crutch, surpassed that of most known theories. Aether was probably the largest waste of effort and ingenuity in the history of science which shows how dangerous it is to found scientific theories in a priori metaphysical beliefs

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such as the mechanistic dogma.

This seems to be a crucial lesson for us living in an epoch ruled increasingly by irrational beliefs, torn by religious, chauvinistic wars and genocides, where dogmatism is gaining all social domains including established science and education, where exorcists graduating from the Pontifical Regina Apostolorum University of Vatican, together with other Creationists and Intelligent Designists infiltrate "scientific education" and start talking about resurrecting geocentric cosmology founded in sacrosanct verbatim interpretation of Genesis. Amidst this deluge of aggressive Dogmatism, the souvenir of Aether mishaps may help to save at least the Rationality of Science.

As the Aether theory has been irremediably scrapped, we shall just mention some of its principal problems without entering into details of involved complex mathematics.

Light propagates through vacuum and "matter" such as glass or water, thus the whole cosmic space must be filled by Aether, whether the apparent vacuum or "material substances". Mechanistic view suggests that Aether should present resistance to movements of stellar bodies. but no such effect has been observed and they keep on moving undisturbed through interstellar space.

So, Aether had to be retackled to make it interact with light but not with "matter". Mathematic difficulties apart, how could such a "substance" be reconciled with mechanistic view, is a mystery. Apparently, the Olympus of a priori allows to stretch any point to make it fit any dogmatic construct.

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Anyway, all these efforts were in vain: going through glass or water light changes speed, so Aether has to interact with "matter".

New mathematical crutches reached hardly ever equaled complexity having to take care of an additional difficulty, namely polarization requiring transverse light waves. Those require in turn the propagating medium to behave as a solid.

So one had to deal with a "substance" which behaves like a solid with respect to light, like no-interaction vacuum with respect to "matter" of stellar bodies, while interacting with "matter" which it permeates like glass or water in a way to modify the speed of light waves in function of their length. Mathematical problems apart, the pile of contradictions involved by such "substance" should have indicated its aberration, but one would shirk nothing to save a dogmatic belief: mathematical acrobatics described a "substance" vacuum-like at macroscopic sizes, solid-like at ultramicroscopic sizes, sometimes interacting with "matter" and sometimes not.

It could be expected that Maxwell's definition of light being a particular case of electro-magnetic Field propagating at the speed  $C$ , would sound the knell of Aether phantasm. Especially, considering that Galilean Relativity banning absolute speed and privileged referentials, required this  $C$  to be the same in all IR's (Inertial Referentials). But the mechanistic dogma was too strong and rather than call it in question, physicists sacrificed on its altar the very base of their contemporary physics, the Galilean Relativity.

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Aether became a universal, ABSOLUTE, absolutely immobile referential, in which light moves at  $C$ .

Strangely enough nobody noticed, or at least nobody mentioned that mechanics being at the time defined and covariant exclusively in IR's, it was illegal to apply mechanistic principles to the absolute Aether, nor that all other IR's became absolute by virtue of their relations to Aether, thus making Physics universally unfounded and undefined.

Be it as it may, light was supposed to move in other referentials, for instance at Earth, at speed  $C_e = C + V_e$ , where:

$C_e$  is speed of light with respect to Earth,

$V_e$  is speed of Earth with respect to Aether.

This assumption called for empiric verification:  $C_e$  measured as different from  $C$  would confirm the existence of Aether and determine the ABSOLUTE speed of Earth with respect to ABSOLUTELY immobile Aether.

However, the Michelson-Morley experiment proved that light moved with respect to Earth at Maxwell's speed  $C$ , thus refuting the hypothesis of universal, absolute and absolutely immobile Aether.

With unbelievable obstination some physicists made last superhuman efforts to save the mechanistic dogma by restructuring Aether so that it would be "dragged" by stellar bodies thus moving in their vicinity at their speed. However, this hypothesis would involve  $C$  depending of the speed of light source which was experimentally refuted and Aether finally died taking with it into the grave the metaphysical mechanistic dogmatism.

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This critique of the Aether Model may look rather severe, but it may by no means be interpreted as looking down on Planck, Maxwell, Lorentz and other great physicists who argued for it with ingenuity surpassing most other scientific endeavors.

It is meant to emphasize the dangers of founding theories dogmatically in a priori metaphysical beliefs, actually more serious for socio-political than for physical theories. For physics such dangers are, after all, restricted to science. For socio-political domain dealing with demography, ecology, religious and ethnic fundamentalism, globalized economy, politics and warfare, they cast doubt upon the very survival of the mankind.

## EINSTEIN AND EXTENDED RELATIVITY

The Extended Relativity (ER) may be seen as a super-model realized in two steps - the Special and the General Relativity.

Derivation and internals of ER are shown in Tome 2. Here we shall look at it from outside, from the epistemological point of view concerning its context, foundations and impact.

The impact of ER exceeds even that of Heliocentrism and Evolution. Besides similarly revolutionizing the Weltanschauung, ER brought about a wholly new reason, by radically dissociating rationality, and science from the "common sense" and by founding it in the basic structure of the human Universe - in the Continuum/Discreteness (CD) polarity.

If by its impact ER is the most important contemporary model,

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it stands alone by the simplicity of its epistemological foundations. We shall review them in two sections referring to Special and General Relativity, preceded by a brief overview of their context.

## CONTEXT

The Michelson-Morley experiment sounded the knell of Mechanistic Dogmatism and of the Aether's phantasm. Physics, deprived of foundations lost momentarily its essential meaning. However, the void was not complete. Aether left in its ruins some most ingenious recipes hanging for the moment in emptiness, but ready for constructive use, once some firm ground reestablished. To mention two of them:

1. Maxwell described the structure of electromagnetic Field, has shown that light is electromagnetic wave and determined analytically its speed  $C$  getting exact agreement with empiric data. But speed with respect to what?

Apparently, to Aether, the unique absolute, omnipresent Referential, even if such absolute Referential wrecks Galilean Relativity. But it was Aether that got wrecked by the Michelson-Morley experiment.

2. Lorentz conceived an ingenious recipe, the Lorentz Transformation (L-Tr) which replaced Galilean Transformation and supported the invariance of  $C$  in Aether's context. It was the last attempt to save the Aether and failing it the L-Tr lost its physical foundation and sense.

In the meantime Mathematics made great progress. Rieman and Lobatshevski conceived parabolic and hyperbolic SPACES,

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Levi-Civita developed Tensor Calculus, which allowed to define metrics of non-Euclidean SPACES, to deal with their curved coordinates and to formulate physical laws in covariant form.

## SPECIAL RELATIVITY (SR)

In this context, unlike other physicists, who tried to mend their collapsed dogmatic crutches, Einstein dared to throw them away and to set out walking by himself. We shall try to retrace some of his most eventful walks.

After the collapse of Aether and of the mechanistic Dogma, Physics found itself devoid of foundations and lacking a Model capable to represent Electromagnetism and Light. The astounding effectivity of Newton's Model and Galilean Relativity in representing mechanics from local to cosmic scale pleaded for extending them over Electromagnetism and creating an "Extended Relativity" (ER) rather than starting all from the scratch.

This extension posed two essential problems:

1. With Aether Physics has lost the support of Field and was left with two apparently disparate and unrelated Continua, Field and SPACE. One had therefore to look for some way of reconciling them. Field being a factual construct and SPACE an abstraction, first to reexamine was Newtonian SPACE, by virtue of the Principle of Preponderance of Facts. The first step consisted therefore in researching some new SPACE capable of founding a Model supporting in IRs the covariance of Electromagnetism alongside with that of Mechanics.

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2. Incompatibility of the Galilean Transformation with invariance of  $C$  in IRs. We have seen above that, trying vainly to save Aether, Lorentz conceived his famous L-Tr which supports the invariance of  $C$ . However, deprived of foundation after Aether's collapse L-Tr stayed an ingenious mathematical construct void of physical sense.

Consequently the new SPACE of the SR, besides reconciling itself with Field has to support a Transformation similar to the L-Tr, or if possible identical with it.

Derivation of SR and of its underlying SPACE is described with mathematical details requiring basic knowledge of Tensor Calculus in the Tome 2, Here, we shall concentrate on the intuitive creativity in Einstein's train of thought, limiting mathematical tools to the Theorem of Pitagoras and recalling that L-Tr postulates that for an IR moving with respect to an observer, time appears to the observer to slow down and length of physical bodies to shrink in the direction of the movement.

## Quadratic Form of Euclidean SPACE

Let's recall the concept of Elementary Displacement in the Euclidean SPACE of the Galilean Relativity.

Let  $RR: 0, X_1, X_2, X_3$  be an IR with center in 0 and orthogonal coordinates  $X_1, X_2, X_3$ . For a point distant from 0 by Elementary Displacement  $dS$  we have by virtue of the Theorem of Pitagoras:

$$dS^2 = dX_1^2 + dX_2^2 + dX_3^2$$

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Now, let  $rr: o, x_1, x_2, x_3$  be another IR with axes  $x_1, x_2, x_3$  respectively parallel to  $X_1, X_2, X_3$ , moving with respect to RR in direction  $X_1/x_1$  at speed  $V$ .

As distance is Invariant under Galilean Transformation,  $dX_1$  transforms from RR to  $rr$  invariantly:  $dx_1 = dX_1$ .

Axes  $x_2, x_3$  are not affected by the movement:

$$dx_2 = dX_2, \quad dx_3 = dX_3$$

and finally:

$$ds^2 = dx_1^2 + dx_2^2 + dx_3^2 = dX_1^2 + dX_2^2 + dX_3^2 = dS^2$$

$ds^2 = dS^2$ :  $dS$  is invariant under Galilean Transformation.

We shall call  $dS^2 = dX_1^2 + dX_2^2 + dX_3^2$  the "Characteristic Quadratic Form" of Euclidean SPACE and note that

QUADRATIC FORM OF EUCLIDEAN SPACE IS INVARIANT UNDER THE GALILEAN TRANSFORMATION.

## Derivation of the Quadratic Form of SR SPACE

Derivation of SR Model boils down to research of an invariant Quadratic Form characterizing a SPACE which would replace Galilean Transformation with one supporting invariance of  $C$ , if possible, with the already existing Lorentz Transformation.

Let  $RR: 0, X_1, X_2, X_3, T$  and  $rr: o, x_1, x_2, x_3, t$  be two IRs, moving relatively at subluminal  $V$ . at  $t=T=0$  both referentials coincide spacially and  $O$  of RR emits a light signal propagating as a sphere. After elementary time increment  $dT$   $O$  will find itself in the center of light sphere of radius  $dR = CdT$ .

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By virtue of the Pitagoras Theorem for each point of the sphere we have:

$$\begin{aligned} dR^2 &= dX1^2 + dX2^2 + dX3^2 \quad \text{or} \\ (CdT)^2 &= dX1^2 + dX2^2 + dX3^2 \end{aligned} \quad [1]$$

Now, due to the invariance of C, o of rr will find itself also in the center of light sphere:

$$(Cdt)^2 = dx1^2 + dx2^2 + dx3^2 \quad [2]$$

Transferring CdT and Cdt to the right hand side of [1],[2]

$$\begin{aligned} dX1^2 + dX2^2 + dX3^2 - (CdT)^2 &= \\ dx1^2 + dx2^2 + dx3^2 - (Cdt)^2 &= 0 \end{aligned}$$

In order to maintain notation similar to that of the Euclidean Quadratic Form we shall write " $-(CdT)^2$ " as " $X4^2$ " and " $-(Cdt)^2$ " as " $x4^2$ " and say that the Quadratic Form of the SR SPACE is invariantly equal zero:

$$\begin{aligned} dS^2 &= dX1^2 + dX2^2 + dX3^2 + dX4^2 = \\ ds^2 &= dx1^2 + dx2^2 + dx3^2 + dx4^2 = 0 \end{aligned} \quad [3]$$

[3] defines the 4 dimensional SR SPACE having 3 real coordinates  $x1, 2, 3$  and one imaginary  $x4 = \sqrt{-(Cdt)^2} = iCdt$  or LightTime (LT) (where  $i = \sqrt{-1}$ ).

Expressing these coordinates in units we get the "signature" of this SPACE: 1,1,1,i

SPACE of this signature is known as Minkowski SPACE (M-SPACE).

Let's note that M-SPACE is Metric as its all 4 dimensions including LT have the measure of distance. Thus it transforms covariantly in all 4 dimensions. In other terms SR SPACE, unlike the absolute Newtonian, is relative, being covariant under L-Tr (anticipation of Tome 2).

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In particular, covariance of  $x_4 = -iCt$ , with invariant  $C$  implies covariance and relativity of time.

Now, a transformation may consist of translation, rotation or a combination of both. We have seen that translation would make  $C$  depending on the relative speed of source and observer, so it's excluded by the Axiom of  $C$  invariance and we are left with rotation: for  $rr$  moving along  $x_1$ , the transformation amounts to rotation in the plane  $x_1/x_4$  (or  $x_1/iCdt$ ).  $x_4$  being imaginary, the plane is complex and the rotation is called "pseudo-rotation". As shown in Tome 2, this pseudo-rotation is equivalent with Lorentz Transformation.

SR is therefore sometimes called "Rotational Relativity" as contrasted with the Galilean "Translational Relativity".

SR marked the demise of dogmatic, noumenalistic science and philosophy laying down the outset of axiomatic, rational science and rational ontology. We shall return to its philosophical impact in conclusions of this chapter, after having reviewed the General Relativity. Now we shall briefly recollect some essential findings and restrictions of SR. ("V" will mean the speed of observed referential relatively to the observer.)

### Findings:

1. Phenomenal nature of Field observable as Force it exerts on detectors.
2. Phenomenal Equivalence of Field and SPACE resulting from dropping all physical supports of Field else than SPACE itself.

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3. Phenomenal nature of SPACE; corollary of 2 and subject of covariant transformations

4. Distance contraction and Time dilation increasing with  $V$ .

5. Phenomenal Equivalence of Mass and Energy ( $E=MC^2$ )

6. Increase of Mass (and Energy, corollary of 5.) with  $V$ .

7. Phenomenal Equivalence of Field, Energy (and Mass, corollary of 5).

Comment of 5. In the postface of Tome 2 "DERIVATION OF  $E=MC^2$ " we say:

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$E=MC^2$  illustrates the P-Equivalence of Mass and Energy. This simple statement has surprisingly deep implications.

Indeed, Mass and Energy have no phenomenal sense and are just coefficients in formulas representing phenomenal, observable construct "Field". Under the disguise of pure abstractions  $E=MC^2$  implies P-Equivalence of Electro-Magnetism and the fields constructing subatomic particles. A decaying particle converts involved quantity of a strong field to enormous amount of radiation weaker by factor  $C^2$ .

Seen from Special Relativity,  $E=MC^2$  appears as anticipation not only of the General Relativity, but also of the Quantum Field Theory.

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## Restrictions:

The French call SR "La Relativite Restreinte" (Restricted Relativity), which describes it quite well: SR, while extended over electromagnetism, maintains the Galilean restriction to inertial referentials (IRs).

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Yet, no strictly inertial referential has ever been observed and the observable cosmos seems to consist exclusively of NIRs (Non Inertial Referentials). True, many can be approximated as IRs and SR is an acceptable approximate model of a vast range of phenomena. Nevertheless, as one could not a priori except the possibility of some other phenomena, incompatible with IRs, it appeared vital to extend the SR over NIRs, i.e. over the total observable cosmos.

We shall now review this extension known as the General Relativity.

## GENERAL RELATIVITY (GR)

It may be said that the more complex a Model is in detail, the simpler are its foundations. GR is founded on three astoundingly simple principles: The Covering Principle, Reducibility to SR and Axiom of Equivalence.

-Covering Principle: For the first time in history an ontological principle is used directly as an axiom of a physical model. We defined it in "NATURAL MODEL" as the general principle of discrete events measuring the SPACE continuum. For physics it boils down to the requirement of measuring distance with physical rods complying with physical rules, such as the Lorentz Contraction.

-Reducibility to SR: Just as SR is an extension of Newton's Model and reduces to it for slow speeds, GR was postulated as an extension of SR reducible to it locally for weak Field areas of NIRs.

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-Axiom of Equivalence: Since Galileo's Experiment, inertial and gravitational mass were known to be equal, but it has been attributed to coincidence. Einstein elevated this equality to identity, improperly called "Equivalence". Using "masses" shortcuts it means that gravitational and inertial fields are indistinguishable from inside of a system. It extends over gravity the GR initially derived for inertial field (see "ROTATING DISK" below).

Never a deeper scientific, intellectual and philosophical revolution has been founded on simpler Postulates.

## ROTATING DISK

The actual derivation was just as simple as the Postulate: it boils down to a simple mental experiment known as "Rotating Disk" which we describe here very superficially. (Details in Tome 2).

Given on a stationary and rotating disk circles of radius  $R$  and circumference  $S$ , Euclidean Geometry tells us that on the stationary disk  $S=2\pi R$ . On the Rotating Disk we'll measure  $R$  and  $S$  with elementary physical rods ("Einstein's Covering Principle"). Along  $R$  the rods perpendicular to the rotation are not affected by it and  $R$  conserves its Euclidean length. However, upon  $S$  they move in rotation sense and experience the Lorentz Contraction by virtue of Reducibility to SR. Thus rotating  $S$  will need more contracted rods to be covered than in Euclidean SPACE and its length will be measured as longer. On the Rotating Disk we have  $S > 2\pi R$ . This defines Lobachevsky or hyperbolic curved SPACE and indicates that rotation determines geometry and SPACE.

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And that's it, GR is derived.

There follows the extension to gravity via the Equivalence Postulate and a lot of most complex mathematical expressions, but it all rests on the simple "Rotating Disk". The most complex theory rests on the simplest mental experiment.

## FIELD AND SPACE

The NIR "Rotating Disk" suggests that rotation determines SPACE. However, Relativity tells us that if NIR rotates with respect to IR, then reciprocally, IR rotates with respect to NIR. And yet, IR's geometry is Euclidean. In other terms the old Galilean definition of IR based upon relative movement is no more sufficient and we have to look for some other criterion to distinguish IRs and NIRs.

Now, a detector placed on the circumference S of the Rotating Disk experiences centrifugal force directed towards disk's exterior: our NIR is a seat of inertial field. On the contrary, a detector placed in IR will detect no centrifugal force and no inertial field.

## REDEFINITION OF IR AND NIR

Thus Inertial Field is the essential difference between IRs and NIRs and SPACE is determined by inertial field engendered by rotation rather than by rotation itself. As, by virtue of the Equivalence Principle, inertial and gravitational fields are equivalent we may consider field (indiscriminately inertial or gravitational), as the criterion allowing to distinguish between IRs and NIRs.

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Finally, we may formulate the relation between field and SPACE as follows:

-Field determines SPACE, whose curvature increases with field's strength.

-SPACE determines field's strength, which increases with SPACE curvature.

This mutual, reciprocal determination of SPACE and field solves Newton's SPACE-Field Paradox: Newtonian field was determined by distance (SPACE), but had no impact on SPACE, which contradicts the Action-Reaction Principle. Einstein considered solving this Paradox as the most gratifying of his achievements because he admired and venerated Newton as his Master.

## A FEW WORDS ON NON-EUCLIDEAN SPACES

We are all familiar with " $S = 2 \pi R$ " in the "flat" Euclidean SPACE.

The " $S < 2 \pi R$ " of Riemann or parabolic SPACE may be easily visualized and verified with pieces of string and circles drawn on any sphere.

Euclidean SPACE may be considered as a limit case of Riemannian sphere getting "infinitely large", its radius tending to infinity and the curvature of the increasing sphere tending towards zero, or "flatness", giving " $S=2 \pi R$ ".

Hyperbolic SPACE may be imagined as going past this limit, where our surface gets "superflat", or its curvature gets negative, giving " $S>2\pi R$ ".

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## PHILOSOPHICAL IMPLICATIONS OF EXTENDED RELATIVITY

SR marked the demise of dogmatic and the outset of axiomatic, rational and falsifiable Science. One may object that its predecessor, the Aether Theory was already an Axiomatic Theory founded on the Axiom of Aether.

It's true enough, but let's keep in mind that, besides its own "intrinsic" Axioms, a Theory has usually other, "external" foundations. When founded on an external Theory, it accepts the external assertions as its own Axioms. Intrinsic Axioms of the founded Theory must be compatible with the external assertions and often, as in the case of the Aether Theory, instantiate them.

Now, the Aether Theory, as the whole pre-Einsteinian Physics, was founded on dogmatic belief that Physics deals directly with transcendental, noumenalistic "Reality", having the mechanistic structure of "billiard balls". Light has been considered as wave and in mechanistic world waves must have some corpuscular fluid support, like air or water. Light propagating through vacuum as well as through transparent "matter", its mechanistic fluid support had to be universally present. Hence the Axiom of Aether, a universal mechanistic support of light, which was not only compatible with the metaphysical mechanistic Dogma, but actually instantiated it.

Consequently, Aether was a very particular concept, Axiom and Dogma at the same time.

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It was an Axiom within the Aether Theory, an ultimate premise of a perfectly legitimate inferential structure exposed to inductive verification / falsification. Yet, it was also an instance of the mechanistic Dogma. As Axiom it has been falsified by the MM Experiment, but as Dogma it opposed unusual resistance to refutation. Greatest scientists endeavored to save it at the cost of superhuman efforts. Lorentz for instance derived his famous L-Tr, a mathematical construct compatible with the invariance of C. However, it was void of physical sense in the mechanistic Newtonian SPACE, affine in space/time planes, thus ignoring in them the notion of distance and, consequently, of any transformation. Facts contradicted Aether, but Lorentz believed in it and endeavored to save it at any price.

One recalls Hegel who, informed that observations contradict his astronomical a priori drivel, that facts disagree with his speculations, answered: "So much the worse for the facts".

However, Lorentz was not a conceited metaphysical preacher, but a great sincere scientist trapped in the universal belief in the apparently necessary Foundation of Physics, the transcendental mechanistic view.

It shows how deeply rooted and how difficult to eradicate is a Dogma, once it takes over a domain of human cognition.

It stresses also the courage it took to get rid of the Dogma with all involved crutches and to set out walking by oneself over the swampy land lacking any founding bedrock.

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Physics deprived of mechanistic foundation seemed to hang in the air; light waves propagating without support defied the reason.

In that situation Einstein conceived new foundation of Physics providing the so far purely mathematical constructs Field and SPACE with astounding physical, Phenomenal sense and Equivalence. Physics and Science, got new, purely Phenomenological Foundations.

All Concepts fell from the inaccessible heights of the Transcendental Olympus of Apriori into the controllable domain of empiric, phenomenal adequacy.

Just as the Scientific Revolution of the First Enlightenment, Einstein's Extended Relativity revolutionized the Foundations of Science which laid the cornerstone of the Second Enlightenment and its Phenomenological Weltanschauung. However, facing tenacious resistance of the still dominating Noumenalism it could not rise far beyond this cornerstone. While Popper's Epistemology and Heidegger/Sartre's Ontology display some of its sprouts, they neglect several fundamental concepts such as Polarity, the base of Relativistic Dialectic which in our opinion embodies the Reason of the Second Enlightenment. Established Logic, untouched by it, is still entirely noumenalistic and so are its explicit or implicit applications to human and socio-political domains. The world is governed by inhuman devastating Dogmatism calling in question the very survival of the mankind. Einstein's assertion "A new manner of thinking is essential if humankind is to survive" gets every day more pressing.