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THE PHILOSOPHICAL CONSEQUENCES OF THE FORMULATION OF THE PRINCIPLE OF INERTIA

EUCLIDIAN SPACE AND ABSOLUTE SPACE

At first glance, the formulation of the principle of inertia—not yet complete with Galileo, more precise with Gassendi, finally systematic with Newton—seems to constitute but one of the aspects of a process of deep transformations at the end of which traditional cosmology was replaced by various world systems. These transformations—or, to use a more classic term, this "scientific revolution"—have been the object of numerous works, a list of which would alone fill the pages of a thick volume. But the principle of inertia itself, a principle about which can be said without exaggeration that it expressed the essence of this revolution at the same time as it stimulated it, has perhaps not received all the attention it deserves. And

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especially the impact of this principle on Western culture has not been fully measured. True, Alexandre Koyré has always insisted on the fact that, by reducing movement to a state like that of the state of rest, the principle of inertia expressed a new vision of the world more than a scientific result. But his admirable analyses deal more with the slow advent of the priciple of inertia among the natural philosophers who preceded, accompanied and then followed Galileo than with the theological, philosophical and literary impact of this principle. Moreover, by examining this impact, we discover that it is necessary to make a distinction between Euclidian space and absolute space, a distinction which is frequently implicit with certain scientific historians, but, and this must be emphasized, is more often ignored.

The importance of this distinction cannot be underestimated. In fact, if the expanse of nature is compared to Euclidian space (geometrization of the universe), the very notion of cosmos is destroyed; while by postulating (as Newton did) an absolute space underlying the expanse of nature, the world is retained, i.e., a sort of universal decor against whose background beings and objects take on relief and depth. Conversely, when the world dissolves into an isotropic, homogeneous and infinite expanse (Euclidian space), beings and objects lose their substance and become nothing more than interchangeable parts.

In that it is the cultural impact of the principle of inertia which first interested me, it is clear why these pages have their origins in remarks made by Jean Starobinski on the nature of space which became part of the consciousness of artists and writers in the 17th century. One of these remarks in particular held my attention for a long time. "Sight," wrote Jean Starobinski, "gives our consciousness an outlet beyond the place occupied by our body."[1] Does our body occupy a place like a stone fills a portion of space? Is sight the only sense by which we can escape the cellular existence of a thing condemned to live closed in on itself? Is it through sight that Jean-Jacques Rousseau, for example, sensed that his body was identified with a cosmic totality when he enjoyed nature? Does such enjoyment not imply rather the disappearance of all distance between the

[1] Jean Starobinski, *L'Oeil vivant*, Paris, Gallimard, p. 14.

self and the universe and from then on the disappearance of all visual comprehension? In other words, if the disappearance of all distance really means the breaking down of the barriers which surround the space occupied by our bodies, then it would not in fact be through sight that we achieve an outlet beyond this place. To see, it is first necessary to be distant from the world or to have an image of it before transporting oneself towards it by desire and imagination. However, as Jean Starobinski points out, thinking of Jean-Jacques Rousseau, "equation with cosmic totality is the point ... where every image perishes."[2] Is there no alternative other than identification with this totality and turning inward on the self?

It is not easy to answer these questions for they are tied by a thousand invisible threads to a problematic which has more to do with natural philosophy (physics) than philosophy pure and simple. However, natural philosophy and the meditations which accompanied it are no longer in vogue today. It is necessary, then, to become a bit of an archaeologist in order to sketch out a response, that is to dig beneath the surface of the philosophical, literary and theological debates of the classic age to rediscover the scientific basis on which these arguments were founded. Fortunately the extraordinary development in the history of science over the last fifty years facilitates the task for us.

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A thing or a being lives closed in on itself only inasmuch as it is only what it is. Is not man only what he is, like a stone which, apparently, rests entirely in the inertia of its mass? Does he not go beyond those spatial limits which seem to reduce him to being only a thing among other things? If we answer in the affirmative, we can no longer ask ourselves how to escape the place occupied by our bodies. Or again, and to use contemporary categories, if man is both identical to and different from himself, it is impossible to localize him absolutely in the expanse of nature. In fact when a thing is both similar to itself and other than itself, it is not possible to give it what might be called an

[2] *Ibid.*, p. 129.

atomic status.[3] It is only possible to reduce to an atom that which remains similar to itself and is *never* other than itself. All experiments of classical physics presuppose that there are things (or a thing) in nature which are nothing more than what they are. As Emile Meyerson has demonstrated, no experiment would be possible if one did not posit the permanence of primary elements beyond the transformations observed in the experiment.[4] If the hydrogen atom were at the same time a hydrogen atom and something other than a hydrogen atom, i.e. if it were like and unlike itself (the same and other), the entire structure of our physics would collapse, bringing down with it the fundamental paradigms which govern our perception of the universe.

A strict identity to self implies a space in which objects are, on the one hand, perfectly contained in the volume which they occupy and, on the other, indifferent to movement or rest. An object which would tend toward a place would not be the same at the end of its movement, for it would be "satisfied," "*perficiatur ex motu*," as F. Bonamico would say.[5] Identity with self implies, then, the homogeneous space of geometry where all "places" are alike and where a translation, consequently, "pro-

[3] It is intentionally that I use the adjective "atomic." In analytical philosophy, atomic facts are expressed by atomic propositions which are independent from one another, just as the atoms of the Newtonian cosmos are independent one from another. Such independence necessarily implies perfect *ontological stability*: the atom, reflected by the atomic proposition, is only what it is (A=A). The consequence is that, inasmuch as the world is made up of atomic facts, it is without form, for every form is made up of elements which are both similar to themselves and distinct from themselves. In such a world nothing can be said—no more, in any case, than can be said of chaos or of a pile of stones. It is thus not surprising to see that the fundamental thesis of the first philosophy of Ludwig Wittgenstein (profoundly influenced by Bertrand Russell's logical atomism) is that it is impossible to say anything at all of the world as a totality. "Wittgenstein's fundamental thesis is that it is impossible to say anything about the world as a whole." Bertrand Russell, "Introduction" to Ludwig Wittgenstein, *Tractatus-Logico-Philosophicus*, new transl., London, Routledge and Kegan Paul. 1961, p. xvii.

[4] "The explicative force of theories resides essentially in the application of the postulate of identity in time... It is in virtue of this postulate that physical theories are dominated by the concept of discrete particles." Emile Meyerson, *Identité et Réalité*, Paris, Felix Alcan, 1908, p. 85. These are, of course, particles which remain perfectly identical to themselves, *no matter* what happens.

[5] F. Bonamico, *De Motu*, I, V, c. xxxv, p. 503. Quoted by Alexandre Kovré, *Etudes Galiléennes*, Paris, Hermann, 1966, p. 25. Bonamico was Galileo's teacher.

duces nothing."[6] Classical mechanics, which seems to have acquired eternal validity in the 18th century, rests on the principle that bodies "retain their identity during movement."[7] In contrast with this, it is easily seen that *ontological changes* (non-identity with self) in a moving thing refer back to a differentiated and anisotropic space and, as we shall see, a finite one. In the cosmos of the scholastics, for example, "the local movement of a body marks the intrinsic mutability of the moving body so that ... the possibility [for a body] to cease being where it is attests to the possibility of it ceasing to be what it is."[8] In this way the nature of cosmic space can be determined by working from a theory on the nature of movement. It suffices that something "happen" to a moving body in order to be able to affirm that the space in which it moves is not Euclidian.

A non-Euclidian space has every chance of being both finite and hierarchical, i.e. of being a cosmos. By reflecting from above on Western political history and the parallel flattening of the universe by the geometrization of the expanse of nature (Euclidian space), we sometimes arrive at the idea that the price of political equality consists perhaps in an infinite world which is stripped of all privileged space (demystification). In any case it is difficult to imagine an egalitarian state in a differentiated cosmos.

A thing which is nothing more than what it is does not go beyond the space it occupies in any manner and is not affected by movements to which it is subject. We know that one of the principal difficulties of contemporary physics is that it is no longer capable of basing itself on these two principles. It does not seem possible to localize matter at its core in a precise point in space; and it has ceased being indifferent to movements which bestir it. Today we can legitimately ask ourselves if there is a thing, a single thing in the universe, which is identical to itself. Jacques Merleau-Ponty affirms without hesitation that "the modern concept of matter excludes the idea of a physical substance indefinitely

[6] Alexandre Koyré, *Etudes Galiléennes*, Paris, Hermann, 1966, p. 23, note 2.
[7] Jacques Merleau-Ponty and Bruno Morando, *The Rebirth of Cosmology*, English transl., New York, Alfred A. Knopf, 1976, p. 77.
[8] Etienne Gilson, *L'Esprit de la philosophie médiévale*, second revised edition, Paris, Jean Vrin, 1944, p. 65.

similar to itself."[9] To doubt the existence of atoms (or of particles) eternally similar to themselves is to doubt as well the identification of the expanse of nature with isotropic, homogeneous and infinite (Euclidian) space. It is certain that in denying the existence of such atoms, we reject at the same time the representation of our universe as a geometric space.

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As for man, he is not identical to himself, even if the Cartesian paradigm of a nature where things are identical to themselves has almost made of him an atom limited by the volume he occupies. It is thus possible to question the proposition according to which man occupies only the volume filled by his body while still recognizing that this proposition has gained acceptance in modern man as a self-evident truth.

In fact a good part of modern literature is devoted to descriptions in which the individual is no more than an atom lost in a flat and contourless expanse. Since the end of World War One, space in the great Western novels is acosmic in the sense that the writer is condemned to construct a purely interior universe. In France, Malraux wrote that "the greatest mystery is not that we are cast by chance between the profusion of matter and that of the stars but that ... in this prison we extract from ourselves images so powerful that they deny our nothingness."[10] While in England and America T. S. Eliot, Ezra Pound and Thomas Wolfe constantly return to the theme of isolation, the absence of relations, the room where the door never opens. In an infinite and homogeneous space, men and objects are necessarily closed in on themselves and in prison (Malraux). Which leads to the remarkable paradox that the infinity of space, better than the thickest walls, encloses, or, as Michel Foucault would say, *closes in*, beings and things in themselves. In an infinite, homogeneous and isotropic space (Euclidian space), I cannot sense the *desire* to go anywhere since all places are the same and I remain eternally identical to myself. It is true that this infinity and the atomic independence which accompanies it can sometimes produce a fleeting exaltation like certain American films and

[9] Jacques Merleau-Ponty, *op. cit.*, p. 194.
[10] André Malraux, "La lutte avec l'ange" in *Les Noyers de l'Altenburg*, Geneva, Albert Skira, 1945, p. 72.

novels in which the hero plunges out alone to conquer the wide open spaces. Jean-Jacques Rousseau had already felt this exaltation in his many wanderings. But this intoxication is brief; the basic harmony is in a minor key. In the long run the "hero" realizes that he has crossed the expanse of his life like a solitary atom.[11]

To say that through sight man creates for himself an outlet beyond the place occupied by his body consequently has meaning only in the framework of a certain concept of man's place in space. Jean Starobinski, moreover, formulated this proposition in the context of analyses and reflections on French literature as it developed from the classical age. However, the classical age geometrizes space by stripping it of every immaterial element. Henry More fought a rear-guard battle when he defended the thesis, against Descartes, that the soul must in a certain manner have extension, i.e. occupy a place, if it is to exist. Confusedly, Henry More divines that if there is nothing but space in space, then man is reduced to having no more than an atomic status, i.e. to being no more than an extended portion among other extended portions.

It is on the basis of the Cartesian distinction between *res cogitans* and *res extensa* that, on the one hand, we can conceive of man as a being enclosed in the place that he occupies and, on the other, that we can think of the means through which he can escape this "enclosure." But we need only question this distinction to begin asking ourselves if there are no objects which might be both like and unlike themselves. However, it is unnecessary to search for a long time to realize that such "objects" exist.

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A being which desires, for example, cannot be but what it is, for it wants to become other than it is. Desire, particularly human desire, manifests not only a tendency to retain itself in its being or to retain its identity jealously, as Spinoza believed, but also a tendency to be transformed. This is evident in the highest forms of desire. The love of God, for example, produces

[11] On the theme of the solitary atom, the monadic life, see Ben Lazare Mijuskovic, *Loneliness in Philosophy, Psychology and Literature*, Assen (The Netherlands), Van Gorcum, 1979.

in a great mystic an inner transformation at the conclusion of which he becomes a "new man."[12] But even the eagerness to consume is always accompanied by the secret desire to be consumed, that is changed, broken or incorporated into a higher life than the life of a fragment closed in on itself. By ingesting food I am not simply assimilating nourishment necessary for my organic survival. I am also opening myself to flavors and aromas which make me take part in a reality transcending the circle of my needs. A woman who buys a dress from a fashion designer or a man who climbs behind the wheel of a sports car define themselves as members of a certain social category through which they are not simply what they are, but also rich, charming or powerful.[13]

Desire, that is the tendency *in any entity* toward an "other" which is not what this entity is, signals that this entity cannot be reduced to that which it is. It contains a share of immateriality (tendency, strength, desire, soul) which makes it different from itself. Conversely, a being perfectly satisfied with being where it is and perfectly satisfied with being what it is would be without desire. Are there such "beings" in the universe? Many philosophers in the classical age thought so. According to them there are in the universe perfectly inert atoms which do not desire reaching a place other than that which they are occupying, nor stopping their movement. Nothing better expresses the classical age's belief in the existence of inert entities than Descartes' "First Law of Nature:" "*Prima lex naturae: quod unaquaeque res, quantum in se est, semper in eodem statu perseveret: sicque quo semel movetur, semper moveri pergat.*"[14]

[12] On desire as a power capable of reproducing substantial transformations in man, see Alexandre Kojève, *Introduction à la lecture de Hegel*, Paris, Gallimard, 1943 and, particularly, Gaston Fessard, *De l'actualité historique*, Paris, Desclée de Brouwer, 1959, volume 1, pp. 121-200. Hegelian philosophy was interested in the transformation or, better, the transsubstantiation of the vertical animal from the natural state into man. On the transformation of man into God (mysticism), see Evelyn Underhill, *Mysticism*, London, Methuen & Co. Ltd, 1911, and Alexandre Koyré, *Mystiques, spirituels, alchimistes du XVI^e siècle allemand*, Paris, Gallimard, 1971.

[13] The work of Jean Baudrillard systematically explores these manners of identifying oneself to another through market mechanisms (symbolic exchange). See *L'échange symbolique et la mort*, Paris, Gallimard, 1976; *Le système des objets*, Paris, Gallimard, 1968.

[14] René Descartes, *Principia philosophiae*, pars 2, art. 37.

(First law of nature: everything, inasmuch as it is dependent on itself, always remains in the same state: nevertheless once put in motion it will always continue to move.)

If we wish to reflect on it in all philosophical innocence, this law is properly astonishing: why would a thing remain perpetually in movement? Nevertheless, among philosophers of the 17th century, only Leibniz refused to accept this law, thereby denying the existence of inert entities. For him, inanimate matter has a propensity to movement and consequently to stop once it has attained its goal. A vague "desire" still animates the lowest layers of creation.[15] Likewise most of the Greek and scholastic philosophers thought that nothing is perfectly free of a tendency to move toward something other than itself. A stone in Aristotelian physics "wants" to return to the center of the earth.

Such a "will" or tendency reveals the immaterial in matter, the invisible in the visible. Only matter in its purest state could be inert, without desire, free of all immateriality and thus perfectly identical to itself. Does matter in its purest state exist in our universe? Aristotle, of course, answered no. It is perhaps less well-known that today many physicists also answer no. "At the sub-atomic level," writes Fritjof Capra, for example, "matter does not exist with certitude in definite places ... [so that today we are seeing ...] an absolute break with the traditional spirit of fundamental research in physics which has always sought the ultimate components of matter."[16]

[15] "It is not in conformity to order nor beauty nor to the reason of creation that only a very small portion of matter enjoys a vital principle or an immanent activity while the greatest perfection requires that the totality of matter be so endowed. Moreover, nothing says that there are not souls everywhere or at least something analogous, although dominant, and consequently, intelligent souls, such as human souls, cannot be everywhere." G.W. Leibniz, "De la Nature elle-même, ou de la force inhérente aux choses créées et de leurs actions," in *Opuscules philosophiques choisis*, trad. Paul Schrecker, Paris, Hatier-Boivin, 1954, p. 106.

[16] Fritjof Capra, "Le Tao de la physique," in *Science et Conscience: Les deux lectures de l'univers*, Paris, Stock, 1980, p. 45. Similarly Werner Heisenberg affirms, "*... dass wir die Bausteine der Materie, die ursprünglich als die letzte objektive Realität gedacht waren, überhaupt nicht mehr 'an sich' betrachten können ... Das Ziel der Forschung ist also nicht mehr die Erkenntnis der Atome ...*" *Das Naturbild der heutigen Physik*, Hamburg, Rowohlt, 1955, p. 18. Along the same lines, David Bohm stresses that "quantum theory shows that the attempt to describe and follow an atomic particle in precise detail has little

Even if perfectly inert objects exist, it is certain that objects also exist "containing" a certain degree of immateriality, if for no other reason than that there are desiring beings around us. Everything in the universe, then, is not like itself. Some beings, and perhaps all beings and all things, are both identical to themselves and different from themselves. If it is possible to see a proportional relationship between this difference with itself and the immateriality "contained" in an object, then we can say that it is man who, of all visible things, "contains" the most immateriality. And if it is possible also to see in the fact that only an object which is only what it is would be an object perfectly limited by the space which it occupies, we can say that *man is the object which, less than any other, is in the space occupied by his body.*

There is a close relationship between the structure of space and the nature of objects contained in space. Let us imagine a space filled with objects which we will define hypothetically as strictly identical with themselves. These objects will be absolutely separated from one another since they will be limited by the space which they occupy. Descartes, who constructed his physics around this model, admitted only one form of interaction among things: shock. The (indefinite) totality of these objects would thus not be structured. A structure is necessarily immaterial. It is not possible to put a finger on a form or a structure. Since in our hypothesis we have excluded all immaterial elements in the objects we are considering, we must admit that space without such objects is without form. The conclusion is evident: a world made up of objects identical to themselves would not be a cosmos but a chaos.

It is such a chaos which appears on the horizon of all encyclopedic, analytical or positivist projects which aim to give a perfectly stable and delimited "referent" to every word in the language. The unexpected result is that, in wanting to know exactly what it is we are talking about, we run the risk of finding ourselves

meaning." *Wholeness and the Implicate Order*, London and Boston, Routledge and Kegan Paul, 1980; Paperback ed., 1982, p. 9. For the convergence between Aristotle and contemporary physics, see Patrick Suppes, "Aristotle's Concept of Matter and its Relation to Modern Concepts of Matter," *Synthese*, September 1974, 28:27-50. See also Theodore J. Kiesel, "The Reality of the Electron," *Philosophy Today*, Spring 1964, 8:56-64.

faced by a world disintegrated into tiny parcels. A language which would refer the mind to objects like a mirror reflects reality would be an *acosmic language*. Then we would have to ask the question which Heidegger raised in *Sein und Zeit*. "How can a common world then still be possible?"[17] No metaphor would be possible within an *acosmic language*, so that poetry, a form of expression in which beings and things are supremely allowed to be both identical to and different from themselves, would be banned.[18]

There is hardly any doubt that 20th century literature and philosophy have been both fascinated and repulsed by the possibility of an *acosmic language*. Fascinated because such a language would reflect the possibility of scientific precision thanks to which beings and things could be classified perfectly and thus, *in a certain manner*, ordered. Repulsed because such a purely spatial order would mark the triumph of what we might call the kingdom of juxtaposition where all objects, animate or inanimate, would be lined up alongside one another to infinity, as in the novels of Robbe-Grillet or Michel Butor.

No philosophical work reflects this fascination and this repulsion better than that of Wittgenstein. The author of the *Tractatus Logico-Philosophicus* at first believed in the possibility of a language which would be the mirror of reality.[19] At this stage (fascination), he was perfectly conscious of the fact that it is not possible to speak of the world in its totality. A mirror-language (acosmic) would shatter the cosmos.[20] Then in his later works (repulsion), he renounced the idea of a language which would label beings and things and "rehabilitate common languages."[21] Everyday words evoke at least a common world in

[17] Martin Heidegger, *Sein und Zeit*, Halle, 1927, p. 64.

[18] For the relation between metaphor and cosmology, see Joseph A. Mazzeo, *Nature and the Cosmos: Essays in the History of Ideas*, New York, Dabor Science Publications, 1977, pp. 28-30.

[19] "The ideal of the *Tractatus-Logico-Philosophicus* was the mirror." Ernest Gellner, *Words and Things*, London, Victor Gollancz, 1959, p. 75. See also Hanna F. Pitkin, *Wittgenstein and Justice*, Berkeley and London, University of California Press, 1972, p. 27.

[20] On the fragmentation of the universe in Wittgenstein, see William Barrett, *The Illusion of Technique*, New York, Anchor Press, Doubleday; Anchor Books, 1979, pp. 34-36.

[21] Louis Vax, *L'empirisme logique*, Paris, P.U.F., 1970, p. 60. As for Jacques Bouveresse, he notes that "Wittgenstein's intention was to show ... that it is

the absence of a cosmos.

As for Heidegger, with *Sein und Zeit*, he attacked the Cartesian representation of space. He attempted to prove that what he termed "*die Seienden*," that is objects perfectly identical to themselves, could not make up a world. It is through the "*Dasein*" (man), which is never identical to itself, that there is a world. And if man is never identical to himself, it is because he is a temporal being modified every instant. If Heidegger had been a little more interested in the history of science, he would have realized that time also traverses matter to render it different or, to use the term coined by Jacques Derrida, *différante* from itself.

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Beings and objects which are only what they are cannot form a world. Conversely, bodies containing a degree of immateriality form an articulated cosmos. There is consequently a close relation between the degree of immateriality "contained" in a body and the capacity of this body to organize, by its presence, the space which surrounds it, like Heidegger's "*Dasein*," whose space is "infinitely richer than scientific space."[22] Practically nothing emanates from a stone. But the presence of a living being creates an entire system of attractions and repulsions in the milieu in which it evolves. With an object capable of assimilating the

completely strange to suppose that every time we speak we must first of all (in thought) have something to say." *Le Mythe de l'intériorité*, Paris, Editions de Minuit, 1976, p. 661. From a concept in which language refers the mind to atomic realities, that is to things identical to themselves, Wittgenstein moved to an exactly opposite concept in which there is no essence, not even a clear and distinct reflection of what the words evoke. The same rejection of language-mirror, -reflection, -essence or -significance is found in Nelson Goodman and Willard Quine. There are only manners of speaking or manipulations of symbols which cannot be reduced to precise definitions. This rejection of intuition and of the essence which corresponds to it belongs to the movement of increasing mistrust in the capacity which language has of bringing an essence out beyond its appearances. On this point existentialism and analytical philosophy coincide. This mistrust would be justified if language was only a reservoir of labels (each label corresponding to an essence). However, language is not just that, even if, under the pressure of acosmism, it has tended to be but that.

[22] Walter Biemel, *Le Concept du Monde chez Heidegger*, Paris, Louvain, E. Nauwelaerts and Jean Vrin, 1950, p. 13. In another passage, Walter Biemel affirms that the spatiality of *Dasein* "cannot be compared to scientific space," p. 72.

greatest possible immateriality, the entire cosmos would be organized around it. Pascal said that through the spirit (the immaterial), we dominate the entire expanse of the cosmos. Let us add that the spirit lives in a body and that from that point this body seems perfectly capable of forming the center of the cosmos.[23]

As soon as space, through the presence of a living thing, is traversed by attractions and repulsions, its parts cease being equivalent. A space whose parts are not equivalent is a cosmos, like Aristotelian space with its special places and its particular zones. Elements contained in a cosmos are not indifferent to the space they occupy. Either they "wish" to remain where they are, or they "wish" to return to their natural place. Their immobility manifests the "satisfaction" they feel in being where they are: their movement, the "desire" which propels them toward the place where they will be happy. There is cosmos as soon as movement and rest refer respectively to a "desire" or to "satisfaction" in the moving thing. Conversely, an equivalence between movement and rest denotes a homogeneous and isotropic space where movement is not fundamentally distinguished from rest. In a homogeneous and isotropic space, no place is intrinsically distinct from another place. In such a space there is no reason for an inanimate or animate element to be given to move itself if it is immobile or to be given to stop itself if it is in movement.

In this indifference between movement and rest we can see the essential consequence of the principle of inertia. According to this principle a body whose speed is constant will *never* modify its movement unless it enters a gravitational field or collides with another body.[24] Consequently, space which corresponds to the principle of inertia is a homogeneous and isotropic space. First, no part is distinct from any other part (homogeneity) and, secondly the direction chosen has no bearing on the speed or the trajectory of a moving thing (isotropy). We

[23] For the relation between the body and the cosmos, see Victor Harris, *All Coherence Gone*, Chicago, The University of Chicago Press, 1949.

[24] The principle of inertia is stated as follows: "*Corpus omne perseverare in statu quo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum ille mutare.*" Isaac Newton, *Philosophiae naturalis principia mathematica*, London, 1687, "Axiomata sive Leges Motu," lex I, p. 12.

might add that this space is also infinite since the principle of inertia rightfully guarantees the theoretical possibility of constant and inexhaustible movement. No attraction, no repulsion, no energy, no force can explain the perpetuation of movement. As Alexandre Koyré has frequently emphasized, movement in classical physics is a state just like rest. Consequently it has no natural end; it can continue indefinitely.

If a cosmos cannot exist until there is a space containing special places which produce movement or rest, the principle of inertia seems to be the basis of acosmism. According to Galileo, who succeeded in making an almost perfect formulation of this principle, it is not simply that the earth ceases to be the center of the cosmos, but also that the cosmos runs the risk of no longer being a cosmos. If in fact the principle of inertia expresses something essential about the nature of movement and consequently about the nature of space, we must state that the universe no longer has any center at all. A universe which no longer has a center can no longer be a cosmos. Galileo still perceived unclearly the consequence of his theory on the structure of space and remained profoundly attached to the idea of cosmic harmony.[25] The Church suspected what the consequences were but did not perceive them any better than Galileo. This is the reason for the confusion and ambiguity which reigned over the fateful trial which opposed them. Galileo's genius is not diminished by suggesting that if he had perceived these consequences, he would have perhaps been less zealous in wanting to push his theories through as absolute truths.[26] And perhaps we can be less forceful in our condemnations of the Church if we consider that it was obscurely attempting to maintain a principle of cosmic order at the dawn of an age which was on the verge of shifting into acosmism.

[25] "He who had discovered the principle of inertia [Galileo] always refused to think of a straight inertial path, because it would have been 'disorderly' ..." Giorgio de Santillana, *The Crime of Galileo*, London, Heineman, 1958, p. 59.

[26] The least that can be said is that Galileo is hardly interested in hypotheses which only preserve appearances or, as Cardinal Bellarmine said, explications *ex suppositione*: "*Giudicai ... comparir pubblicamente nel teatro del mondo, come testimonio di sincera verità...*" Galileo Galilei, *Dialogo sopra i due massimi sistemi del mondo* (1632), in *Opere*, Turin, Franz Brunetti, 1969, p. 15. On this point see also Pierre Duhem, *La Théorie Physique*, second edition, Paris, Marcel Rivière, 1914, p. 59.

In contempory scientific milieux, it is rare to find people who still believe in the paradigm of a homogeneous, isotropic and infinite space. In reality, we can even ask if such a belief ever existed in these milieux. It is true that this paradigm seems to appear on the horizon of classical physics. But it was particularly the philosophers, and of these especially Descartes and Kant, who postulated an absolute convergence between Euclidian space and the expanse of nature.

Let us observe first of all that the notion of a homogeneous, isotropic and infinite space is not the automatic complement to the principle of inertia even if the notion is logically the necessary corollary to this principle. Galileo did not believe that the expanse of nature was a Euclidian space. He thought that the effect of the "impetus" was permanent, but he was not able to neglect the effects of gravity. But a moving thing cannot move at a constant speed in a single direction indefinitely unless it can escape gravity. Galilean space is not Euclidian because the weight of bodies it contains is a property of the bodies themselves.[27]

Giordano Bruno posited more directly an infinite universe, that is an expanse without center or outer edge where "the worlds which make up the universe are in possession of the internal principle of their movement."[28] The places of such a world, consequently, "are not determined relative to the cosmos, ... but relative to such and such ... mechanical system [all bodies united by their participation in a common movement]."[29] Absolute relativity! Giordano Bruno concluded from this the plurality of worlds, the inescapable corollary of an *acosmic space*. Working from a space without structure and movements proceeding from an inexhaustible inner energy, Bruno was in a good position to define the principle of inertia. He no longer sought to associate the trajectory of moving objects with an "appetite" for regaining a natural place. But his thinking was so profoundly permeated with hermetism that even if he explained the principle of inertia

27 "Nowhere, in fact, does Galileo ever state what the motion of a projectile would be if no forces were acting on it... Galileo regards the impetus as permanent but is unable to neglect the effects of gravity." Allen Franklin, *The Principle of Inertia in the Middle Ages*, Colorado, Colorado University Press, 1976, p. 60.

28 Emile Namer, *L'Affaire Galilée*, Paris, Gallimard et Julliard, 1975, p. 19.

29 Alexandre Koyré, *Etudes Galiléennes*, p. 174.

with a great deal of intelligence, it is difficult to place him alongside those who used the principle to attempt to draw philosophical conclusions about the nature of space. In fact, his reflections on the work of Copernicus, for example, took him in the exact opposite direction from that which modern science was to follow. Frances Yates went so far as to say that if Copernicus had been alive at the time of the publication of *La Cena de le Ceneri*, the work in which Giordano discusses the theories of Copernicus, the latter would have burned every copy.[30]

In any case, comparison between the manner in which Bruno interprets the principle of inertia and the manner in which this principle is generally understood is not without interest. Before the fact that a body tends to maintain itself indefinitely in its state of movement, no matter what its position in space, Giordano Bruno postulates in each body the existence of an eternal soul or an inexhaustible vital energy. Movement, in his eyes, does not express a relation of the body to space but manifests an eternal energy indifferent to its environment. According to Emile Namer, "all change [in Giordano Bruno's philosophy] proceeds not from the extrinsic relation of certain particles to a determined place, but from the *natural thrust* which causes every body to seek the state in which it can best maintain itself."[31]

The convergence between the ideas of Giordano Bruno and those of William Gilbert is striking. For the latter, space has no reality. The position and movement of material masses is explained by the relations which these masses have among themselves and not by the relation of these masses to the expanse. "It is not place," wrote Gilbert, "which determines the rest or the movement of bodies. For place as such is neither a being nor an efficient cause. It is rather through the forces which are in them that bodies determine their respective place and position. Place is nothing; it does not exist and it exerts no force. *All the power of nature is contained in bodies themselves...*"[32]

[30] Frances Yates, *Giordano Bruno and the Hermetic Tradition*, London, Routledge and Kegan Paul, 1964, p. 297.
[31] Emile Namer, *Giordan Bruno*, Paris, Seghers, 1966, p. 46. My underlining.
[32] William Gilbert, *De mundo nostro sublunari philosophia nova*, Amsterdam, 1651, lib. I, cap. 28, p. 60. My underlining.

According to the principle of inertia, there is also no relation between bodies and determined points in space. But, according to this principle, it is not possible to conclude from the "capability" of indefinite "movement" that there is a natural power for movement situated in these bodies. According to the principle of inertia understood in a scientific sense, matter is *truly* inert so that space, even if it had a structure, could have no influence on it. According to Giordano Bruno or William Gilbert, it is the vital autonomy of matter, on the contrary, which makes it independent from space. A body does not seek to return to a place which is proper to it since it is perfectly "satisfied" to be what it is. With Giordano Bruno, the *ontological sufficiency* of matter derives from the fact that the soul is not form but substance. Each part of the universe has received a share of the divine soul, and this spiritual substantiality bestows on all animate or inanimate elements their energetic independence, so to speak. Such views are in complete contradiction with the Aristotelian-Thomistic doctrine in which the soul does not reside in a place (the body) since it is form and not substance. The Scholastics did not imagine the relation of the soul to the body like a captain in a ship, a model which Bruno explicitly defended before the judges of the Inquisition. "I do not believe," he explained to his judges, "that the soul is form, but that it constitutes a spiritual reality *actually present in the body* ... captive, in a certain sense, in a prison..."[33] This insertion of the soul in bodies obviously makes bodies independent of any form which might attract them in a cosmic totality to *locate* them there. It is on this independence (a metaphor in a certain way for the principle of inertia) that modern science will be constructed. But with Bruno this independence is the direct consequence of animism or cosmic pantheism. Nothing of the like is found in modern science, even if pantheism and animism seem at times to follow like a shadow the evolution of modern physics.[34]

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[33] Quoted by Emile Namer, *Giordano Bruno*, Paris, Seghers, 1966, p. 30. My underlining.

[34] On the facility with which animism and modern science can be merged and on the effort of the founders of our physics to free themselves of animism, see Robert Lenoble, *Mersenne ou la naissance du mécanisme*, Paris, Jean Vrin, 1943.

If Galileo did not produce a complete formulation of the principle of inertia because he was unable to conceive of the expanse of nature in the form of a Euclidian space, at least he cut all the ties which, for Giordano Bruno, still connected this principle to an animist metaphysics. It is in this that he was revolutionary and that his trial represents a turning point in the history of humanity. In fact this break between the principle of inertia and metaphysics is so profound that it makes possible theoretically a universe stripped of every immaterial element. We cannot help observing that the principle of inertia seems to lie at a crossroads. One path leads to the pantheism of Giordano Bruno where the capacity of a moving object to perpetuate its movement indefinitely and independently of any mover is the sign of an inexhaustible energy or of an eternal soul completely lodged in the bodies in movement (Bruno). The other leads to the materialism of Hobbes or Descartes for whom inertia or the maintaining of movement permits explaining all motion in the universe, and in the final analysis life in the universe, in materialist terms. On the one hand movement expresses the universal presence of eternal spiritual energy which is consequently indifferent to the origin and the end of the itinerary of the moving object in which it is temporarily set (death and birth are only stages in the propagation of this energy). On the other hand, indifference to rest and to movement manifests absolute inertia, that is that the moving object contains no life and, *a fortiori*, no soul. In sum, the principle of inertia can be interpreted as the sign of either an abundance or an absence of souls in the universe.

It was Gassendi who outlined with a great deal of precision the space which is correlative to the principle of inertia. He asks us to imagine a universe reduced to nothing and space which is completely empty, just as it was before God created the world. "And then, since there would be no center, all parts of space would be the same." From this he draws two conclusions. First of all, an unmoving stone would remain unmoved in this space for nothing would attract it, or, more precisely, no matter would exercise pressure on it by subjecting it to a flow of particles (Gassendi did not believe in attraction). Secondly, a stone thrown into an empty space "would continue its

movement perpetually in the direction given to it at the outset."[35]

The definitive formulation of the principle of inertia is closely connected to the hypothesis of a space rid of all matter. In Gassendi's terms, we must imagine ourselves in a point in time and space when creation had not yet taken place. This would mean that the space necessary for the observation or the confirmation of the principle of inertia does not exist in the reality of the created universe. This space can only exist in the minds of those who formulate the principle of inertia, just as the forms of reality exist, from the point of view of modern philosophy, only in the knowing subject.

As a result there is no reason to be astonished that in the eyes of Gassendi and of almost all his contemporaries, the notion of an empty space, homogeneous, isotropic and infinite, is only a working hypothesis. The majority of 17th century philosophers was not of the opinion that this hypothesis taught us a great deal about the fundamental nature of the expanse. On the one hand, Galileo's trial urged prudence. On the other, an effort was made to distinguish between the discourse on nature and metaphysical discourse. For Mersenne, "it is in heaven that we shall see how things are in reality."[36] Richard Westfall notes that for Gassendi "man is, by nature, banned from the place where he could obtain an ultimate understanding of things."[37] To Mersenne's contemporaries and to Mersenne himself, Descartes seemed "as complicated as Aristotle because his method seeks to give access to an ontological truth."[38]

When it appears with the formulation of the principle of inertia, the idea of a homogeneous, infinite and isotropic space (Euclidian space) is consequently considered as a being of reason and not as a reality. Even the Newtonian universe, which gives a central place to the principle of inertia, is not an infinite, homogeneous and isotropic space since it is differentiated into empty zones and zones filled with matter. From this matter emanates an attraction (of divine origin) which removes from

[35] Petri Gassendi, *De motu impresso a motore translato*, Paris, 1641, c.xv, p. 59 and c.xvi, p. 62.

[36] Quoted by Robert Lenoble, *op. cit.*, p. 276.

[37] Richard Westfall, "Newton and Absolute Space," *Archives internationales d'histoire des sciences*, April-June 1964, 67:121-132.

[38] Robert Lenoble, *op. cit.*, p. 276.

space its isotropic nature. Depending on the direction taken, the nature of space will not be the same. Here a star will accelerate the moving object, there a weak density of matter will barely have an influence on its trajectory. It is true that Newton postulates an absolute space which *seems* to coincide with Euclidian space corresponding to the principle of inertia. Absolute space cannot be comprehended in any manner whatsoever so that at first appearance it does not seem to be but a being of reason also. "By its very nature," wrote Newton, "absolute space has no relation with anything whatsoever exterior. It always remains uniform and unmoving in itself."[39] Absolute space *cannot be perceived* in any manner whatsoever. It has no material reality. And yet Newton affirms that it exists. Berkeley reproaches him for this since, according to him, there is no greater heresy than that of supposing realities which "have an existence outside the mind."[40] It is tempting to conclude with Max Jammer that Newton's absolute space is really "the necessary condition for the first law of movement (principle of inertia) to be valid."[41] And yet this identification of absolute space with Euclidian space is incorrect.

In fact absolute space as Newton conceived it allows distinguishing absolutely between rest and movement, whereas in the space corresponding to the principle of inertia, in Euclidian space, such a distinction is excluded. In Euclidian space we must have at least two bodies in order to be able to discern movement, for, once again to quote Berkeley, who criticized the notion of absolute space without realizing that he was in fact rapping the notion of Euclidian space, "if we suppose that all bodies but one were annihilated, no movement could be discerned."[42] Berkeley refuses to admit Newton's proposition that "place is is a portion of space occupied by a body,"[43] a proposition which clearly indicates that movement for Newton does not occur

[39] Isaac Newton, *Philosophiae naturalis principia mathematica*, London, 1687, p. 5.

[40] George Berkeley, *Principles of Human Knowledge*, par. 110 in *The Works of George Berkeley, Bishop of Cloyne*, A. A. Luce and T. E. Jessop, eds., Edinburgh, I. Nelson, 1948, 2:89.

[41] Max Jammer, *Concepts of Space: The History of Theories of Space in Physics*, 2nd ed., Cambridge, Mass., Harvard University Press, 1969, p. 101.

[42] Berkeley, *Works*, vol. 4, p. 47.

[43] Newton, *Principia*, p. 5.

essentially in relation to other bodies as Leibniz and Descartes believed, but in relation to the immateriality of absolute space. One of the professors at Cambridge who had a major influence on Newton's natural philosophy was Henry More[44] who stated that when a body moves, it does not do so only in relation to other bodies but also in relation to space, so that, by moving, it really changes place.[45] Absolute space, for More as well as for Newton, provides a sort of perfectly stable and immaterial (but extensive) background against which movement stands out in all clarity. On the other hand, in Euclidian space nothing like this is possible. There, in order to say that the earth is in movement, it is necessary to clarify immediately that it is in movement in relation to the sun or to some other point of reference which is itself either moving or unmoving relative to another point of reference, and so on to infinity. Nothing like this occurs in absolute space. Moving bodies there really *are* in movement or at rest, while in Euclidian space they cannot be said to be so other than in relation to a system of reference. In short, absolute space does not need matter (two bodies, for example) to be the basis of order, of movement and of rest. Euclidian space, on the other hand, cannot constitute such a basis since it is obtained through abstraction and presupposes a pre-existing cosmic order allowing the perception of objects and of their movements. Absolute space is thus an object of faith whereas Euclidian space is arrived at through simple reasoning.

* * *

The notion of absolute space is both quite close to and quite different from the Kantian notion of space as primarily a sensible form. Kant began by believing that the perception of space required matter, that is bodies relative to which distances would be perceptible. "I should never say that a body is unmoving without specifying relative to what it is unmoving... If I wish

[44] On Henry More's influence on Newton, see Frank E. Manuel, *A Portrait of Isaac Newton*, Cambridge, Mass., Harvard University Press; New Republic Books, 1978, pp. 87, 334.

[45] See Henry More, *Enchiridium Metaphysicum sive de rebus incorporeis succinta et luculenta a dissertatio*, Londini, 1671, cap. VI, 7, pp. 55-56.

to imagine ... a mathematical space freed of all created things and receptacle for all bodies, this would still not help me. For through what would I distinguish the different or similar parts if nothing corporal occupied them?"[46] Later, in the *Critique of Pure Reason*, Kant would reject this concept to adopt the position in which space, far from being deduced from the relative position of perceived bodies, is instead the basis for all our perceptions of beings and things. "The Kantian subject," wrote Alexis Philonenko, "is not originally in relation to a world, but only to space."[47]

And so Kantian space seems to correspond to Newton's absolute space. But there again we are dealing with a superficial resemblance. Inasmuch as for Kant space is primarily a sensible form, it is not for him an object of faith. In other words, it is not necessary for Kant to *believe* that absolute space exists, just as it is not necessary to believe in Euclidian space flowing naturally from the principle of inertia. If we think (like Kant) that the principle of inertia gives us access to the ultimate and definitive essence of movement, it would be tempting to believe that Euclidian space, too, constitutes an ultimate and definitive reality, or at least a reality so profound (*a priori*) that without it we would not be able to perceive anything. If we merge Euclidian space and absolute space, we would conclude that the order of the cosmos can be perceived independently of any act of faith. Then we can declare, as Kant did not fail to do, that faith is one thing and the study of nature another. In other words, we would consider that rest and movement, and beyond that the place of objects as well as the order of the cosmos, are realities which are perceptible independently of all belief.

The mingling of Euclidian space and absolute space gave credit to the idea that the study of the cosmos could be separated from all theological problematics. After Newton (who paradoxically never thought of such a separation and even encouraged his theologian friends to use his "world system" to give a better basis to Christianity), it became increasingly difficult to associate

[46] Immanuel Kant, *Gesammelte Werke*, Berlin, Akademie Ausgabe, 1905, vol. 2, p. 13. My translation.

[47] Alexis Philonenko, *Qu'est-ce que s'orienter dans la pensée?* Paris, Jean Vrin, 1959, p. 69.

a reflection on the cosmos with a reflection on the Creator. Despite numerous works of literature and poetry which, from the beginning of the 18th century in England showed that Newton had given a new and solid foundation to traditional faith,[48] despite the recent success of the works of Pierre Teilhard de Chardin, modern culture and modern thinking reject the possibility that cosmic order is a divine order. This apparently comes from the fact that the basis of such an order, that is the space which localizes and orders beings and things, was considered both as a necessary corollary to the principle of inertia and also merged with the notion of Euclidian space. In reality, only absolute space in the sense Newton meant it can provide such a foundation, and this foundation cannot be dissociated from an act of faith, which is the same as saying that it cannot be simply derived from the principle of inertia.

* * *

In Euclidian space moving objects are only in movement in relation to a system of reference. They are not, then, truly in movement. We cannot *attribute* movement to them since it is possible that, in relation to another system of reference, they are not moving. And so, with the principle of inertia (which implies necessarily the relativity of movement), attributive logic became relational logic in cosmological matters. In relational logic, the word has no more meaning since the movement which brings the mind to attribute a quality to a body (movement, rest, color, sound) is forbidden. Only mathematical language can be used there.

The demystification of the world as a consequence of the triumphs of modern science is a commonplace. It is quite evident that if we cannot attribute sounds, colors and odors to the objects surrounding us, the world loses all its charm. But we have not yet sufficiently insisted on the fact that it is not simply these sounds, colors and odors which disappear in this demystification process, but also movement and rest. It is

[48] See Bonamy Dobrée, *English Literature in the Early Eighteenth Century*, Oxford, Clarendon Press, 1959, pp. 499-500.

true that the founders of modern science claimed to retain matter and movement, following Descartes. In reality, *movement is only retained if we retain the postulate of an absolute space.* Inasmuch as Descartes did not retain this postulate, we can say that movement and rest in his physics have only a relative or relational reality. We cannot *attribute* rest and movement to a "Cartesian body;" it only moves or is unmoving in relation to another body.

It is only by postulating absolute space that we can, within this space, *attribute* movement and rest to objects. *As soon as the possibility of attributing rest or movement is retained, the possibility of discussion of the cosmos is likewise preserved.* In other words, Newton's absolute space constitutes the foundation for cosmology. It is on this foundation that Anglican theologians attempted in the "Boyle Lectures" to reconcile Christian faith and natural philosophy (physics), in full agreement with Newton's intentions.[49] They sensed that without this foundation it is impossible to *say* something about nature. However, how can we believe that a universe about which man can say nothing could have been created by the "logos" of God? Absolute space allowed retaining a metaphysical and religious element in a physics which by its own logic was plunged into relativism and undermined the possibility of discussion of the cosmos.

In addition the notion of absolute space allowed affirming or at least believing that the universe is limited. Much has been said of the infinite time-space in Newtonian physics. However, when we look at things more closely, we see that this infinity is a problem. For if movement can be absolutely distinguished from rest, it is because beyond that the totality of space (the cosmos) is in a certain manner perceived or present. Certainly we cannot imagine this totality, but we can understand it. Newton reproached Descartes for having hesitated to posit an infinite space for, according to him, it was possible to

[49] "Newton was delighted that his cosmology was thus presented [in the Boyle Lectures given by Richard Bentley] in relatively simple terms to vindicate God's active role in the world." Michael Hunter, *Science and Society in Restoration England*, Cambridge, Cambridge University Press, 1981, p. 184. See also James R. Jacob and Margaret Jacob, "The Anglican Origins of Modern Science: The Metaphysical Foundations of the Whig Constitution," ISIS, 1980, 71:251-267.

understand the infinite.[50] By that Newton was affirming that our minds, far from being powerless before infinity, are on the contrary perfectly capable of mastering it. It is this mastery which allows concluding the existence of absolute space as well as the reality of rest and movement. Contrary to space corresponding strictly to the principle of inertia, absolute space is not infinite in the sense that we might think of it as always being beyond all limits, for it necessarily *embraces* the entire interstellar expanse as God embraces all creation.

By postulating absolute space Newton tried to eliminate or to obscure the extreme consequence of the principle of inertia: the dissolution of the cosmos in the homogeneous, isotropic and infinite expanse which Gassendi had imagined to better understand this principle. It is consequently not surprising to find Newton closely associating absolute space with God since absolute space *limits* the universe, *guarantees* the possibility of discussion of the universe and, last but not least, periodically reestablishes planets in their trajectories, thereby inhibiting gravitational force from making the planets collapse into one another. It is through the mediation of absolute space or ether that God maintains order in the universe. Newton could not strictly separate the visible from the invisible. He tried to retain a metaphysical element in his physics; for he feared that in losing that element (absolute space), he would similarly lose the means of *contemplating* the cosmos and we would find ourselves confronted with chaos. Upon reflection, what kind of universe would it be, in which we could no longer distinguish movement from rest, if not chaos?

But God and absolute space were not to reign for long. Laplace soon demonstrated that the equilibrium of the solar system had no need of the interventions of a watchmaker God working through the mediation of the ether. Laplace, true enough, did not say that the solar system is eternally stable. "Can we still affirm that the conservation of the planetary system enters into the views of the author of nature? The mutual attraction of bodies in this

[50] "If someone objects that we are unable to imagine an infinite universe, this I concede; contending nevertheless that we are able to understand it..." *Unpublished Scientific Papers of Isaac Newton*, A. Rupert Hall and Marie Boas Hall, eds., Cambridge, Cambridge University Press, 1962, p. 101.

system cannot alter its stability, as Newton supposed, but if there were no other fluid than light in celestial space, its resistance and the diminution which its emission produces in the solar mass should in the long run destroy the arrangement of the planets. And in order to maintain it, a reform would no doubt become necessary."[51] However, Laplace's work was generally interpreted as proof that the world is stable and autonomous. "Laplace demonstrated the conditions of order and duration in the universe and in our globe,"[52] exclaimed François Arago to the Chamber of Deputies in 1842.

And so belief in the structural solidity of the visible cosmos, independent of divine presence, was affirmed. The notion of cosmic order lost all immaterial components which underlay it. When, at the end of the 19th century, Mach wanted to eliminate metaphysics and physics in order to establish mechanics absolutely, he began by declaring that the notion of absolute space is a conceptual monster.[53] He did not want the expanse of nature to be dependent on the disturbing immateriality or invisibility of absolute space. The expanse of nature must contain nothing other than an expanse. Newton's absolute space is a metaphysical and almost magical space: God is present in it. It must therefore be eliminated in order to create a physics which is perfectly solid. This would be all the easier since the notion of absolute space played no role in Newtonian physics.[54]

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Because of the postulate of an absolute space, Newton retained the possibility of distingishing between rest and movement.

[51] Pierre Simon de Laplace, *Exposition du système du monde*, liv. V, chap. VI, in *Oeuvres complètes*, Paris, Gauthier-Villard, 1878-1912, vol. VI, p. 477.

[52] François Arago, *Oeuvres* (Paris: 1959), volume III, p. 456. Quoted by Jacques Merleau-Ponty, "Situation et rôle de l'hypothèse cosmogonique dans la pensée cosmologique de Laplace," *Revue d'histoire des sciences*, January, 1976, 29: 21-49.

[53] In *Die Mechanik in ihrer Entwicklung*, Leipzig, 1833, Ernst Mach spoke of absolute space as a "*Begriffsungetüme*" (conceptual monster).

[54] "In England, by the middle of the nineteenth century, it became clear that the concept of absolute space was useless in physical practice." Max Jammer, *Concepts of Space*, 2nd ed., Cambridge, Mass., Harvard University Press, 1969, p. 140.

According to Richard Westfall, Newton would have been horrified by the infinite universe of Descartes, a universe in which it is impossible to discover any fixed reference point whatsoever. Newtonian *infinity* fully constitutes a *totality* in which beings and things are organized in an absolute and not relative order. "The comfortable universe of Aristotle and the Scholastics collapsed, and man found himself confronted with ... the kingdom of infinite space," wrote Richard Westfall. "We can never admire too much the audacity with which Descartes confronted this alien universe and, casting off bravely, set sail on the sea of relativity. Newton was unable to follow him. In absolute space he found a substitute for the psychological security which he had lost."[55]

Should we say that Newton was unable to follow Descartes or that he did not *want* to follow Descartes? The nuance is important. If we say that Newton was unable to follow Descartes, we reduce to a psychological dimension what Newton and his contemporaries were discussing from a theological and philosophical point of view. By retaining the possibility of distinguishing between rest and movement, Newton proclaimed that the universe, although infinite, nevertheless formed a cosmos.

This conjunction between the infinite and cosmic totality is obviously impossible to imagine. Retracing the difficulties met by Kant in the creation of his natural philosophy, Alexis Philonenko asked "how can infinity be a whole?"[56] The answer is that this infinity is necessarily a whole as soon as we postulate that the movements which occur in it can be clearly distinguished from rest. In a certain manner, absolute space combines the infinity which a geometrized universe implies with the spatial finiteness implied by the reality of movement. This is obviously an unsatisfactory solution, but it shows up the depth of the metaphysical intuitions of Newton, who refused to postulate a universe which corresponded strictly to the principle of inertia despite the central place which this principle occupied in his physics. By affirming the reality of movement, he affirmed the

[55] Richard Westfall, "Newton and Absolute Space," *Archives internationales d'histoire des sciences*, April-June 1964, 67:121-132.

[56] Alexis Philonenko, *L'Oeuvre de Kant*, Paris, Jean Vrin, 1969, vol. I, p. 73.

finiteness of the universe even if he did not assign a limit to space and to time.

The distaste of men of science for admitting the extreme consequences of the principle of inertia (Euclidian space and the dissolution of the cosmos) allows measuring the capital importance of the theory of movement for physics and metaphysics. *Depending on whether or not we posit the possibility of perpetual movement at a constant speed, we destroy or we retain the cosmos.* Where prior to Galileo it was by retaining the possibility of attributing movement or rest to a moving body that the reality of the cosmos was affirmed, after Galileo it was by postulating a principle rendering such attribution impossible that a physics was developed which threatened this reality. Of couse, at the same time as this countermining was occurring, efforts, whether frightened or hesitant, were being made to prevent it.

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The cosmos is a sort of background against which rest and movement stand out. It obviously seems impossible to *represent* this background exactly as Aristotle and St. Thomas Aquinas did. A representation, particularly a geometric representation, implies space without limits.[57] But it is possible to affirm, on a conceptual level, that any philosophy which posits the reality of movement also posits the reality of the cosmos. Conversely, affirming that it is impossible to distinguish absolutely between rest and movement in effect destroys the cosmos. Alexandre Koyré noted that with Einstein, that is once the principle of inertia, basis of classical physics, was called into question, talk of cosmology began again. There is nothing surprising in that. As long as the principle of inertia is held as an absolute truth, the condition for the possibility of a cosmology is eliminated. It is consequently not astonishing that with Kant, who, contrary to Newton or to Galileo, did not doubt the coincidence of Euclidian space and the expanse of nature, cosmology was

[57] "Geometrization of space implies necessarily its infinitization: we cannot assign limits to Euclidean space." Alexandre Koyré, *Newtonian Studies*, Chicago, The University of Chicago Press; Phoenix Edition, 1968, p. 7, note 1.

eliminated in Western culture. Kant built his philosophy on the principle that "propositions from geometry give us information relative to the world of experience."[58] With such a principle, it is impossible to design a cosmology. A Hobbes or a Descartes had already adopted this principle, rejected by most scholars who contributed to the formulation of the law of inertia and today questioned once more because of developments in contemporary physics. Curiously it was philosophers and not scholars who exercised that greatest influence on the representation which Western culture made of the universe.[59]

This influence was not felt immediately in the 17th century, although we can already note in the literature, poetry and philosophy of this era signs of unease before the disintegration of the cosmos under the pressure of the Euclidian representation of the universe. Pascal's celebrated words about "the silence of infinite spaces" opens the era of great cosmic anguish in France, while in England this same anguish is expressed in John Donne's famous verse: "'Tis all in pieces, all cohaerence gone." Two centuries later, Nietzsche pointed out the paroxysm of all this anguish in a few lines which contain such evident reference to the problems of natural philosophy that it is perhaps better to interpret them in terms of physics rather than metaphysics. "What did we do," he wrote, "when we unloosed the chain between this earth and the sun? ... Do we never fall? Forward, backward, to the side, to every side? Is there still an above and a below? Are we not simply wandering as in an infinite nothingness? Is it not colder?"[60]

If this passage expresses something essential about the condition of modern man, we can conclude that Newton's absolute space was not a solid barrier against the *acosmic pressure* contained in a physics based on the principle of inertia.

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[58] Ronald Calinger, "Kant and Newtonian Science," ISIS, September 1979, 70: 349-362.

[59] On this point see Herbert Butterfield, *The Origins of Modern Science*, rev. ed., New York, The Free Press, 1966, p. 177.

[60] Friedrich Nietzsche, *Die Fröhliche Wissenschaft*, in *Werke*, Karl Schlechta, ed., Munich, Hanser, 1954-56, vol. 2, p. 127 (No. 125). My translation.