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Physics and the Intelligibility of Nature. A Critique of Meyerson's Scepticism

Miguel Espinoza

L'esprit humain est absurde par ce qu'il cherche; il est grand par ce qu'il trouve.

PAUL VALÉRY

RESUMEN

En la filosofía meyersoniana, lo interpretable como escepticismo son las observaciones según las cuales, *primo*, numerosos fenómenos naturales son resistentes a la identificación reductora al espacio y al tiempo reversible ejercida por la física, y, *secundo*, la importante afirmación de que cuando la razón explica, lo consigue solamente reduciendo la diversidad y el cambio que se trata de explicar. Lo paradójico de esta situación es que, según la física, en la naturaleza nada ocurre. Esto es así porque, para Meyerson, la identidad y la unidad existen sólo en tanto que condiciones racionales a priori: no hay ni identidad ni unidad en la diversidad natural. Luego en la filosofía de Meyerson la tendencia epistemológicamente realista de la física no está basada en una metafísica realista, razón por la cual, en este ensayo, del análisis de las ideas del eminente filósofo francés nace la sugerencia de que al menos parte del escepticismo es evitable si se dejan de lado los fundamentos metafísicos dualistas de su epistemología y si se la sustenta sobre bases metafísicas más realistas y naturalistas.

PALABRAS CLAVE: *Émile Meyerson (1859-1933); física; inteligibilidad; escepticismo; razón; causalidad-identidad; unidad; diversidad*.

ABSTRACT

What can be interpreted as scepticism here is Meyerson's twofold observation that many natural phenomena resist physics' reductive identification of phenomena to space and to reversible time, and his important remark that, when reason explains, it does so only by reducing completely the diversity and the change it tried to explain. This amounts to saying, paradoxically, that for physics, in nature nothing actually happens. This is so because, for Meyerson, identity and unity exist only as a priori rational requirements: there is no real identity and unity in natural diversity. Then, in Meyerson's work, the epistemological realist leaning of physics is not based on a real-

ist metaphysics, and this is why in the present essay the analysis of the ideas of the eminent French philosopher gives birth to the suggestion that at least some sceptical properties can be avoided by removing the dualistic metaphysical foundations of his epistemology and by placing it on a more naturalistic and realist metaphysical basis.

KEYWORDS: *Émile Meyerson (1859-1933); Physics; Intelligibility; Scepticism; Reason; Causality-Identity; Unity; Diversity.*

I. EXPLANATION, CAUSALITY AND IDENTITY

The Meyersonian scepticism is, as we will see, the philosophical outcome of a scientific enquiry whose beginning is not sceptical. The way of explanation is thus paradoxical. Nevertheless, in our contemporary positivistic age where the theory of explanation has been largely abandoned because it is believed that science, and physics in particular, does not explain, the development of a clear-cut theory of explanation is not one of the lesser merits of Meyerson's philosophy. It seems to him, contrary to the opinion of all non-realist epistemologists, that science is a search for explanation.[1] "The unique aim of all this work [done by the participants of the Physics Conference in Brussels in November 1911] was the search for a true physical theory, for a hypothesis concerning the mode of production (so obnoxious to Auguste Comte, and so unacceptable according to his conception of science). What is wanted is a hypothesis capable of explaining an entire series of phenomena observed in an indubitable manner by scientific authorities, phenomena which neatly contradict all the theories formulated until then" [Meyerson (1927) pp. 62-63]. "An explanation can only be achieved when a number of laws are united in a single law, and when one is recognized as a special case of the other. In that case, one and the same formula will describe a number, or indeed, an arbitrary number, of processes. This is the essence of Meyerson's interpretation of the role which 'identity' plays in the interpretation of nature" [Schlick, M. (1949) p. 19]. To explain means, in a Meyersonian sense, "to identify", but the truth is that as a typical French philosopher of his period, Meyerson did not exactly define the central concepts of his thought. He gave instead a good deal of examples to show that his main concept, "identity", "identification" and "identify", assimilates notions such as "invariance", "conservation", "permanence", "equivalence", "equality", "necessity", and even "to exist potentially", ideas which, according to the physical or metaphysical context, do not mean the same thing.

To state that physical explanation is a search for identity amounts to saying that physics rejects as unintelligible and irrational the properties of phenomena which, in some way or other, are not conveniently described by the family of ideas just mentioned. For instance, physics is a struggle against

irreversible time. This is clear in the formulation of its laws and principles (inertia, momentum, mass, conservation of energy, etc.). Meyerson's notion of explanation also means that if something is accidental or contingent then it is, because of that, beyond the reach of physics. Equating identity to "potential existence" is meant to say that what actually exists is, in some ways of interest according to the context, equivalent to its source, the deployment of something that was already there (let us think of the transformation of potential energy in physics, or consider, in biology, how a full fledged entity is the result of an identical programme). To explain is to explain causally, which means, in the end, to reduce all phenomena to time and space: "Theories draw their explanatory force […] almost solely from considerations of time and space, and, above all, from the preservation of identity through time. It is necessary that something persists; the question of knowing exactly what it is that remains the same, does not really matter. Our mind, aware (unconsciously aware, if you allow me this apparent paradox) of the difficulty inherent in causal explanation, is, so to speak, resigned in advance, willing to accept almost anything, even something unexplained and radically unexplainable, provided that the tendency to persist in time is satisfied" [Meyerson (1951) pp. 111-112].

Identity is for Meyerson not only an a priori category: it is also plausible. "Plausible" is one of Meyerson's favourite notions to qualify the family of concepts assimilated to identity, and by it he means that these concepts are to some extent reasonable or probable, which is partially verified by the fact that sometimes we realise that nature tends to fulfil them — without complete success. The framework of identity is a priori, its content is a posteriori. Laws and causes reveal natural uniformities which would be impossible without the homogeneity of space and time; such homogeneity is presupposed in the search for laws and causes.

Meyerson's philosophy of physics is thus encapsulated in these three notions which, in his system, are synonymous: explanation, causality, and identity in space and time: "Concerning the notions of cause and causality in particular, we are not at all unaware of the fact that it is possible to define them in a way strongly different from ours, and we realise how shocking, to begin with, is the attempt to reduce these concepts to the precise assertion of the identity through time (and, by extension, through space). But the reason is that these notions appear to us as the sole ideas effectively used by science" [Meyerson (1951) p. ix].

He arrived at the conclusion that the intellect seeks causality-identity by a kind of analysis or interpretation of the workings of the mind. Aware of the eminent role played by the unconscious in thinking, Meyerson did not trust at all in the way scientists themselves talk about what they do since, like other people, "they do not perceive themselves thinking, and so their interpretation may be wrong" [Meyerson (1936) p. 110]. Concerning the general theory of

relativity, let us remember, for instance, how strongly some physicists would like to show that gravitational phenomena are just accidents in the geometry of spacetime [Meyerson (1925) pp. 92-93].

As is well known, the speculation that the motion of matter was to be understood as a variation in the curvature of space is found earlier in William K. Clifford's paper "On the space-theory of matter" (1870), an idea inspired by Riemann's notion of the constant curvature of space. From the point of view of the general theory of relativity, matter seems to be reduced to physical space which makes us think of Descartes' identification of matter and extension, and physical space is confused with geometry, where "confused" is not to be considered in a pejorative way for two reasons: in the first place, if matter is conceived as pure extension or space as in Descartes' physics, then, to that extent, the external material world, intelligible in itself, is also intelligible for us since there is a well developed science of space: geometry; secondly, the ambiguity of space – space as external reality, space as mathematical concept – bridges human understanding and extensive nature.

But panmathematism is a chimera. Indeed Meyerson finds these identifications illegitimate: matter and gravitation are not just geometrical space. If relativity theory explains matter and gravitation *via* these identifications, then this theory, in a way typical of any successful physical theory, eliminates what it tries to explain. And this elimination is clearer here than anywhere else in physics because the tendency towards identification is nowhere else nearer to its final achievement: "If electricity did not exist, i.e. if everything in nature were just mechanical phenomena, or if electricity could be taken back to mechanics, then all its essential phenomena, without exception, could have been predicted by a geometer of genius, all of them would be deductible. They become so if, to Einstein's theory, we join the extension made by Weyl. From then on, as Eddington states it, we can see the reason why the Universe has necessarily to have the form we have found in it" [Meyerson (1925) pp. 130-131].

The identification or reduction of phenomena to the properties of space produces laws and, consequently, a legal determinism since laws stipulate the identity or invariance of the *relationship* among phenomena by spatial translation. Now, if to the spatial identity of the relationship among phenomena the *identity in time of phenomena themselves* can be added, then there is causality and causal determinism: "In fact, if there is always a complete equality between causes and effects, if nothing neither appears nor disappears, it is the case that [in causality] not only laws but even things persist through time" [Meyerson (1951) p. 31].

There is determinism in the sense that from knowledge of causes it is possible to progress towards knowledge of their effects and vice-versa; and there is *causal* determinism in a sense Meyerson took from the scholastics

and Leibniz: *Causa æquat effectum*, "The whole effect can reproduce its entire cause or a cause similar to it" [Meyerson (1951) pp. 17, 19, 238].

Thus conceived, causality is a conservative principle: there is just as much matter or energy in the cause as in the effect. It is a renewal of a principle stated by Anaxagoras and which appears also as a leitmotif in the most impressive philosophical poem of all times, Lucretius' melancholic and lucid *De Rerum Natura*: "Nothing comes out of nothing… and nothing goes over nothingness". Plato, in the *Timaeus*, had already written that "any birth without a cause is impossible". In modern times it was a guiding principle for Lavoisier and Schopenhauer, among other scientists or philosophers.

A confusion present in many physicists' minds since the origin of modern science, and enhanced in quantum physical descriptions of phenomena, consists in treating determinism, lawfulness and causality as if they were roughly the same thing. Let us distinguish them. Modern, *scientific determinism* is, in a word, the human faculty to foresee phenomena with a high degree of accuracy by means of calculation. *Lawfulness* is the property of a series of phenomena of being ordered by one or several laws, and the functional law describes the way in which some phenomena vary together. *Causality* is an ontological principle which describes a property of the relation among real things. This principle adapts itself to various alternative definitions and one of them is the Meyersonian causality-identity already seen. According to another concept, it means that the same or similar causes produce the same or similar effects by translation in space and time. Yet another concept is a negative characterisation of efficient or motive causes: *ablata causa, tollitur effectus*.

II. Physics As an Impossible Endeavour

It seems to me that Meyerson is right in pointing out that the great principle *ex nihilo nihil* is essential not only to reason in physics and science, but, more largely, to reason in common sense. Consequently, spontaneity, chance, contingency, irreversibility in time, the universal constants, in a word, everything that is or implies creativity, everything not deducible from the unique rational a priori – identification – is irrational. The history of thought has revealed to Meyerson the existence of just one a priori principle of enquiry, identification: "Identity is the eternal framework of our mind. Thus we have no alternative except to find it in everything the mind creates, and we have noticed, in fact, that science is penetrated by it" [Meyerson (1951) p. 322]. "If it [reason] calls a halt somewhere [in its search for identity], make no mistake about it: it does it only [temporarily] because it is forced to do so, forced by something it knows as not coming from itself" [Meyerson (1936) p. 63]. Reason is a power of identification, i.e. causality, which means identity of

things in space and time, and a power of deduction from identity. Everything else is irrational.

As a remote echo of the Heraclitean struggle of opposites, Meyerson sees strife between rational unity and identity on the one side, and real multiplicity and diversity on the other. The like is known by the like, as the Ancients said, and so reason can know only what adapts itself to it. This is visible in physics as a network of equivalence relations and equations since for physics nature is understandable to the extent that what is now, was, and will be. When someone states an equivalence relation or an equation, when two members of a proposition are considered to be equal, it is not the case that there is perfect identity of all the aspects of the things represented: otherwise it would be absurd to write two sets of symbols representing two different phenomena or two different sets of phenomena. What is meant is that there is identity only in a quantitative sense. Physics retains only primary qualities. The rest has no physical meaning.

Since the beginning of natural philosophy in Western thought scientists and philosophers have tried to distinguish the real and objective properties of nature from those properties whose existence depend essentially on the contributions of our organism and mind. So, for Democritus, "there are two kinds of knowledge, real knowledge and obscure knowledge; to obscure knowledge belong the things of sight, hearing, smell, taste or touch; real knowledge differs from that kind of knowledge". "The sweet and the bitter, the hot and the cold, colour are nothing but opinions; only atoms and the void are true". The history of the hunt for primary qualities is very long and the main modern physicists and philosophers have participated in it: Descartes, Galileo, Locke, and so on up until now. The hope of finding the real properties of nature has never been abandoned by physicists who continue the search for invariants and symmetries. It is thought that much objectivity is gained by trying to express qualities in quantitative terms. Hence the importance of measurement and the invention of scales, as well as the importance of the physicist's criterion of meaning: a term has physical significance if it is quantitatively expressed. The advantage of quantity and number is that, numbers combined to numbers yield other numbers. This analytical extension makes it possible for hypotheses to be controlled in a precise way, an important feature of the growth of knowledge.

Meyerson knew how paradoxical it is to state that according to the notion of causality-identity, to explain a change means to show that it is only appearance, an epiphenomenon since the reality underlying it stays the same, whereas, on the other hand, causality was conceived by ancient thinkers like Aristotle precisely to explain becoming, change, generation and corruption. Anyway what remains through change is supposed to be something very abstract and theoretical such as atoms or energy. Let us remember that the concept of energy, as well as the principle of its conservation, was forged explicitly, un-

der intellectual pressure, to save the appearance of the continuity of something describable in quantitative terms, when other less abstract values, such as matter and weight, were found to vary through change. Nevertheless even physics' great conservation laws, often mentioned by Meyerson as examples of the satisfaction of reason's quest for identity, do not seem to be completely sheltered from the possibility of change. And of course we do not have any way of verifying that the total amount of energy of the world is an invariant – but in general, what is the value of our hypotheses concerning the Universe as a whole given that every verification and control can only be partial and local? These observations give us an idea of how strong reason's faith has to be in order to continue its search for identity through becoming. Intuitively it seems to us that when something changes, something stays the same; otherwise we would not say that *something* changes. If in some changes there were really gaps or intervals, the *ex nihilo nihil* principle would not be followed. Furthermore, in the nineteenth century it was commonly believed that what cannot be annihilated cannot be created, and conversely, that everything which begins has to end. Now since energy is not annihilated it follows, from this principle, that it did not have a beginning and is then eternal.

Insofar as reason searches for identification, every causal proposition (which postulates the identification of phenomena in space and time) seems plausible from the outset. Our understanding is prepared to accept it. And so, to rule it out, what is needed is nothing less than a down right denial from experience [Meyerson (1951) p. 162]. Sometimes reason is indeed successful in identifying, as is clear from the knowledge accumulated through the centuries. Sometimes it does not succeed. This is not astonishing when we realise that there are wide regions of nature oriented by an irreversible temporality and made up of untamed phenomena such as sensation and the universal constants which are not deducible a priori from identity. Clearly then, the relationship between a reason which tries to tame the real and the real which resists, is not an all or nothing affair. To think that nothing is intelligible is a baseless scepticism – why should we feign being more ignorant than we are –; to think that everything is intelligible is an excessive optimism: nature surprises us every day.

As a typical epistemologist, Meyerson avoids metaphysics and, cautiously, thinks that causality exists at least in those places and phenomena where it has actually been discovered, while recognising the existence of many phenomena resistant to identification. On the other hand, it seems to me that epistemology is a minor discipline necessarily based, consciously or unconsciously, on metaphysics. This is why to solve or undo epistemological dilemmas or paradoxes sometimes what has to be done is nothing less than to bring to the surface the metaphysics underlying epistemology in order to modify it, and this is what I intend to do now. Paradox is nothing but appearance. It

exists only symbolically in our representation of nature. Let us then abandon Meyerson's scruples and get back to metaphysics.

III. ONE NATURE

Meyerson mentions "the causal illusion" [Meyerson (1951) pp. 315, 319] which consists in considering that, if physics were successful in everything we try to explain, then the demonstration would be accomplished that everything is made of just one *stuff*, and that, contrary to appearances, nothing happens since cause and effect are interchangeable. Yet this is illusory given that sensation, which is our first contact with external reality, shows the diversity and irreversibility of phenomena. So once in a while we are forced to choose between physics and common sense, and it seems to me that it is wise to reject the fictions of mathematical physics, for instance, when it tends to eliminate the irreversibility of time and when it tries to reduce everything to perfect identity and unity. "It is impossible to meditate on time and the mystery of the passage of nature without an overwhelming emotion at the limitations of human intelligence" (Whitehead). Concerning other points of disagreement between common sense and physics, good sense will probably force us to stand by physics.

According to scientific realism, science has the last word concerning what there is, whereas for common sense and philosophy there is no reason to think that under all circumstances science and physics in particular is a better knowledge of nature: after all, as physics progresses, its high abstractions grow apart from concrete reality more and more and only a very careful examination of its abstractions can tell us whether physics, in a given situation, is or is not on the right track. So happily we have both common sense and philosophy to help us carry out this critique. My conclusion is then that there is no valid reason to think, systematically and in all cases, that physics has the last word concerning reality. All three of them – physics, common sense and philosophy – stand on an equal basis and much is to be gained by considering any two of them as critics of the other one. And before distributing priorities, one would have to examine the concepts of intelligibility, explanation and understanding: what do they mean; what do we expect from them; what are their objectives. Such an analysis would show that scientific realism is far from evident.

In order to remove the apparent paradoxes of physics I go on to propose – and contrast to Meyerson's ideas – some arguments developed from the point of view of a realist metaphysics. Nevertheless, and before this, it is important to remember that he based his epistemology on a great deal of detailed analyses set forth on several voluminous works which make up a rich source of information for the historian and philosopher of science. Meyerson,

eloquently, leaves no doubt: physics actually works and progresses as he describes it, and his analyses of the way physicists work, his hermeneutics of their science, is correct. This means that any indication about the manner to dissolve physics' paradoxes has to be as profound as the depth of the roots of these paradoxes.

The main root is a metaphysical dualism with Cartesian origin: the world is divided in two, mind and matter. There is the observer and the observed. These parts are supposed to have quite different properties, the main difference being, from a Meyersonian point of view, that to the physicist's rational search for identity there does not always correspond an identity in nature: indeed what is sometimes found seems to be an irreducible diversity. Descartes' dualist heirs renew the paradoxes of the relationship between man and nature. Jean-Paul Sartre, for instance, ends up by saying that man is a useless passion because consciousness, which is nothingness, strives during the entire life to be some *thing*, which is impossible. We could say, similarly, that for Meyerson, understanding is a useless passion as far as it tries to explain everything by reducing it to identity.

Consider, as a critical excursus, that against Meyerson's discovery according to which physicists and scientists in general seek identity, we can observe that science has also developed by denying unity and thus by exploiting a tension between opposites: in mathematics, the finite and the infinite, discontinuity and continuity (this paradigmatic opposition has been immediately inherited by mathematical physics). Then in physics we witness also the opposition between space-time and matter-energy. The biological sciences have been marked by the opposition between mechanism and vitalism, by the duality of physico-chemical forces and final causes. Nowadays, consider how the psychological sciences progress thanks to the opposition between brain and mind. This series of paradigmatic oppositions is clearly an alternative way of conceiving the progress of science: when in a given period scientists favour one of the members of the duality, some other scientists show that such a member does not explain everything and go on to develop the possibilities offered by the opposite.

Here is an important caveat: the correction of the Meyersonian analysis of physics means that my critique is primarily addressed to the foundations of this science and, only secondarily, to Meyerson himself. Meyerson is here criticised only to the extent that he did not try to dig deeper in order to see and remove the metaphysical grounds of the paradox according to which physics, through causality-identity, annihilates the object of explanation, i.e. change and natural diversity.

Cartesianism presupposes the existence of a mind facing nature and a material nature standing up against it. For Descartes nature was intelligible since it is extension, the object of a mathematical science, namely geometry. Geometry is the background of rational mechanics and rational mechanics is

the model for the entire science of physics. Time disappears: physicomathematical time, in this model, is reversible like the properties of space, that is, it is not real time. For instance, the film of the phenomena explained by rational mechanics, like some celestial phenomena, could be projected backward and that would not make any difference.

According to Meyerson, everything irreducible to identity in space and time is unintelligible – the list is long: secondary qualities, life, sensation, time irreversibility, Carnot's principle, all irreversible psychological, biological and physical phenomena, the universal constants, free will, action by contact, action at a distance, force, everything which is not spatial, the heterogeneity of cause and effect in the case of efficient causes, etc. It is this dualism of Cartesian origin which has to be revised if we want to have a chance of diminishing the kinds and the number of definite irrationals elements. How? I answer: by restoring the continuity between natural man and the rest of nature, by not forgetting that man is a natural, emergent system among others; by realising that nature, in the formation of man, including of course the emergence of his understanding, brings to bear the same mechanisms it engages elsewhere.

I remember these evidences to suggest that only the naturalism according to which there is a world-man continuity can be the basis of a science devoid of the kind of paradox and mystery uncovered by Meyerson. If Cartesian dualism is kept then only some parts of nature are explained by reduction to the unique a priori condition of identity; or else more a priori conditions are admitted (think, for instance, of the Kantian a priori apparatus) whose end result would be a larger success in explanation. But notice that in all cases, explanation, as the satisfaction of a priori conditions, appears as a miracle: there is no reason whatsoever why an a priori element, which could be one emerging from an infinite number of possibilities, should coincide with what is given to our experience of nature. On the other hand, according to emergent naturalism, man and his intellect is an emergent system among other natural systems, and it is emergent since, considered as a whole, it presents properties, behaviours and laws which are absent in its components: obviously our symbolic understanding is absent from our neurons taken in isolation. But emergence never occurs out of nothing, and, in the present case, our symbolic understanding presupposes, at least, a biological basis: the brain, and a social basis: communication. Thus in emergence, in a sense, there is discontinuity – coming-to-be of new properties, behaviours and laws – and, in a different sense, there is the continuity of space, time and causality, since the elements of the new system were already there, the novelty being the result of a new combination of old components. The like is known by the like: it is then the continuity of these old components in human understanding, the fact that the understanding shares with other parts of nature some elements and structures, which, metaphysically, filters out the mystery of explanation. For instance,

the laws of mechanics are inscribed in our own body, and this is why mechanical explanations seem so natural to us, and this is probably also why physicists developed mechanics before the other disciplines of physical science.

IV. Criteria of Reality

Physics is for Meyerson the endeavour to explain reality, and his criterion of reality is the resistance to identity and to deduction from identity, a resistance to what the mind is capable of developing by its own means. As we saw, the examples given by Meyerson make up a long, impressive list of irrational elements. But what valuable reason is there to state that only things rebellious to reason are real? The objects external to the subject that we get to understand in a Meyersonian way do not, for all that, become unreal. Consider, for instance, the phenomena explained by rational mechanics: they are real before and after explanation. True, the resistance to our power of a priori deduction is an efficacious rule to determine the real as anything mind-independent, but there is no reason to think it is the only rule, and what I have just said, that some explained things do not cease to be real after explanation, shows that Meyerson's criterion cannot be the only one. Here is a better criterion, composed of two parts, which includes Meyerson's: (I) *Invariability*: something is real if it is independent from our subjective states, if it remains the same, whatever we do. The Moon is there where it is and at a certain distance from the Earth, regardless of the means we use to establish this: consider the first ingenious strategies of Greek astronomers like Aristarchus of Samos who observed lunar eclipses, the method of parallax, the use of radard, the time it takes men to reach the Moon at a given speed, and today's use of laser light reflected on the large reflector placed on the Moon's surface by the Apollo astronauts. Of course I do not mean to say that all these ways of measuring give exactly the same result (the average 384,400 km), but these are different ways of proving that there is really a natural satellite at a given distance from the Earth. (II) *Causal efficacy or sensibility*: to be is to act. Something is real if it is the agent or the patient of a causal action. Thus a real thing can stand up against us in several ways, and not only as far as it is irreducible to a priori deduction. By "causal efficacy" I do not mean only the action of the efficient cause or motive power as modern thinkers interpret it: I extend this efficacy to any of the four causes of the Aristotelian tradition inscribed in the motive power. All these kinds of causes act, and because they act, they are real. Nothing indicates that Meyerson would not have agreed that invariance, variously verified, is a reliable criterion of reality. But he would have partially rejected causal efficacy to the extent that he rejected the four Aristotelian causes.

The point I have just made, useful to undermine Meyerson's scepticism and the paradoxical way of viewing physics, is that legitimate criteria of reality exist which allow us to say that something is real even if it is understandable. Let us continue the examination of Meyerson's presuppositions.

V. Towards the Realist Metaphysical Solution of Meyerson's Paradoxes

In Meyerson's philosophy, physics has a realist beginning since it tries to explain natural diversity and real change as they are given to our perception. Physics presupposes the concept of external thing.[2] From this undeniable epistemological leaning Meyerson concludes that positivism is wrong. Thus Auguste Comte and Ernst Mach, among many other philosophers or scientists, have not understood the psychology of physicists: a true physicist is never satisfied with a disordered collection of laws; he does not think that his science is just a patchwork of laws: he sees his discipline as a contribution to the true image of nature. We can add today that all the major physicists, including those who have developed quantum physics – a theory which is rather far from given us a coherent image of reality – have indeed seen themselves as natural philosophers and they have seen physics as natural philosophy. Negatively put: most physicists today are not happy with the positivist idea that physics probably can only be a recipe which works, a calculator. Meyerson was an anti-positivist and very often his discussions, in all of his books, begin by showing the handicaps of positivism and, in particular, by showing what is wrong with Comte's doctrine. Since the lowest common denominator of positivistic doctrines is the rejection of metaphysics, I regret that Meyerson, since he did not give to metaphysics the importance it deserves, did not go far enough in his rejection of positivism.

The way physics begins its enquiries is one of the sides of the paradox which consists in transforming the realism of this beginning in an idealist end. This occurs because since Descartes and Galileo to today's physics, physical theories look for mathematisation, for a mathematical explanation of natural phenomena where mathematics is either applied to physical concepts previously existing, or, more strongly, by constituting physical concepts, so to speak, "from the interior" (I mean concepts indescribable without mathematics such as acceleration, entropy, the curvature of space-time, and so on). The first pole of the paradox is the observation that there are external, material things subject to becoming. Think, for instance, of the movement of matter resulting from gravitation, consider the decrease of useful energy, and so on. Nevertheless physics, in its most developed theories, tends to do away with moving matter by stating, at least according to some versions of the general theory of relativity, that what counts in these phenomena is the geo-

metrical structure of space-time. Meyerson would have seen a further proof of his epistemology had he had the opportunity of knowing that, according to Gödel, it is possible to show mathematically that the Universe, following the general theory of relativity, could be reversible, a possibility Einstein said should be avoided for physical reasons. Matter is reduced to a mathematical structure, becoming can be shown to be circular and time reversible: such is the second pole of the paradox, the idealist result of the intransigent a priori requirement of identification of phenomena to space and time. Physics develops towards a panmathematism Meyerson, as we have already seen, considers an extravagant ambition: the Universe is not just an algebrico-geometric structure. There is matter and its mysteries which take us by surprise at every corner of the world, and the great natural variety of things is not reducible to an abstract concept of space, as some relativistic physicists have thought. This reminds us of the way the romantics followed by some phenomenologists and existentialists have judged mathematical physics: they think this science creates a fantastic world inhabited by mathematical or theoretical entities and laws, by Platonic Forms: it has nothing to do with nature as it is given to men of flesh and blood. Meyerson, quite conscious of this, says that physics creates ontology; the romantics, the phenomenologists and the existentialists say: physics creates a world of fiction.

The omnivorous tendency to explain everything by reducing to it to the properties of reason is present not only in physics but also, of course, in philosophy, where this plan has been constructed with the tools of ordinary language. This programme has not given a true science. Consider, for instance, Hegel's or Schelling's attempts. In several of his books Meyerson has compared in particular Hegel's philosophy of nature to other systems like those of Descartes and Einstein.[3] The point they have in common is the unreasonable and excessive hope of deducing the entire nature from a few ideas by making the most out of the generativity of our symbolic systems. Hegel chose qualititative, ordinary language, and with it he wanted to explain even sensation, mental and cultural phenomena. Einstein's programme, based on the possibilities of mathematics and restraining itself to primary qualities, was less ambitious but more fruitful.

In the Meyersonian epistemology one of the main paradoxes of physics is, as we have seen, that it has a realist beginning and an idealist end. The way to solve it seems evident: consider the entire process of knowing exclusively from a realist point of view, or, exclusively, from an idealist point of view. The second way contradicts several important realistically oriented convictions of the French philosopher: there is a world independent from our minds yet knowable to a certain, limited extent – remember his criterion of reality. And there is also his remark that science presupposes the concept of thing. The object of physics is the explanation of external phenomena given to our perception. On the other hand, Meyerson's main idea presents a defi-

nite idealist character since, for him, what is essential for there being knowledge is contributed by reason, not by external nature: nothing can be known which is not moulded or certified by the mind. In nature there is diversity and change understandable only as far as they collapse in reason. Meyerson's philosophy is then neither realist nor idealist; his is a third way running more or less at equal distance from both doctrines. I do not think it would be difficult for idealists to solve some of Meyerson's paradoxes by extending his field of a priori requirements and powers: this is what Kant and Husserl have done; this is what idealists generally do.

Meyerson's problems clearly arise then from his lack of metaphysical boldness. Since he learned from the history of science that reason imposes on things just one a priori condition, he did not feel at all authorized to add some others. Indeed being very careful in forming our beliefs is a virtue, but it is not the only one we expect to find in a thinker. Following the concept of philosophy guiding the great thinkers and deployed through history, I see natural philosophy as the search for a comprehensive and true system of ideas where every system and every experience could find its place. To build such a natural philosophy it is necessary to have deep ideas whose consequences can be seen far away. Meyerson would have certainly classed this programme among those attempts he denounced as being too ambitious to be reasonable. It is his opinion, and it is above all the reason why he developed a philosophy of the intellect instead of a metaphysics or a philosophy of nature. But now we find ourselves, by necessity, on metaphysical grounds since it is the only way of avoiding the paradoxical procedures of physics.

VI. Unity Within Diversity

We have already exposed two properties of a realist metaphysics: a criterion of reality and a brief description of emergent naturalism. A third major idea is that identity and unity exist not only in the intellect but, ontologically, before that, they exist within the diversity of natural beings and objects. I have in mind the long tradition of form: natural things, as Aristotle observed, are not only matter, they are a form and have an essence. Forms are archetypes or paradigms inscribed in natural things – they do not inhabit a world apart, as Plato mistakenly thought. Nevertheless for both thinkers and actually for most philosophers of their time – the sceptics were the exception – it is because things have a form, or because they participate in a form, that they are knowable. Without form there is no knowledge. The form is the identity of essence within the diversity of things, the one in the many. It follows that archetypes or forms are the metaphysical bases of analogy.

In physics, mathematics has made it possible to realise that phenomena, visibly different, do share one and the same structure. If one and the same

equation applies to different sets of phenomena the proof is made that there is in them a hidden analogical structure, and this unveiling is the main value of mathematics for the natural sciences. And then, of course, the phenomena covered by one and the same law have among them analogical relations. Notice that empirical laws are ways of disclosing the unity and identity of phenomena, of revealing what is essential in them, and that at a superior level of abstraction, theoretical laws and entities summarize empirical laws. Furthermore there is also the order seen in the world of living beings: species, genus, family and so on up to life: at each stratum of this hierarchy there are some characteristic analogies useful to define the stratum. These archetypes are the answers given by nature to the problems encountered by these beings in order to live. Classification is one of the first stages in a scientific enquiry. Natural analogies make all that possible. Abstraction of identity and unity is thus another important realist point absent in Meyerson's mind. It is important to realise that the main element responsible for the Meyersonian struggle between the a priori search for identity and natural diversity is the absence of the concept of the identity and universality of form, the account of what-it-is-to-be, for instance, the shape of an animal, its idea. The identical ideas immersed in things, the shape of things, are repetitive. It is because there is repetition of identical forms (archetypes) that there are natural analogies, and it is because there are natural analogies that reasoning by analogy, which is a kind of induction, can be a road to reality, thus helping us to reduce ignorance and scepticism.

Realist metaphysics implies neither an exhaustive nor a naïve epistemological realism. Given our own properties and limitations as natural systems among others, not everything is observable and understandable, our point of view is forcefully partial, and what is observed and understood are some real aspects of things. We have no idea of what perfect objectivity could amount to concerning the external world or mind itself. Then, as we cast our eyes over the infinitely small and the infinitely large, our intuition of things becomes fainter and rapidly disappears – our knowledge becomes symbolic belief. In the most developed physical theories, this belief concerns the supposed capacity of mathematics to represent the world. As far as realism is concerned, what counts is the recognition of the fact that the essentials for there being knowledge and understanding are contributed by reality: order, pattern, causality, stability, unity, analogy and reason exist first in the nature outside the mind, and only secondarily and in a derived manner in the nature inside the mind, in our understanding. We have, once again, abandoned Meyerson.

Nature is intelligible and some of this intelligibility is accessible to us. Those of us who try to build a coherent and comprehensive real metaphysics and epistemology, to avoid any internal contradiction, have no choice: we have to presuppose that intelligibility is a real property of nature. Now the idea of abstraction means that our understanding has an active role in the

process of actualizing nature's intelligibility in our minds, but even if some aspects of the intelligibility grasped are manufactured, this does not imply that order, causality, stability, unity, analogy and reason are man's inventions. Notice that no animal could live if its representation of the world did not essentially correspond to the world. This realist metaphysics concerns first of all some basic and vital elements and needs. I am not interested in discussing here whether realism, as an interpretation of the latest and very sophisticated theoretical entities and laws in physics, is right or wrong. Realist metaphysics is not to be confused with scientific realism. Scientific realism is a truncated metaphysics, actually another name for a kind of reductionism: scientific materialism.

VII. Causality-Identity and The Four Causes

Meyerson's notion of causality-identity is the exact opposite to Hume's conception. In Hume's analysis, temporal asymmetry is essential: the cause precedes the effect. Aristotle does not require this condition and Meyerson sees in physics, more radically and more generally, the systematic tentative to eliminate time.[4] Hume writes: "In a word, then, every effect is a distinct event from its cause. It could not, therefore, be discovered in the cause; and the first invention or conception of it, a priori, must be entirely arbitrary" [Hume (1963) p. 39]. For Hume, we do not have the perception of any information passing necessarily from cause to effect and so from the knowledge of the cause nothing can be known about the future and vice-versa. Now if – what is even more serious – between cause and effect there is only an arbitrary connexion, then no inferential knowledge of nature is possible at all: scepticism follows. But Hume's statement is simply unbelievable and goes against our most evident experience of nature. People's acceptance of Hume's analysis of causality – beginning with Kant – has always been a mystery to me.

If Hume's statement were true, nature would not be stable: anything could follow or grow out of anything and we would be condemned to a solipsism of the present moment. However one of the most solidly established truths is the existence of communication, and, before that, the truth of the existence of a stable world: in nature there is structural stability, order, analogy, repetition, uniformity. Thus Hume's position on this point is quite wrong both from the point of view of common sense as well as from the point of view of science as science is actually carried out. Many physicists tend to repeat Hume's words on causality but it is a well known fact that often scientists say one thing about what they do while proceeding differently. In the present case, fortunately, they do a different thing. Notice how interesting it is to realise that both conceptions, Meyerson's causality as an identity between cause and effect and Hume's causality as an arbitrary connection between cause and effect, lead

straight to different forms of scepticism. We are thus forced to look for some light elsewhere.

Because of its non reductive character I suggest to reconsider the Aristotelian doctrine of the four causes. Of course this is not the place to review this doctrine in a detailed way. I will say just enough to show that on some critical points the Aristotelian notions of formal and final causes may contribute to the reduction of scepticism. Let us remember that according to Aristotle, there are four kinds of causes, i.e. explanatory principles which are as many answers to four kinds of important questions. Given an oak tree leaf we can ask: what is it? The answer is the essence of it, the formal cause. The answer to the question: Out of what is it made? is the material cause. By what agent? The answer is the efficient cause. And the answer to the question: for what end? is the final cause.[5] Now if we consider these four kinds of causes we can say that Meyerson sees an explanatory value only in structural, formal causes. I will explain this a little later.

Concerning motive and material causes, Aristotle and Meyerson – once their conceptions are adapted so as to make them comparable – agree in that those kinds of causes are not the main elements of intelligibility. For Aristotle, matter and motive causes *condition*, each in its own manner, what is to be done. But the *sense* of material activity and the *sense* of the action of motive causes come from the model to be realised (formal cause) and from the objective (final cause) of the entire process. Meyerson rightly states that no one really knows what matter or energy is. (Let us say that matter is an inexhaustible source of information and surprises). To be sure, matter and energy are not things given to our senses. They are the hypothetical substrata of phenomena postulated in order to show that something unobservable remains identical despite observable changes. So matter and energy, which in physics are ultimate explicative principles, from a metaphysical point of view are themselves in need of explanation. At least in classical physics matter can explain only if it can be reduced to a multiplicity of identical atoms.

Efficient or motive forces, generally introduced to explain movement and change, just like matter, cannot be explicative, unless they can be reduced to identity. How can this be done? By considering every conceivable change exclusively as a series of displacements, i.e. atomic changes of place in a homogeneous space. This is the closest we can get to saying that, even if something varies, nothing happens. Think, for instance, of inertia in Newtonian rational mechanics. In Meyerson's account of physics, displacement is the most simple and easiest phenomenon to understand, and we can say then that it is the first principle of mechanical and atomistic intelligibility. Now whether it is also the first principle of intelligibility *tout court* is a different matter. As far as I am concerned, the first principle of intelligibility is form.

Meyerson's notion of causality-identity is neither a kind of motive cause nor a kind of final cause. The first, in its modern sense, requires tempo-

ral asymmetry, which is required, as we saw, neither by Aristotle nor by Meyerson, and final causes are explicitly rejected by Meyerson. Causality-identity could be a kind of material cause in the sense that primary matter is conserved through all change, just in the sense that nineteenth century physicists elaborated the principle of the conservation of energy to make sure that something remains unchanged when matter and weight vary.

I would say more willingly that causality-identity is, neatly enough, a kind of formal cause. It is not that the other kinds of causes are not considered at all by Meyerson. What happens is that, as far as explanation is concerned, only conservative, formal causes have explanatory value. For Aristotle, the formal cause is an ambiguous entity meaning both the figure of an object (let us think, for instance, of the form of a boundary of a material object shaped by the change of phase of matter) and its idea, essence or definition. What counts in our Meyersonian context is form as essence: everything strives to carry out its essence which acts as a model. Now if to this notion we give a structural, quantitative interpretation, we can legitimately say, I think, that formal causes are present in mathematical physics. Even if everything in nature is not mathematical, the architecture of physical phenomena is structured or modelled by archetypes, invariants, symmetries, regularities, laws and equations.

In point of fact causality-identity is a kind of formal cause provided we accept two semantic changes: the first is to reduce the notion of form to what can be mathematically expressed. The formal cause in physics is an invariable structure or magnitude. Mathematical formalisms, equations, are the essence, the logos: they are the order of phenomena. But notice that this modification is not a major change since Aristotle himself gave, as one of the main examples of formal cause, the existence of mathematical proportions.[6] The second adaptation of the meaning of form requires considering every phenomenon not *as something individual* but as phenomena ruled by laws: the form is the law, the function, the mathematical relationships among phenomena. For Aristotle the formal cause is mainly the idea, the model which guides the development of natural beings so that they can become the adult individuals they have to be. He thought in biological terms and so, to follow him here, we also have to adopt his biological attitude, and this explains the following brief detour into living matter.

Now if in the only sense that counts for physics, the quantitative aspects of phenomena, the cause is identical to its effect, there is no change, but, again, causality was introduced precisely to explain the several kinds of change we experience. This strange situation results from the truncated metaphysics according to which only primary qualities are real, physical and significant. On this topic Aristotle's metaphysics is wiser than the image of physics drawn by Meyerson. In the first place, it is remarkable that Aristotle stated that in all kinds of change, including substantial change, there was a

preservation of a *materia prima*, a substratum of every form, even though he did not have ways to measure it. His statement was derived from his principle that the matter of everything is eternal. It persists through all change. He stated clearly the doctrine of the conservation of matter and, in this sense, he thought, as I said, like the nineteenth century exponents of the law of conservation of energy. But Aristotle's metaphysics, being less reductive than the one which founded modern physics, has no problem recognising that in change, substantial change included, something remains. For instance, when only some properties vary, one can show that some others remain, and so there is continuity of something and discontinuity of something else in what is, fundamentally, the same thing. On the other hand, when there is substantial change, what remains is, as always, primary matter, whereas what changes completely is form.[7]

Form and finality are two aspects of the same fact. A thing would not have the function it has if its form were different, and vice versa. For Aristotle, nature is teleological. Every natural being tends to an end. In nature there is tendency and finality. Tendency is in fact a criterion for knowing whether there is finality. And this criterion can be made more explicit by adding that, if there are proportions well taken in order to achieve something, then there is finality. There is finality when a high number of (relatively) independent causes and elements of different kinds collaborate together in order to produce the end sought. Among the classic examples described by teleological thinkers we find these: a chicken egg, unless there is an accident, i.e. the action of elements foreign to its normal development, will grow up harmoniously to become an adult chicken; in the formation of the digestive system, numerous physical, chemical and biological elements, working in quite different causal series, gather together to give shape and guarantee the functioning of the entire vital apparatus, and in order to prevent the system from assimilating itself, it protects itself by constructing the epithelium. One of teleologists' favourite examples is the setting up of the visual system. The world of living beings just cannot be conceived without finality. The idea that every element in a living being is there for a reason, that it makes sense, that it plays a role in the life and in the survival of the organism guides the biologist's enquiries. Biologists can feign there is no finality and act as if what they do had nothing to do with teleology, but that is only appearance.

Clearly then, formal and final causes are directing or organising powers. The reason I call attention to this fact – it is a fact – is to point out that in many ways, extra mental, unconscious biological nature acts like conscious beings. There is form and finality above all in every biological entity, organ or organism, conscious or unconscious. To recognise form and finality in nature amounts to recognising order, organisation and therefore intelligibility in nature itself: intelligibility, as I have said, is not a gift human reason offers to nature.

Indeed nowadays for most people finality is a remnant of a bygone age. Joining the long series of modern philosophers and scientists who think that the rejection of final causes is essential to modern science, Meyerson claims that final causes can only be provisional explanations: they can be useful where causality-identity has not penetrated yet. But in those places where this causality begins to show itself, teleology moves back – a fortiori where causality-identity is established. Finality, for Meyerson, presupposes something which disgusts reason, namely that a future event can have an effect on something existing now. This is so shocking for reason, that many thinkers have preferred another idea, almost as shocking: the efficient or motive power is identical to the final cause, the past is identical to the future and the Universe is just one natural block. Nothing happens. Furthermore, since for Meyerson finality implies consciousness, it cannot exist in non conscious beings or objects. Referring himself to the notion of directing power, he says that conscious freedom is needed. If the builders of a house have not conceived a house themselves, as conscious human beings they can freely choose to follow the architect's directives. But non-conscious beings or objects are supposed to follow inflexible laws; there is no choice, everything is determined. The idea is then that for there being finality, freedom or contingency is needed. Now since freedom and contingency – if they exist – are lawless elements and, a fortiori, not causally explained, they are irrational. It follows that teleology is, at best, according to our author, a provisional explanation, a scaffolding to be cleared away once the true explanation is found. Teleology is always irrational and it is, at worst, inexistent.[8]

Meyerson's judgment on teleology is correct as long as one accepts *his* notion of finality which is clearly the traditional way of considering it. But it is possible to develop a naturalistic reinterpretation of teleology and of the formal cause which does not present the properties rejected by most critics. Remember what I have said about final causes and, in particular, the criteria I gave for there being finality. According to that, nature abounds with teleological systems. Moreover consider the following properties which are not subject to Meyerson's criticisms: not everything directs itself towards an end (there is no panteleology); not every final cause requires consciousness or freedom (for instance, insects work unconsciously towards a collective end); teleology is immanent to many natural systems (the question of a possible end for the entire Universe is meaningless); teleology is not anthropocentric (things do not exist for our wellbeing).[9]

The point of the above discussion on causality is to suggest that the thought process in physics would probably be less paradoxical if, instead of searching exclusively for a causality-identity, physicists were more receptive to a richer and more sophisticated notion of causality such as Aristotle's doctrine of the four causes.

VIII. From the Philosophy of the Intellect to the Philosophy of Nature

Since the beginning of Western modern physics in the seventeenth century, mankind has developed as a two-headed animal: one head works with physical categories while the other applies psychological ones. The result is a series of wide ranging natural and cultural divisions. Natural, since nature is seen as composed of discontinuous strata such as the physico-chemical stratum, that of living beings and the stratum of consciousness. Cultural divisions, since the categories of the natural sciences are not those idiosyncratic to the social sciences and the humanities. There is not yet (and maybe there will never be) a comprehensive philosophy of nature capable of giving a harmonious explanation of all the kinds of systems of the world. We do not have the suitable concepts to bring to a successful conclusion such a project. In spite of that, it seems to me that the construction of such a comprehensive natural philosophy is the most interesting and significant metaphysical programme.

The remark concerning the division of nature and culture has been made by several philosophers and poets rebellious to science, while, on the other side, physicists have tended to become scientistics: even if physics is no longer considered omnipotent, it is often thought that experiences and concepts are meaningful when they satisfy physics' principles and criteria. Now this opposition between physics and the other cultural activities has taken place between different people or schools of thought, and so, what is remarkable in Meyerson's account of physics, is that this opposition lives, consciously or unconsciously, in every physicist's mind. The physicist begins by wanting to explain natural change and diversity, but he ends up by denying both. The opposition between empirical knowledge and reason is thus re-enacted.

From the French philosopher we have inherited several paradoxes and enigmas in the workings of physics, and our problem is that what he says often sounds convincing. We feel and think that there is, or that there must be, a smooth transition from the senses to reason: then why is reason so tyrannical and ruthless? If the search for causality-identity is an a priori requirement for every search for explanation with no counterpart in the diversity of nature, how is it that reason in physics sometimes does explain, does get the identity and the unity it was looking for? (Remember what I said about analogy and the identity of real forms). Are these paradoxes and enigmas the price to pay for our mathematical physics? Is the expression *mathematical physics* an oxymoron – how can the eternal and motionless explain things which are temporal and in motion; how can mathematical form explain matter-energy? These are major problems and this is why I said that only a revision of the metaphysical bases of physics is likely to afford some light. The main change

I proposed was to abandon the dualistic Cartesian background of physics and develop in its place an emergent comprehensive naturalism, a realist meta-physics. As long as physics continues the way traced since the seventeenth century it will be one of the best illustrations of Paul Valéry's sentence: "The human mind is absurd by what it looks for; it is great by what it finds".

Département de Philosophie
Université de Strasbourg
14, rue Descartes
67084 Strasbourg Cedex. France
E-mail: miguel.espinoza@orange.fr

NOTES

[1] "Science looks for explanation" is the title of Chapter 2 of Meyerson's *De l'explication dans les sciences* (Paris: Payot, 1927). Most of the examples designed to justify this scientific aim are taken from physics. (All the translations of Meyerson's quotations are mine).

[2] The title of the first chapter of Meyerson's *De l'explication dans les sciences* is "Science calls for the concept of thing".

[3] *Vide*, for instance, *La Déduction relativiste*, Ch. X "L'explication globale" where Meyerson compares relativistic physics as a system of global deduction to Hegel's philosophy of nature, *De l'explication dans les sciences*, Livre III, Ch. XI "La tentative de Hegel", Ch. XII "Les objections de Schelling", Ch. XIII "Hegel et Comte" and Ch. XIV "Hegel, Descartes et Kant".

[4] *Vide* Meyerson (1951) Ch. VI "L'élimination du temps".

[5] See, for instance, Aristotle, *Physics*, II, (3).

[6] "In another sense (2) the form or the archetype, i.e. the statement of the essence, and its genera, are called 'causes', e.g. of the octave the relation of 2 : 1, and generally number, and the parts in the definition". Aristotle, *Physics*, II, 3, 194 b 26-29.

[7] *Vide* Aristotle, *De Generatione et Corruptione*, I, 2, 317a 17-27.

[8] *Vide* Meyerson (1951) pp. 359-364, and *De l'explication dans les sciences* (1927) Livre II, Ch. VII "Les phénomènes biologiques".

[9] The reader can find many marvellous examples of this naturalized teleology, among others, in Paul Janet (1876).

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