On the first part of his activity, Gr. C. Moisil shared (and his ***Logical Pluralism*** *bears witness to that) E. Meyerson's opinion that physics is not possible without metaphysics. Nor is, added Moisil, mathematics without epistemology, i.e. science – without a philosophy, because the positivistic imperative of eliminating philosophy was based on a philosophy too. Nevertheless, the studies in which he expressed his philosophical ideas were quite scarce before 1946, while in the second part of his life, when the importance of philosophy seems to have diminished in his eyes (assigning it the mere role of unifier of scientific knowledge) we only find them in his volumes of essays or interviews..*

This division into two periods (1925-1945 and 1946-1973) is also valid for his scientific creation. It was not determined by external events or an internal crisis; it was perhaps the result of a certain oscillation between the two main fields of his scientific interests: mechanics and logics, or rather, natural sciences and humanities.

Moisil's ideal of happiness was "to live among people who think correctly". Certainly, in order to converse with them. He turned this passion, which had become a vocation with him, into an actual model of knowledge based on the dialogue between the knowing subjects. A model he brilliantly presented in a 1945 lecture quite significantly entitled ***I and the Others****, which he delivered as part of the cycle Science and Knowledge (and which deeply impressed the then student Mircea Malița). He had phrased it in more detail in 1940-1941, in his study* ***Determinism and Concatenation****, written for O. Onicescu's seminar in the philosophy of science, and in 1965 he mentioned it in the afterword to [14].*

His ability to converse, to consider the others his equals (even if "officially" it was otherwise, for instance, he was the professor and they were his students) originated in his capacity of repeated halving (of taking his thoughts for an object, a subject for meditation, and the result – again for an object), in a transfinite recurrent process. He described it (quite significantly – in a dialogue too in which he argued the impossibility of carrying out the apollonian and the Socratic urge to self-knowledge) on some sheets of paper he had preserved since he was 20. It is an operation (which he later called thematic regression or the iteration of thematization) which strikingly resembles "the paradox of the spiral ego", discovered by A. Koestler at about the same age and time, and which he turned into a fundamental principle of knowledge (in ***The Act of Creation****). Moisil mathematized it in a number of books of "elementary" logic, under the form of deductive schemes of various orders.*

In the first group of essays (from 1939-1945), "freedom" appears as a leitmotif – axiomatic freedom (in choosing principles), freedom of assertion (in asserting one's own thoughts) and freedom of sympathy (in communicating with the others). This is however a limited kind of freedom, one that imposes its own exigencies: coherence (the compatibility of axioms), correctness (the use of correct patterns of thinking) and communicability (the existence of certain transformation rules, rules from passing from One to the Other). Since, even if the subjects have access to the concrete, communicability is not perfect, it is necessary to give up the particular and the accidental in the intersubjective relation and to carry it out using only universals. The known "real" thus becomes "a class of inexact representations", a group of abstract invariant significations..

Following in Poincaré's footsteps, Moisil gives up the Kantian apriority of the spatial-temporal and logical forms of consciousness, replacing it with an a priori consisting in an epistemological group of spatial transformation. To this he adds an epistemological chain of temporal succession, and later, an elementary logic still based on chains, but also on lattices.

In ***Determinism and Concatenation****, the outer world still appeared in this collective, dynamic and constructive epistemology (inspired by Einstein's relativity and by quantum mechanics), in which he came to "the construction of a reality that collaborates with us and with which we collaborate, creating and observing it, that is, putting it in circumstances in which it creates itself, according to the question asked and to its possibilities". The assertion that "geometry and logic [..] reflect the problematic nature of reality in the structure of the concept of truth" does not mean in this case that reality imposes a certain logic on the subject, because its nature is determined by the way in which the subject conceives it.*

Later, in ***I and the Others****, the given reality disappears entirely from the scope of the subjects' interest, so that the result of knowledge and communication seems purely imaginary. It is only in the afterword to [14] that he defines his model more accurately and reintroduces*

the objective world in the dialogue, because "comparing one's own experience with that of one's fellow men is conceivable only as a continuous reference to the outer reality". However, he is now more favorable to a genetic epistemology (perhaps influenced by Piaget's ideas) and finds out that, by using chains, he had succeeded in building elementary logic and temporal succession, but their algebraic theory had proved uninteresting.

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Leaving aside the superficial philosophical conventionalism (which he admitted he had adopted out of idleness, or rather, I would say, because it gave him a free hand), I do not think we can speak in Moisil's case of philosophy proper, but of a philosophical position – rationalism (which he defends and enlarges upon together with O. Onicescu and A. Dumitriu). He argued his confidence in human reason by pointing out the faulty character of instinct and reason, but also the incorrigibility of the former as compared to the correctable character of the latter (in human ethics – the constancy of evil, as opposed to the expansion of good).).

His rationalism was of a non-dogmatic type, one that focused on ego, reality and science ("learn to doubt yourself whenever you think you are right", he told himself and others), eliminated the apodictic certainties in science (by introducing the non-Euclidian geometries and the non-Chrysippian types of logic), and accepted the extensive and intensive non-finitude of science ("a problem is never solved, it is more or less solved"). In the ephemeral character of knowledge he discovered proofs for its eternity ("the laws enunciated by science are definitively known exactly because, since they are provisionally known, the new ones include the old ones").

Mathematics was to Moisil the center of resistance of rationalism to such an extent that he considered the degree to which a theory was scientific to be given by the degree to which it could be mathematized. At this point, his belief turned into a real pan-mathematicism, and this was based on the remark that "whenever limits were mentioned with regard to mathematical knowledge, they were transcended". He viewed his field as ranging from philosophy to engineering, with the possibility of expanding into humanities.

A mathematician, said Moisil, is the one who sees in any problem its mathematical point of interest, and most of all, the one who not only knows, but also produces (quality) mathematics. "Mathematicians should not fear the obstacles of philosophy. Philosophy must explain science", he wrote towards the end of his life, in a funny ad hoc application of the Realpolitik principle of the accomplished fact (in which the mathematician was seen as a warrior and the philosopher, as a diplomat). Mathematics is to him "the modern way of thinking", this also due to its changes in the last century. Many have reiterated Moisil's idea that mathematics is no longer quantitative, but structural. However, the second characteristic he indicated (as a confirmation of that principle of the reiterated thematization of consciousness so dear to him) has been referred to more seldom: the fact that concepts are imported not from the real world, but from the very concepts of mathematics (just as, I would add, Ion Barbu's ***Nastratin Hogea*** *was feeding on his own flesh).*

If Ţiţeica and Pompeiu belonged (as the first generation of great Romanian mathematicians) to the classical age, Moisil was a romantic creator, a rebellious innovator fond of exotic realms and unusual, nonconformist methods. Just as Camil Petrescu "saw ideas", and the equation of his art was "reason plus passion", Moisil saw structures everywhere, and mathematics seemed to him a combination of imagination and rigor. Imagination man-

ifests itself in the invention of the new "mechanical creatures" and in devising methods of demonstration. Imagination is more difficult to use in demonstration because it operates under the restriction of "the two poles of logic: what precedes and what follows".

Science ultimately seems to Moisil a collection of objectively valid laws that cannot be changed according to one's wishes, and that can only be used for theoretical predictions and practical applications. It begins when (in a positivistic spirit) it gives up the search for essences and succeeds to solve problems. Modern science combines refined deductive reasoning with rigorous experimenting (therefore, with inductive reasoning). Scientific research goes through a cycle consisting of several stages: "the experimenters discover new laws, the theoreticians give them a mathematical form, the mathematicians draw the logical conclusions", and if the science is established, it is applied in technical design and industry, which is "a huge testing laboratory". There is a specific interaction between these stages that make up a whole.

In the '40s, he considered the fact created by the scientist, by the questions he asks and the isolation it imposes; in the '60s, this creative aspect remains valid only on a psychological level. Experiments do not amount only to measuring and statistics, because statistical judgments, unlike inductive judgments, do not lead to universal sentences, like the scientific ones. He will call the concepts used in inductive science stochastic and will try to formalize inductive reasoning. The essential principle of scientific thinking would be "the agreement between calculations and experience", but experience cannot invalidate the mathematics used by theory; it can only invalidate the theory, namely, in its entirety. It is an assertion which, I think, needs to be detailed because, for instance, the crisis of the Pythagorean mathematics could be considered to have been generated by the failure of applied mathematics, which however did not result in the invalidation of that whole mathematics.

Scientific objectivity is not obtained only by correlating theory and experience, but also (according to K. Popper) by publishing and critical discussion of hypotheses and results among colleagues, in accordance with the social epistemological model indicated above. Mistakes are only tolerated, not allowed, but fearing them may lead to conformity. It may well be that there is no science without philosophy, but – says Moisil – science "cannot be held responsible for the philosophy people develop starting from it", because there is no univocal relation between them: "one and the same scientific theory can accommodate several philosophies". I would like to add that, in scientific theories, the mathematical expressions of laws and their interpretations are not unique either (the case of corpuscular or undulatory quantum mechanics).).

The crisis brought about in physics by the theory of relativity and especially by quantum mechanics is – in Moisil's opinion – of an ontological, not epistemological nature (it therefore has to do with the way of being of nature, not of science – which is, I think, difficult to harmonize with his constructive epistemology). Determinism (according to his approach, which he calls axiomatic philosophy and which consists in reducing a philosophical theory to its principles, followed by the study of their consequences) means an external determination of phenomena. It manifests itself physically through their interdependence on other phenomena, and logically (i.e. theoretically), through the existence of the laws describing the respective phenomenon. This interdependence can be described either from a causal, or from a finalist perspective (through variation principles); the latter method is but the reciprocal of the former, and implies no cosmic theology. On the contrary, the free act is spontaneous, unique, unpredictable, independent, it is its own cause, and judgments on it are problematic not apodictic. Physical determinism or non-determinism would allegedly have no influence on the psychical one, which seems to me arguable at least if we take into consid-

eration their co-presence. This assertion is, however, symptomatic for the young mathematician's feeling of absolute freedom.

Reducing mathematical physics to its representation through systems of differential equations, Moisil presents in ***Determinism and Concatenation*** *"a limited theory of determinism" by resorting to two principles: 1) the determination of evolution by the initial conditions of differential equations, and 2) the continuity of solutions as compared to the initial data (we would call it stability). Both classical and quantum mechanics (in its undulatory version, through Schrödinger's equation) thus prove to belong to the limited determinism, while the latter is "a deterministic evolution of a probability)". If we add a third principle (that of continuity as compared to the variation of physical laws) we get a "complete determinism".*

Moisil then studies the consequences of the incomplete knowledge of the physical world, an acceptable hypothesis revealing a non-dogmatic rationalism. This incompleteness might have to do either with a) the existence of substances with unknown characteristics, or with b) the incomplete knowledge of physical laws. In the first instance, the complete determinism leads to an essential non-determinism, and consequently it must be abandoned in favor of its limited version. The latter can be interpreted as a condition for the applicability of the laws, in case the experimental conditions are not rigorously fulfilled. The mathematical theory can thus be viewed as "a prototype of an infinity of laboratory as well as imaginary experiments" that differ very little. In agreement with these principles, Onicescu will provide a stochastic representation of quantum objects, with the help of complete link probabilistic chains.

The connection between physics and metaphysics explains, according to Moisil, the existence of the deductive or assertive knowledge in antiquity and the Middle Ages related to the concept of an apodictic – respectively necessary (due to the nature of Divinity) – existence. The fact that modern rationalism accepts the variability (contingency) of the laws of nature, as well as the stochastic ontology of quantum mechanics led to the need to use new types of logics in science – the non-Chrysippian modal logics and even the non-Aristotelian one (studied by Moisil).

By pointing out the conditioning of science by the collective mental, and by paying attention (as we shall see) to the social circumstances of science, Moisil is close to Th. Kuhn's outlook. The dynamic and constructive part of his epistemology brings him close to Gonseth and Bachelard's neorationalism (whose writings, unfortunately, he seems not to have known).

We have seen that the two fields in which Moisil primarily worked were mechanics and logics. We have a strange situation here: while, in logics, he was attracted to modal, non-classical aspects, in mechanics, he focused on classical, non-probabilistic aspects. One might speculate that, deep in his soul, freedom was a human attribute, while nature remained a realm of necessity.

The alternation of his interests is also quite clear if we take into consideration the two periods I have mentioned at the beginning: between 1925-1934 and 1946-1953, he dwelt mostly on mechanics, while between 1936-1945 and 1954-1973, he focused on logics. In the first three sub-periods, there is an average of 35 studies (leaving out the 10 papers in his university years), while in the last one (dedicated to the applications of mathematical logics to the theory of automatic mechanisms), he produced over 200 studies.

His activity in the field of mathematics, logics and mechanics is presented in S. Marcus' forewords to the volumes in [22], as well as in the articles published by E. Radu, S. Marcus, N. Cristescu and P.P. Teodorescu in ***Rev. Roum. Math. Pures et Appl.****, 23 (1978).*

After 1968, Moisil started investigating the analogies between the different types of algebra that modeled different types of logics with an infinity of values and the fuzzy sets introduced by L. Zadeh and Y. Gentilhomme. He also explored the possibility to use them in humanities and to surpass the opposition between the fine spirit and the geometrical one by developing the "logics of nuance reasoning" [21]. These researches revealed a new stage in his creation. He considered that mathematization, which was to help humanities turn into real sciences (with laws like those of natural sciences), was made easier by the structuralization of mathematics and the use of computers that could process large amounts of data. He considered the precedent of logic quite significant, and anticipated the mathematization of linguistics (he contributed a number of studies that broke new ground in the field), which was to score remarkable successes with the studies of S. Marcus and his students. He considered mathematical economy a success and pleaded for the use of mathematics in biology, history and archaeology. He nevertheless warned against the haste with which such sciences as futurology and scientics were considered established sciences, especially by certain political officials who used them in an attempt to impose norms and goals to fundamental scientific research.

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Moisil's outlook on the psychological and social conditions of science and its systematic character, as well as the plurality of his perspectives were first of all the result of his constructive efforts (in organizing the Romanian Mathematics Society, the two series of ***The Mathematics Gazette*** *and the University Computer Center). Then, they were also the outcome of the struggle he had to carry on in two stages: during the Gheorghiu-Dej regime (against the preconceived ideas of the Stalinist dogmatism against cybernetics, computer science and operational reasearch), and during the Ceauşescu regime (this time, against the obtuse attempts of eliminating fundamental research under the pretext of drawing science closer to production).*

His three books of essays ([19], [23], [25]), published towards the end of his life or posthumously, contain – in a scattered form – his ideas on the process of scientific creation and the objectification of individual knowledge (by turning it into science and into transmissible or applicable knowledge). They also allow glimpses of his struggle during the second stage (for the first stage, archives and library research would be needed). It is interesting and, at the same time, funny to notice that in the second (defensive) stage, he used as arguments the successes he scored in the first (offensive) stage, although both struggles were against political bureaucracy, and that this adversary had to be defeated with its own weapons: the Marxist-Leninist ideology.

According to Moisil, contemporary science is based on three pyramidal social structures: research institutions (fundamental, departmental, industrial), education (university, high-school, elementary) and publishing (publishing houses, libraries, bookshops), as well as on the essential connections with the international community. All three have as driving principle the genuine researcher, who carries out fundamental research, brings living science into education (molding and informing ordinary teachers and future researchers), absorbs information from the national and the international publication system, fueling it, at the same time, with his ideas and achievements.

Moisil described the organic relations between the three subsystems and militated for freedom of scientific creation, multidisciplinary and interdisciplinary research, separate

laws for research and education, permanent education for teachers and engineers, multiple qualification, humanistic-scientific high-school education, providing scientific libraries with the most important magazines and books, non-profit publication of fundamental books, bookshops selling foreign scientific literature, the possibility to order this literature directly, direct scientific contacts. All these are still valid today, 30 years later.

"[Fundamental] research must be rid not of its application, but of the obsession of its applications". Even the most abstract science is applied to production sooner or later, but one cannot plan its application, because it is unpredictable. Science cannot be done in order to apply it, and even less so can scientific discoveries be planned.

*

Moisil considered that the issue of the two cultures (scientific and humanistic) is not just false, but also indicates a decline of civilization, a diminishing of its creative vigor, because the epochs of creative effervescence did not know such a separation. He was convinced that he was witnessing their unification and militated for it. He permanently tried to point out the similarities (in terms of creation, reception and objectives) between art and science, by emphasizing the emotional aspects of scientific creation and the cognitive aspects in the works of art.

A theory is like a painting: it is an unfaithful but significant copy, which simultaneously informs on reality and its creator, indicating not just the truth, but also the mood. "The scientist is a whole man", who engages his whole being, not just his mind in the process of knowing. Scientific creation (especially mathematical creation) implies a great deal of inventiveness and imagination, but also nostalgia of communication. A science book "first appears like a dream, clear and absurd. It wants to unfold, to live, a thought of your thoughts, in the others' thoughts". A scientific work is also a confession, just as an artistic work should also be a testimony – and not just a sentimental one – about the experience of the author or of others, that aims at objectification and universality. Their reception and understanding imply a corresponding spiritual and intellectual training. If important, scientific and artistic novelty brings about opposition. The author must struggle for his work, and so courage and perseverance as well as the ability to endure blows, are part of one's talent.

Moisil's Socratic genius displayed these qualities both in his youth, when he took the liberty to contend his innovative ideas by unconventional means, and towards the end of his life, when he opposed the truth of the necessary laws to the dictatorial arbitrariness. This is not the only paradox he experienced.

He practiced logic for the sake of free creation, but found a justification for it in its practical applications. He militated for a connection between science and technology, but he had to struggle against exaggerated focus on practice. He felt stimulated by the others' existences and by communicating with them, but also suffered because of social subordination and his colleagues' envy. He permanently tried to expand his field of expertise, but had to defend it from the others' incompetence. Lastly, he succeeded to provide many explanations, but he will remain actual due to the questions he asked others and mainly himself.

As he used to say, he let "the future its own share of the knowledge joy.

(L. B.)