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PLATO, GÖDEL, AND THE REVERSED COSMOS

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SÍNTESE – Uma estrutura formal das leis da física moderna consiste em que elas são reversíveis em relação ao tempo. Isso cria problemas para a cosmologia relativista a partir do momento em que Gödel mostrou que a reversibilidade em relação ao tempo pode ser uma propriedade real do Universo. Mesmo que o mito platônico do cosmo invertido no *Político* tenha tido uma origem essencialmente política, o argumento do tempo invertido no Universo continua relevante para a filosofia moderna da ciência.
PALAVRAS-CHAVE – Tempo. Universo. Reversibilidade. Relatividade.

ABSTRACT – One formal feature of the laws of modern physics is that they are time-reversible. This creates problems in relativistic cosmology, since Gödel showed that time-reversibility could be a real property of the universe. Even though Plato's myth of the reversed Cosmos in the *Statesman* was primarity political in essence, the argument for reversed time in the universe remains relevant for moderm philosophy of science.
KEY WORDS – Time. Universe. Reversibility. Relativity.

In *Timaeus*, Plato argues that symmetry is resemblance (*analogia*) with the intelligible forms. Even though these forms are in principle unknowable, symmetry can be found in sensible things. In fact, the discovery of symmetries allows human beings to reach the only possible knowledge of the sensible world, which is the knowledge of a resemblance, or a copy. Scientific knowledge according to Plato is the result of an effort made by human beings to find resemblances between sensible things and intelligible forms, assuming that these resemblances manifest themselves as symmetries. Now, a symmetry is essentially a property that does not change during a certain transformative change. For example, the regular motion of celestial bodies is endowed with a constant speed: the speed of rotation is that which remains equal to itself while the change lasts. Therefore, this motion is to be used as yardstick for the measurement of time. This is the object of scientific inquiry: What, in any given change, is the property that remains unchanged? There is still, however, some kind of change that this inquiry is totally unprepared for. To be sure, any change is a change in time, but is not time itself a form of

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change, and in this case couldn't we ask: what is it that does not change in this change? The response is, for Plato as well as for us today: we don't know, and moreover, in light of more recent work (Gödel), it seems that we cannot know.

Evidently, the kind of question that has just been raised stems from a modern conception of the laws of nature; for the Greeks, time is not separable from the actual motion of physical bodies, and it is with respect to motion that the question of change arises; the pure flow of time is not for them a meaningful entity in the way it is, for example, in Newton's mechanics. Yet, it is interesting to try to think in reverse, as it were, and see if the Greek conception of physical action, when somewhat forced in light of the modern conception, might not teach us something important with regard to the most fundamental core at the basis of our understanding of nature. As it turns out, on at least one occasion, Platon himself might have suggested that we proceed in this way.

The dilemma was well captured by Aristotle, when he noticed that since a circumference has no definite beginning, middle, or end, the movement of rotation of the stars "is stationary and motionless in one sense, and moves continuously in another" (*Physics* 265b). This peculiar association "motion + motionlessness" is nevertheless the source of all physical action in nature. To be sure, our modern cosmology has dropped the subordination to the spherical model, but the principle of relativity at the basis of the mathematical laws of nature simply asserts the *formal equivalence* of motion and rest under certain conditions; it says that the same physical action prevails in equivalent reference frames, but it does not deal at all with the origin of action. For the modern law of nature, expressed in mathematical form, is based on the conflation of symmetry with the intelligible forms themselves. The scientific revolution of the seventeenth century is a kind of radical Platonism, which suggested that, through the alliance of mathematical symmetry with certain techniques of experimentation, we do have access to the intelligible forms pertaining to the real world. The mathematical techniques are thus now applied to the sensible world in becoming. As a result, nothing in the world has a beginning or end. Consider Galileo's law of free fall: thanks to its mathematical expression, we are able to know exactly how much space a body in free fall has traversed in any given time interval, *however small it may be* – it can even be infinitesimally small. But by inspecting the mathematics of the minute infinitesimals, we cannot say when the fall as a complete motion began, or when it will end; contrary to the Greeks, we are no longer interested in the origin and possible finality of such an event as the free fall of a body in the vicinity of the earth's surface. In other words, the logical dilemma that prevailed at the circumference of the Greek cosmos has been extended to the whole cosmos, which is now some kind of chaos: the world of modern mathematical physics is indifferent to a fixed cosmological scheme to sustain its laws. For all we know, the sequence of successive events in nature could be reversed, yet nothing would be changed to the laws of nature; the body in free fall could move up instead of down, for no special physical reason, yet the law would still be the same. Virtually all the laws of nature that we know today are time-reversible. Thus, the independence of our physical laws with respect to a fixed cosmic scheme has worsened Aristotle's original dilemma: it is not only the case that the physical event at the basis of the measurement of time could be said to be both moving and not-moving; for in addition to that, if it moves, it could go either way, from past to future or from future to past.

Nevertheless, modern physics refers to the time implicated in its fundamental equations as *absolute*, whereas contemporary physics, following the theory of relativity, calls it *relative*. What does this mean? Whether relative or absolute, the laws are still time-reversible, and physicists tell us that this contradicts some fundamental facts of daily life (for example, the broken glass on the floor does not spontaneously become an ordinary glass on the table). Is there a way of constraining the laws so that the flow from past to future – which is the level of the lived experience of time – rules out the inverse flow from future to past? The tentative responses to this problem have revived the significance of cosmology. For example, in recent chaos theory, dynamical systems become so sensitive to initial boundary conditions that the reversibility of physical processes is no more than an ideal condition, never to be realized in nature. There is something really strange here: the founders of modern science warn you that the immediate evidence of the senses is deceiving, that you should trust the mathematical laws of nature inasmuch as their intersubjective validity overcomes the lack of reliability of your own individual senses. For example, the forces that you feel in your muscles have nothing to do with the rigorous notion of universal gravitation in accordance with Newtonian mechanics. Why is the lived experience of time supposed to be so untouchable that not even our most abstract laws could afford the luxury to violate it? And moreover, who is to say that the lived experience of time is essentially the monotonic advance from past to future – what are we to do with, for example, the memory of the past?

Interestingly enough, it so happens that modern physics emerged from what was then thought to be a successful demonstration of impossibility against reversed action. The physical problem bequeathed by the Copernican argument in favor of the earth's rotation was that the earth should be conceived as a natural clock, while in Greek cosmology this function was fulfilled by the uniform revolution of the stars. Thus Galileo could do hardly better than mock the suggestion, which according to his records was made in his own days, that "after a short time the mountains, sinking downward with the rotation of the terrestrial globe, would get into such a position that whereas a little earlier one would have had to climb steeply to their peaks, a few hours later one would have to stoop and descend in order to get there."[1] Could the continuously forward flow of time be responsible for such reversed action? Galileo thwarts this fear by using the concept of homogeneous / isotropic *space* and the concomitant equivalence of up and down. Once this new concept of space is accepted, it does not matter whether the earth as clock moves backwardly or forwardly.

[1] G. Galileo, *Dialogue concerning the Two Chief World Systems* (1632), trans. S. Drake (Berkeley: University of California Press, 1967), p. 330.

This example illustrates how the time-reversible character of the earth-bound laws of modern physics saves this physics from collapsing in the face of evidence borrowed from ordinary life. But it does so by placing the burden of proof on space. Moreover, in relativity physics, space absorbs time completely in the space-time continuum. On balance, it looks as if integrating the lived experience of time in the form of the laws of nature amounts to nothing more than eliminating time altogether. The mathematical law of nature is formulated in such a way that the sheer passage of time explains nothing.

Two philosophers in the entire tradition of philosophy and science (Plato and Gödel) can be singled out for contributing to a better understanding of time with regard to the question of whether or not it itself is a symmetry – assuming that it supports all other symmetries. Gödel is better known as a formidable logician, who defended Platonism in the area of the nature of mathematics; but he also contributed to cosmology with a series of famous papers in 1949. I will show that his ideas could be read, surprisingly, as another kind of promotion of Plato, one that he could not be aware of.

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As it turns out, Plato was probably more lucid than any of his successors, since he tackled the question of the symmetry of time (or lack thereof) *outside* the realm of epistemology. It is in the *Statesman* (268ff), not the *Timaeus*, that Plato discusses various ancient legends in which the question is "how the sun and the stars rose in the west and set in the east" (269a). The point is to reflect on the general principle common to these various ways of thinking about the reversed cosmos. According to these legends, the present configuration of the heavens is the result of such a reversal following a divine action. The world is something mechanical inasmuch as it participates in bodily nature; Plato seems to view it as a sort of spinning top. Indeed circular motion has been imparted by the divine being to the body of the universe, because this motion is what differs least from the motion of a body poised on a single point; the latter is the only motion that contains in itself the very principle of motion. The actually existing universe is, as far as embodiment permits, the closest possible resemblance to the principle of motion. But such closeness is not a continuous gradation from the less to the more. Rather, the natural world is the product of a logic of less *and* more. This is made evident by the retrograde motions of the planets, which is irregular in appearance, though not in reality (*Laws* 821b-822c). The world is thus a stage of reciprocal action of opposites, not a continuous gradation to the model of perfection, which explains that divine action itself is subjected to constraints. First, as principle of motion, the divine being would contradict itself if, of its own accord, it were to change the direction of the motion of the universe; second, since motion in its own being is one, there cannot be two principles of motion affecting each other, as if two Gods were to oppose one another. The only remaining hypothesis is that the mechanical world is something like a spring tightened by the divine being, but "there is a time, on the completion of a certain cycle" (269c), when, left to its own devices, it begins to revolve in the opposite direction under the action of its own impulsion. As long as it is guided by the divine power, the world "receives life" from it (270a), but as living creature it exhausts itself and, once the maximal concentration of forces has been reached, it declines toward a state of no motion. Plato assumes that the direction of revolution defines the direction of time, but he obtains a much higher degree of asymmetry between the two worlds than in any of the contemporary models of the universe. For what is not indifferent to the direction of time is the age of those who live in this world (270d): all beings have this in common that, whether they grow older or younger, they are bound to die (270e), but of course in the case of those who grow younger, it means simply disappearing from the face of the earth after reaching the stage of newly-born child. The question is now (271c): Given that the reversal must take place after some time in both worlds (+t and -t), to which of the two worlds do we belong now? The clue is provided by the fact that the people of the reversed cosmos have no memory at all, even though they were born old (272a); they let themselves live, as it were, because the earth gives them spontaneously an abundance of fruits, without farming. This is a time-reversed world in which, however, there appear none of the paradoxes generally associated with it (like the many fragments of broken glass that spontaneously rush together to form an ordinary glass). Such a paradox-free world is achieved by taking into consideration the absence of memory among the people in the reversed world; in fact, it is enough to postulate the absence of communication between the two worlds. As it turns out, we are told in due course that this stage of spontaneous generation is the stage "in which God superintended the whole revolution of the universe" (271c). Plato goes on to speculate that a sudden shock, like a mighty earthquake (273a), preceded the return to the world in which we live now. But as the world becomes master of itself, and God lets it go, it is also incumbent on its parts to grow and generate of themselves (again, as far as they can). Ultimately, we have the following asymmetry between the two worlds. In the reversed world, inert matter generates, so that people can be viewed as earth-born creatures (271b). But in our world, the principle of life cannot be other than life itself. What differentiates the two worlds is that, in the case of the reversed revolution, the mere flow of time does affect inert matter, and this is sufficient to explain the course of events; whereas in our world (273c) the action of time is only responsible for the inexorable growing of forgetfulness, so that finally we can only attend passively to the universal ruin of the world as a whole and in all of its parts.

So, even though Plato's argument is completely independent of physical theory, it remains quite relevant to our context because it develops the implications of what is probably the highest thinkable degree of interaction between free action and embodiment in a world dominated by inexorable natural law (270e). And it does so without relying on a future physical theory that would mitigate the natural deficiency of our present knowledge: Plato argues that the mythical character of the argument makes up for the absence of a "satisfactory reporter of the desires and thoughts of those times" (272d), that is, it makes up for our ignorance of the kind of action that might prevail in such a world. Modern physics does not usually deal with what might be going on in the mind of those who live in a reversed world; for a change, both the professional physicist and the ordinary person agree: they will simply laugh when they think about the broken glass that spontaneously returns to the state of ordinary glass.

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In the celebrated collection of essays that Einstein was offered at the occasion of his seventieth birthday, a certain number of criticisms leveled against the theory of relativity and its interpretation have been discussed in a particularly sharp manner. Einstein's reply to a famous contribution by Kurt Gödel is certainly one of the most interesting in this series of original arguments. For in this reply, Einstein confessed that Gödel's insight forced him to think again about the problem that most seriously disturbed him at the time of establishing the theory of general relativity; he admitted that he then failed to resolve the problem completely. Let us take a look at this argument, precisely inasmuch as it reveals that the theory of relativity was built on the premises of a problem that was not completely solved.[2]

What is the problem? In modern natural science, you have not only a principle of relativity (which is a kind of principle of impotence, asserting the identity of phenomena as you go from one reference frame to another, equivalent frame). You also find demonstrations of impossibility (foe example: the speed of light as absolute limit in special relativity, the reciprocal exclusion of position and momentum in quantum mechanics). But no such demonstration is available in the case of the arrow of time: Gödel was the one who found a cosmological solution of the equations of general relativity that demonstrated the possibility of going against what was thought to be the very worldview constitutive of these laws. Recall that special relativity had destroyed the objectivity of simultaneity at a distance (i.e., the very notion of one instant at two different points). Why would we not continue in this direction and drop any reference to the objective sequence of different moments at one point? But standard relativistic cosmology did not proceed that way – perhaps because it could not. The models of universe compatible with the Copernican principle (no observer is at the center) require a cosmic time function superimposed on all local times. Obviously this conservative attitude is understandable, because at the core of the idea of relativity, over and above its beautiful and powerful formal consequences, you find this frightening consequence: if the notion of determined reality includes the temporal relation, then the very notion of reality should be relativized in some way. It seems to me that the fear is not unlike the difficulty of thinking a reversed world down to its ultimate implications. The Gödel universe is a homogeneous universe obeying the laws of general relativity, in which the local times of the observers who move with galaxies cannot be fitted

[2] K. Gödel, "A Remark about the Relationship between Relativity Theory and Idealistic Philosophy," in P. Schilpp (ed.), *Albert Einstein: Philosopher-Scientist* (La Salle, Ill.: Open Court, 1949), p. 557-562.

together into one universal temporal order. In this model, it is theoretically possible to travel into any region of the past or future and back again. Generally, the question of whether time is asymmetrical in the theory of relativity is supposed to be reducible to questions of the kind: What are the conditions required to make such transition from the local to the global? What is it that must be postulated for preserving physical sense throughout? The essence of Gödel's metric of space-time is that the aggregate of *local* past/future distinctions associated with the observation of light-rays does not automatically constitute a *global* past/future distinction. Note that in Gödel's world, a traveler who follows his time-like world-line never meets a point at which the direction assigned to time is reversed. Rather, his world-line is always oriented toward a locally definable future; in this solution, the problem of temporal priority is thus supposed to be solved at the local scale, which is not quite like Plato's world, where the reversed world implies a reversal point. And yet, in some deep sense, both worlds point to the same difficulty.

To begin with, the failure to obtain a global past/future distinction is independent of something like a crucial experiment that would be proposed to decide in favor or against asymmetry. Thus, it would be certainly absurd to try to tell experimentally (for instance by monitoring a light-signal over very large spatio-temporal intervals) *when*, as the separation between two events A and B grows larger, event A as "after" (or "effect", in the language of light-signals) turns into "before" (or "cause") of event B. In his reply to Gödel, Einstein was of the opinion that the absence of earlier/later distinction at the global scale, which makes no sense, occurs only as a special case to be discarded without touching upon the foundations of the theory, a violation of the otherwise accepted asymmetry as a general case.

But this is far from clear. Gödel believes that the breakdown does make sense theoretically, precisely because *only* a practical impossibility is available. His calculations showed that the velocity required in order to make a complete circuit in time in his model must be very close to that of light, which he found to be virtually forever beyond technological means. Moreover, the observer who would try to go back to his own past would die well before he could meet his own self in a younger state. From this the theoretical conclusion follows: Gödel writes that "it cannot be excluded a priori, on the ground of [this] argument, that the space-time structure of the real world is of the type described." Now, one would like to think that the more standard models of the relativistic universe, in which there is a globally distinguished direction for the arrow of time, are independent of practical conditions. This, however, is not quite the case. Indeed, Gödel argues, in those models where an absolute time function can be defined, the actual existence of an objective duration depends on the determination of the mean motion of matter in each region of the universe. Yet only approximations to this concept can be obtained, and moreover the particular configuration of the universe at any time remains contingent. Thus, asymmetry as the most general case could be dropped altogether.

But now suppose, for the sake of argument, that this practical impossibility is turned into a possibility. Would this be enough to go back to the conservative view? Gödel's aim was to show that a certain type of action is necessary for the paradox of time-travel to occur. He writes that if someone were to travel into the past of those very places where he has himself lived, "he would find a person who would be himself at some earlier period of his life. Now he *could* do something to this person which, by his memory, he knows has not happened to him." Thus, the action required in order for the paradox to arise is a contingency that implies an actually living person capable of memory, not just a physical apparatus capable of recording a certain number of data according to a pre-determined sequence. And now the question is: if he could do it, would he do it; or should he do it?

Plato warns us that when, after the turnaround, all things changed, the people of the reversed world could only imitate the condition of the whole universe, which in this instance is consistent with an irrepresentable mode of conception and generation (274a). The mere passage of time can only explain a reversed world, in which nothing motivates the need for superintendence of things by people (what we call "science"): not only do they have no memory, but they have certainly no reason to change their destiny since their food is growing spontaneously.

Now, Gödel argued that his cosmological model is the reflection of a philosophical position about time. He claimed that special relativity in its original meaning, undistorted by further cosmological constraints, tallies with Kant's remark that the very perception of change presupposes the particular constitution of human sensibility, namely, time as pure intuition; these affections that I represent to myself by means of inner sense as changes, other beings equipped with a different form of intuition could not perceive them as changes. According to Gödel, beings co-extensive with the Minkowski space-time of special relativity, in which time is absorbed in space-time continuum, are living this non-specifically human life referred to by Kant as an irrepresentable sensibility. But on the other hand, Gödel goes on to point out, "the concept of existence [...] cannot be relativized without destroying its meaning completely." Is this not what Kant seems to be doing when he speaks of putative beings with other forms of cognition? As we now see, the possible encounter of an observer with himself at different times of life cannot so promptly be taken as an invitation to *do* something to his self, like an irreversible damage. It is, rather, an invitation to meditate on the following question: are the intuitive world (in which a "simple" notion of free will would be assumed) and the relativistic world two different worlds, or do they both derive from a unique world? In the former case, the kind of intuition prevailing in the relativistic world would be simply irrepresentable, and the paradoxes of time travel would reflect the irreducibility of the constructed world of relativistic cosmology to human sensibility; in the latter case, the paradoxes discussed by Gödel occur because the intuitive world in which we actually live could never be done away with: it is this world which, however obscure it may still be, continues to fix the very meaning of existence in the first place.

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Plato's myth does not belong to physics, not because Plato was ignorant of modern science, but, as Gödel's debt to Kant shows surprisingly, because the mythical story of the reversed cosmos belongs to what Kant called later the Transcendental Aesthetics in the *Critique of Pure Reason*. What is it that science owes to our being originally related *to* the world and open to it in some way, prior to the awakening of our reflective capacities that aim at grasping the effectiveness of our concepts *in* the world? Scientific knowledge cannot account for this opening, yet, as we have seen by means of the example of the direction of time, one of its driving forces is the ever renewed attempt to do so.

A world without at least a trace of living memory cannot meaningfully be "there" in the first place. Moreover, any attempt to efface this memory, so that we could be left with the purely material / causal world studied by physics, is doomed to fail. As the apparently harmless example of the reversed direction of time shows, only the phenomenology of the lived experience of nature can save physics from collapsing into non-sense. But what does mythical speculation have to do with contemporary cosmology? The myth is a particular type of historical discourse, while we would like to think of our cosmological theory as a perfectly rational way of making up for the deficiency of sensible representation. In historical discourse, the actions of the actors are reconstituted from the consequences that these actions gave rise to; freedom is ascribed to the actors only in reference to a forward-looking project that reached, or failed to reach, our own present. Inasmuch as this project "speaks" to us in some way, that is, insofar as it makes sense at all, we must be able to transpose ourselves into the past situation; historical understanding requires a minimum of fictive participation in order to be meaningful. Thus, it is certainly not the exclusive privilege of "another" world, for instance a world in which the direction of time is reversed, to require fictive participation in order to lend itself to a minimum of intelligibility; this requirement is proper to all understanding dealing with time. To be sure, the universe which is described and explained in cosmological theory is wholly constructed, so that it does not really have an intuitive plausibility in terms of situations that could be lived. Why, then, should we refuse that, here too, judgment can result only from the consequences of these actions? Time travel may well be compatible with our theories of relativistic cosmology, but instead of throwing light on the ultimate origin of physical action, as physicists seem to hope, it contributes to revealing how and why this origin remains occulted by the overly massive evidence of our own life.