UNIVERSITAS PHILOSOPHICA 46, (pp. 79- 98)
junio 2006, Bogotá, Colombia

TIME SYMMETRY AND THE COSMOLOGICAL ARROW OF TIME: TOO SOON FOR A DEFINITE ANSWER?

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ABSTRACT

The text addresses a proposed solution to the question for the direction of the cosmological arrow of time, interpreting some of its conclusions and exposing some of its drawbacks. Some alternative answers are explored, including an extension of the so-called Gravitational Symmetry Argument.

Key words: Price, Temporal Symmetry, Inflation, Space-Time Geometry.

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LA SIMETRÍA DEL TIEMPO Y LA FLECHA COSMOLÓGICA DEL TIEMPO: ¿MUY PRONTO PARA UNA RESPUESTA DEFINITIVA?

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RESUMEN

El texto aborda una solución propuesta a la pregunta sobre la dirección de la flecha cosmológica del tiempo, interpretando algunas de sus conclusiones y exponiendo algunos de sus problemas. Se exploran algunas respuestas alternativas, incluyendo una extensión del llamado Argumento de la simetría gravitacional.

Palabras clave: Price, Simetría temporal, Inflación, Geometría espacio-temporal.

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1. Introduction

There are two senses in which the question about the arrow of time is usually formulated. On the one hand, one could be interested in knowing if there are differences between past, future and present, and how is it that these three "parts" of time permeate and define what could be named the "temporal structure of the universe." Does time have an origin? From where to where does time flow? At was speed does time flow? What can be used to measure the passage of time? Are past and present, and future all alike? If not, what is the difference? Those are questions for the direction of time itself. On the other hand, there is the question of the movement of things in time. The target of this question is the temporal organization exhibited by events, the organization that allows us to define them as belonging to the past, or the present, or the future. Did the big bang come first than the big crunch? Are there more events in the past that in the future? Why can't we reverse some physical processes? These are the questions about the movement of things in time.

For about two decades, Huw Price has defended that the result of the long history of responses to the question for the arrow of time, usually stated in terms of thermodynamics, is that they lead us to the question about the universe's initial low entropy state. Such a question, as opposed to the question for the direction of time itself is, according to Price, the *real* question worth asking. It is also the reason why any suitable response to the problem of the physical arrow of time should move to the territory of cosmology, the place to where it naturally belongs. The first part of the paper addresses in some detail Price's solution to the question for the cosmological arrow of time. Price's central claim about the cosmological arrow is current theories answer the question about the initial low-entropy universe by appealing to what he calls a Temporal Double Standard. Price contends current cosmological models explain the universe's initial state using time-asymmetric principles, making their solutions biased towards temporal asymmetry. Recognizing the origin of these time-asymmetric principles and their role in the current interpretation of the evidence becomes then a preliminary task to obtain a more acceptable answer to the low entropy question. In fact, Price finds a suitable answer in terms of a temporal symmetric model of the universe has already been advanced, but cosmologists simply have not given it the attention it deserves. But, beyond the exposition of Price's view, my main goal is to show what I consider to be some of its major drawbacks by exploring some current alternatives that seem to undermine Price's answer. As second goal I'll set the ground for what could be some alternative paths both friends and foes of Price's general program could follow in order to extend or limit Price's Gravitational Symmetry Argument. But let's not spoil the end of the story and let's go to see its beginning.

2. The arena

Our current view of the evolution of the universe is stated in terms of the Big Bang theory. The theory describes the actual universe as originating in an enormous burst of plasma that resulted from the internal tension generated at the heart of an infinitely dense, pre-universe, singularity. From this explosion the universe received all that it needed to develop into the actual distribution of stars, galaxies, solar systems, empty spaces, dark matter and energy flow that we witness today. The Big Bang theory is very successful in many aspects. It predicts the current ratio of expansion of the universe, the existence of a cosmic background of microwave radiation, as well as the abundance of light chemical elements and the unification of strong, weak and electromagnetic interactions at certain energy's scale. The experimental confirmation of all these results strengthened confidence in the model and it quickly became the standard model of the origin of the universe.

But the model is not problem-free. Among the problems troubling the Big Bang scenario two are of particular importance. First, there is the "horizon problem" (Weinberg, 1972; Thorne and Wheeler, 1973), a problem that originates in the inconsistency between the large-scale homogeneity of the universe, as evidenced by the uniformity of the cosmic background radiation, and the expected uneven distribution of radiation that should have resulted from an original explosion such as the big bang. The problem here is to explain how a very homogeneous universe resulted from a very inhomogeneous starting point. The second problem is known as the "density fluctuation problem" (Guth, 1981; Blau and Guth, 1987). In this case, the problem is the difference between the large-scale homogeneity of the universe and its local inhomogeneous structure; while matter and energy seem to be evenly spread throughout the universe, its concentration in local systems such as galaxies, clusters and the like is very hard to explain from the big bang model. These problems are complementary in that they both refer to different aspects of the universe's mass-energy distribution and they highlight the same limitation in the model: the global homogeneity and the mass density perturbation have to be assumed as part of the initial conditions rather than being deduced from the model. According to the Big Bang model, the only way in which the universe would exhibit the distribution we observe, uniform in one scale and non-uniform in the other, is to assume that in the universe early stages the energy distribution was dramatically smooth. From such an original smoothness the actual even energy distribution is a natural result, because the formidable explosion would have expanded the universe preserving its original distribution.

A solution to the problem of the smoothness of the early universe is the so called "inflationary hypothesis." According to this hypothesis (Linde, 1979; 1982a, 1982b; Guth, 1981), very dramatic physical conditions in the early stages of the universe brought about a period of exponential expansion that increased the scale of the universe by a factor of about 10^{50} times its original scale. The extreme physical conditions of the unborn universe in its inflationary phase "ironed out" all the inhomogeneities that otherwise would have existed, resulting in a smooth universe. The period of inflation was followed by an equilibrium state, which ended with the actual bang, from where the story continues as in the original, non-inflationary, big bang model.

The inflationary model solves several of the problems of the original big bang theory. However, it still leaves unanswered some questions about the initial conditions of the early universe. One set of questions belongs to what Linde calls the problem of the uniqueness of the universe.

> The essence of this problem was formulated by Einstein in his talk with E. Strauss: "what I am really interested in is whether God could create the world differently." The answer to this question in the context of the inflationary cosmology appears to be rather unexpected. Namely, the *local* structure of the universe is determined by inflation, which occurs at the *classical* level. The universe after inflation becomes locally flat, homogeneous and isotropic. However, its *global* structure is determined by *quantum* effects. It proves that the large-scale fluctuations of the scalar field...created in the inflationary chaotic scenario lead to an infinite process of creation and self-reproduction of inflationary parts of the universe. In this scenario the evolution of the inflationary universe has no end and may have no beginning... One may say therefore that not only could God create the universe differently, but in His wisdom He created a universe which has been unceasingly producing different universes of all types (Linde, 1987: 607).

Because we do not have a definite physical explanation of the chaotic inflation scenario on which Linde bases his case for the possibility for the multiplicity of universes, and because of our lack of understanding of the possible mechanism responsible for the differences between the global and local features of the universe, a solution to the uniqueness problem is still wanted. More interesting for our purposes, is another set of questions addressing the problem of the initial conditions of the universe. Questions like (Ibid, 606) "What is the origin of the universe?" "Was it created in a singular state or has it appeared due to a quantum jump 'from nothing'?" or "Which initial conditions in the new-born universe are most natural?" still remain open and receive different kinds of answers.

Reformulating the problem by asking "why did the classical evolution phase of the universe start off the way it did?" (Hawkin, 1987), Hawking answers the question for the early conditions of the universe by his "no-boundary solution", a solution that, as one can see from the very formulation of the problem, is a development of the inflationary hypothesis. According to the no-boundary solution, the way to answer questions about the initial state of the universe is to restrict the possible accounts to those in which the universe's original state "does not refer to any unobserved asymptotic region and it does not involve any boundary or edge to spacetime at infinity or a singularity where one would appeal to some outside agency to set the boundary condition" (Hawkin and Israel, 1987). Such a self-contained universe would then be determined completely by the laws of physics, without any resource to points where those laws get broken and without any room for external influence to play a role. The no-boundary solution derives the time-asymmetric dynamics of our present universe from a symmetric set of laws by eliminating the possible boundary conditions that would determine asymmetric laws for the evolution of physical systems. A universe without boundaries makes recourse to asymmetric laws unnecessary by taking for granted that the same laws are satisfied at every moment in time. This appeal to the symmetry of the physical laws seems to make Hawking's proposal to imply that entropy must be low both during the initial moments of its "classical phase," i.e., near the big bang, and during the final moments of that phase, i.e., during the "future" big crunch. In other words, it seems that the no-boundary model cannot offer a plausible answer to the question of the universe's entropy asymmetry. According to Hawking, the question is solved because "the no-boundary condition *implies* that the universe would have started off in a smooth and ordered state with all the inhomogeneous perturbations in their ground state of minimum excitation. As the universe expanded, the perturbations would have grown and the universe would become more inhomogeneous and disordered (Hawkin, 1987: 648).

But implying is not the same as explaining and, therefore declares Price: the no-boundary model does not show that all, or almost all, possible universes have at least one ordered temporal edge. Because it lacks such a demonstration, Hawking's argument becomes a clear example of the temporal double standard.

> After all, we know that we might equally well view the problem in reverse, as a gravitational collapse towards a big crunch. In statistical terms, this collapse may be expected to produce inhomogeneities at the time of any transition to an inflationary phase. Unless one temporal direction is already privileged, the statistical reasoning is as good in one direction as the other. Hence, in the absence of a justification for the double standard- a reason to apply the statistical argument in one direction rather than the other, the appeal to inflation doesn't seem to do the work required of it (Price, 2004: 24).

3. AN ANSWER

FOR PRICE THEN, THE problem with the no-boundary model is that it assumes the asymmetry between the temporal extremes, rather than explaining it, as it should. But, as a matter of fact, Hawking has suggested an explanation of such an asymmetry can be found in terms of an anthropic interpretation of the no-boundary. According to Hawking's anthropic solution, while the laws of physics define the global symmetry of the universe, they leave open the possibility that creatures like ourselves can exist in only one of the two possible phases of the universe, that during which a low entropy state is considered the past. In Hawking's own words,

> Because the 'no-boundary' quantum state is CPT invariant, there will also be histories of the universe that are CPT reverses of that described above [inflationary big bang-like histories]. However, intelligent beings in these stories would have the opposite subjective sense of time. They would therefore describe the universe in the same way as above; it would start in a smooth state, expand and collapse to a very inhomogeneous state. The question therefore becomes: why do we live in the expanding phase? To answer this, I think one has to appeal to the weak anthropic principle. The probability is that the universe will not recollapse for a

> very long time. By that time, the stars would have burnt out and the baryons would have decayed. The conditions would therefore not be suitable for the existence of beings like us. It is only in the expanding phase that intelligent beings can exist to ask the question: why is entropy increasing in the same direction of time as that in which the universe is expanding? (Hawkin, 1987: 649).

Price finds this proposal to be "exceedingly costly in ontological terms." The anthropic principle divides the universe into two main regions, the region in which we, intelligent creatures, have evolved, and the "rest of the universe," where this type of intelligence did not, and could not have, evolved. It is this division that makes the principle insufficient as an answer to the question for the particular initial conditions of the universe as a whole. At best, the model would be useful to explain things in the little local region we inhabit. But the question about the inclusive 'larger' universe still remains unanswered. Price's request for a "cheaper" ontological model is a plea for a model that explains at once local and global properties of the universe. And without recourse to the anthropic principle, cosmology faces the challenge of answering the question of the universe's origins while being forced to acknowledge that nothing in physics tells us that there is a right or wrong orientation of the temporal coordinates.

Price attempts to solve the issue by introducing what he calls the Gravitational Symmetry Argument. The gravitational symmetry argument has three-steps: First, we ask what the universe might be expected to be like after a process of gravitational collapse, which, from a thermodynamic analysis leads us to consider the early universe as a very inhomogeneous system. Second, we apply the temporal symmetric principle that rules the evolution of physical systems, i.e., the time-symmetric nature of the laws of physics, to the universe. Accordingly, we see that a commitment to the notion of the universe originating with an explosion that rapidly increased the universe's size and distributed its matter and energy imposes also the notion of the universe's future as sinking under its own gravity and accelerating toward a final crunch. Finally, we acknowledge the fact that there is nothing in physics that tells us that any particular end of this exploding-collapsing universe must be considered either its beginning or, its end. In short, Price's gravitational symmetry argument is nothing but the recognition that there is no physical reason for treating the early and the late stages of the universe differently. In other words, Price is arguing that our current view of the universe in terms of inflation and gravitational collapse does not differentiate between the big bang and the big crunch situations. What cosmologists should do then is to develop a model that uses the gravitational symmetry argument as a foundational principle.

Looking back in history, Price finds that such a cosmological model along the lines of the gravitational symmetry argument was introduced by Gold in the early 60'^s as part of his program of trying to connect the expansion of the universe with the second law of thermodynamics. According to Gold's model, it is the large-scale motion of the universe that accounts for the observed temporal irreversibility of a physical system's evolution, with the thermodynamic arrow of time being directly determined by the expansion of the universe. Gold pictures the universe as originating and ending in singular points, with a closed evolutionary pattern of expansion and collapsing, and with entropy increasing in the expanding half of the universe's evolution while it decreases in the collapsing half. It is precisely the symmetry between the origin and end of the universe in Gold's model that attracts Price. Ironically, it is because of this symmetry that the model was not accepted by the community of cosmologists and became rapidly overridden by the flourishing inflationary model.[1] At any rate, the moral that Price draws from Gold's is that it is possible to develop a reliable interpretation of the temporal evolution of the universe from an atemporal perspective, one in which past and future are treated evenhandedly. From this new viewpoint, past and future are symmetric points in the time-like dimension of spacetime, with the same claim to be used as reference marks for the physical description of events. Given this perspective, looking 'toward the past' becomes as legitimate a way of interpreting physical behaviors, as looking 'toward the future' is currently seen. In the case of interacting systems, this new approach makes the temporal evolution of the systems' states describable either as coming from a common past or as going to a common future. This, needless to say, is precisely the sort of feature that Price wants for any model on which his atemporal view would rest. Within a model that considers present and past to be undistinguishable, a future state of a system that brings about the systems' past states might be not only unexceptional but might actually be one of the expected results.

1. For a detail account of Gold's model see Gold (1967). For a history of the reception of the model, see Bondi and Gold (1995), and Kragh (1996).

Summarizing then, Price finds Hawking's no-boundary model to be insufficient to account for the asymmetry between the temporal extremes of the universe it proposes, and its appeal to an anthropic principle impossible to be used to solve the problem. Trying to do so would incur in having to pay an "ontological price," higher than the benefits we could possibly derive from it. Price proposes to replace the Hawking's model by a fully symmetric one and sees Gold's picture to offer the expected symmetric treatment of the initial and final moments of the universe: the big bang and the big crunch. Only this model, states Price, accounts adequately for the physical evolution of the universe in terms of the symmetry of its temporal extremes. Using Gold's model Price places himself in his desired Atemporal Archimedean Point, a point from where the notions of "temporal evolution to the past" and "temporal evolution to the future" become nothing more that ways of speaking, which lacks any physical content.

4. The problems

There are reasons to find Price's criticism of Hawking's no-boundary solution appealing. One could argue that the project of contemporary cosmology rests on the attempt to explain the actual universe by retrospection. By tracing down the past of the universe, its present, as well as its future, are expected to be understood in terms of the possible original scenarios, of initial conditions, that would naturally evolve into a configuration like the one we currently experience. Such a project is based on the symmetric nature of the physical laws, according to which the past can be extrapolated from the present in the very same way that the future can be extrapolated from the past. One could even follow Price and warn against the vice of this project, the possibility to forget that the symmetry of the physical laws implies that past and future should be treated alike, a problem exemplified by the a common cosmological motto: 'when we look far into space, we find ourselves looking far into our past.' But if the past and the future can be both inferred from the present, the fact that we cannot get access to the future, at least not via observation, should not lead us to the conclusion that the past is in any sense more fundamental than the future. Because of this, we seem to have very good reasons for exploring the origin and structure of the universe by means of models that are fully committed to the symmetric character of the physical laws.

But not all are good news. Callender (1998) has shown that Price's interpretation of Hawking's no-boundary model is wrong. Although explicitly denied by the Hawking's model, states Callender, Price understands the no-boundary model as one in which entropy depends exclusively on the size of the universe, with the corollary that the temporal asymmetry exhibited by the model has been put in there by hand. Furthermore, Callender finds hard to accept that both Price and Hawking models go after the same target, a final explanation of the universe's low entropy past.

> My worry is that Hawking's theory may not have *anything to do* with Price's dilemma. By ignoring the details of Hawking's project, Price hasn't realized how alien it is to his own project. One way to see this is to reconsider Price's corkscrew-factory analogy. This analogy is not a good one. In three spatial dimensions, there really is a difference between right-handed and left-handed corkscrews, i.e. they are enantiomorphs. But as Price has cogently argued, yet seems temporally to have forgotten, from the atemporal standpoint there is *no genuine difference* between low-to-high and high-to-low universes. They are the same universe differently described. But if *all* the solutions are symmetric *in the same way* (say, right handed) then the equation can't be a symmetric one. Price cannot make sense of what he claims is Hawking's 'loophole' without resolving this puzzle. This requires delving into the details of Hawking's theory. Once there, the philosopher will find himself in a strange new land, one brimming with questions that need answering before contemplating time's arrow (Callender, 1998: 142-143).

Because of these problems, Callender declares Price's conclusions, as well as the general program of investigating quantum cosmology's implications for the arrow of time, premature. And these are but only some of the major problems Callender points out about Price's answer to mechanism underlying the low-entropy past hypothesis, his cosmology's 'real' question, the other one being the high probability that we do not happen to live in a Gold-like universe. In a nutshell, Callender argument is that to the date scientists have not found any of the effects that a universe running towards an entropy-increasing final collapse, as Gold's, is expected to exhibit (Ibid, 145-146). Without such evidence, Price's model seems to blindly driving towards a wall, with final results easily predictable, regardless one's believes about the past, or future, hypotheses. Additionally (Callender, 2004), the very project for explaining the past hypothesis seems to be undermined by Price's commitment with the indispensability of a clear determination of the mechanism responsible for the initial universe's low-entropy state. Relating Price's project to that of the physicists of solving the horizon and density fluctuation problems, Callender finds that Price holds on to the low-entropy past hypothesis while trying to explain why such a past state is obtained. But this seems to be a self-deflating project, for any explanation of the universe's initial state in terms a basic mechanism that would have produced it implies that the low-entropy past hypothesis cannot be used as a basic explanation any longer.

> If we stick to Price's new explanandum, explaining the Past State itself, and it is the first state, then any kind of novel causal process that brings this state about would seem to require referring to a mechanism outside spacetime – or adding more spacetime to current models than is warranted by empirical evidence. But that seems to me suspiciously akin to adding some untestable mechanism merely to satisfy one's *a priori* judgment of what facts can be brute. Worse, why should I prefer this brute element over the previous one? (Callender, 2004a: 251).

Callender then sees more than enough reasons to recommend not to follow Price's lead and to avoid getting to conclusions too briskly, before having considered all the alternatives.

Callender's serious criticisms notwithstanding, one could still be interested in pursuing goals similar to Price's ones and try to find a mechanism that explains the universe's low-entropy past, or developing a fully temporally symmetric cosmological model, not necessarily directed over against the no-boundary theory. In such a sense, the lesson we are meant to learn from the analysis of Gold's model is that we can use it as a frame for the construction of a symmetric representation of the physical evolution of the universe in which past and future are treated evenhandedly. In other words, Gold's model fulfills the need for a temporal symmetric reference frame. Such a treatment is the heart of Price's Gravitational Symmetry Argument, for which past and future are symmetric points in the time-like dimension of spacetime, with the same right to be taken as reference marks for the physical description of events. It is in this sense that we say that the temporal evolution of a physical system can be described as coming from a common past or as moving towards a common future. And Gold's model fits the required profile for a just, temporally speaking, judge of the universe's dynamics. However, it is worth asking what exactly the puzzle is that an appeal to Gold's model helps solving.

Given the way Price's conclusion is built up, it seems that the problem was merely that of finding a cosmological model consistent with the temporal symmetry of the laws of physics. But it is not easy to see how Gold's model answers the question that Price has moved to the spotlight, that for the early universe's low entropy. According to Gold's, due to the relation between entropy and the global structure of the universe, the initial conditions have to be considered symmetric, temporal reverse twins, of the universe's final conditions. The Big Bang and the Big Crunch are then indistinguishable in terms of entropic considerations. But nothing in Gold's model seems to say anything about the low entropy states found at the origin and the end of the universe. One can agree with Price in saying that there is no intrinsic asymmetry that makes the universe's initial conditions more special that its final ones. One can also, even at the cost of neglecting the conclusions of Callender's devastating attack, agree that even if Price's analysis sinks it still makes some damage, or that there are escape routes from Callender's conclusions and to continue with the original task of finding a time-symmetric frame from which the universe's initial conditions could be explained. This is when Gold's universes are supposed to come out to help. However, the lesson to learn from Gold's model is just that the origin and end of the universe are identical, and this still leaves unexplained the question of why those temporal distant ends happen to be very low-entropy states. If we ask 'how is the problem of the initial conditions solved?' and try to find an answer exclusively in terms of Gold's picture, we will not find any answer. But acknowledging the limits of one's use of Gold's model and declaring that the problem to be solved is only the one the model actually solves is a significant concession. This would imply that the question about the initial conditions of the universe is not "the question to be solved," making the explanation of the difference between symmetric and asymmetric models more important than the explanation of the universe's initial conditions. This is of course a route Price cannot take if he is to retain the force of his argument. Therefore, Price's appeal to Gold's model turns out to be a two-edged sword. It offers a symmetric interpretative frame for cosmology, but it leaves unanswered the question about the universe's original low-entropy state. If, in response, Price chooses to minimize the importance of answering that question, he undercuts his own criticisms of the asymmetric models he rejects.

There is yet another problem faced by Price's answer to the question about the cosmological arrow of time, coming from recent cosmological models intended to offer both a symmetric cosmological picture but which also make room for an objective arrow of time. Two of such models are worth mentioning here, those of Castagnino, Lombardi and Lara, and of Butterfield and Isham.

Castagnino, Lombardi and Lara (2003a; 2003b; hereafter, CLL) address the question about the cosmological temporal asymmetry in terms of the problem of determining if the basic physical asymmetry between past and future is conventional or substantial. Their approach to the problem of time-asymmetry shares some of Price's intuitions, in particular the idea that in order to answer the question about time's arrow it is necessary to "step out of time." Nonetheless, contrary to Price's view from "nowhen", instead of trying to disprove the existence of a physical temporal arrow, the authors investigate the possibility of grounding the physical arrow of time on the direction of time itself. Recall that Price regards questions about the direction of time itself as meaningless. By contrast, CLL think that it is perfectly meaningful to ask whether the temporal arrow refers to a property of time itself or whether it is just a feature of the way things are ordered in time. By a series of geometrical arguments over the topological properties of the universe, as pictured by general relativity, CLL argue that there is a clear sense in which the direction of time is physically determinable, and that, in fact, a global arrow of time appears as a consequence of two principles: first, the time-reversal invariance of the physical laws, i.e., the temporal symmetry of the laws and, second, the orientability of spacetime, i.e., the existence of a non-vanishing time-like vector field on spacetime. The first principle states that the distinction between past and future, between temporal directions, is just a matter of convention, while the second states that, despite conventions, there is a definite sense in which we can define a temporal direction of spacetime. Using these principles CLL find not only that there is a sense in which the direction of time itself can be determined, but also that this temporal arrow is more fundamental than the proposed entropic, thermodynamic, arrow. After all, CLL declare, "the geometrical properties of the universe are more basic than its thermodynamic properties" (CLL, 2003b: 886).

Along similar lines, Butterfield and Isham (1999a; 1999b) have advanced a case for the emergence of time in quantum gravity. Like CLL, Butterfield and Isham use a topological approach in their argument, but unlike CLL they find that there is no objective way to determine whether or not the universe has an overall objective temporal direction. Their conclusion is not that timedirectness is a fundamental feature of our universe, a substantivalist claim, but instead that "time as a continuous ordering of events is only an approximation, valid for sufficiently large scales of time and length"(Butterfield and Isham, 1999a), a relativist claim.

Apart from the technicalities of and differences between these two alternative models, the problem they present for Price is that they demonstrate that his demise of the question for the existence of an arrow of time itself, as opposed to an arrow of things in time, seems to leave unattended some very important issues. The conflict is not merely about the consequences of certain technical geometrical or statistical considerations. Nor is it merely a matter of counting, or of making sense of what we find in the world. The conflict goes deeper, into considerations of what counts as real. Price has admitted that he is not interested in finding any possible arrow of time, because he finds that problem to be of no interest at all. In this sense, Price's project is continuous with those of Williams, Smart, Mellor and Grumbaum, who presuppose that what is objective about the direction of time itself is that it is a matter of perspective, an anthropocentric notion, and that there is no sense in which a global arrow of time itself can be objectively defined. But with alternative theories offering an explicit objective account of a global temporal arrow, it seems that this common presupposition cannot simply be assumed. Even if these new alternatives do not disprove Price's proposal, after all they may be just wrong, the fact that both target the question that Price rejects forces us to see Price's alternative in a new perspective. Asking the question that Price refuses to ask may shed light on both the temporal structure of our universe and why its initial conditions are what they are. In this sense, we can say that these models are more general than Price's, because they address both questions about both the arrow of time and questions about the direction of things in time.

It seems, then, that rather than closing the case Price has actually opened the door for reformulating the question for the objectivity of the direction of time itself. By restating the question about the objective direction of time it may be possible to get a better formulation, if not a solution, to the question about the thermodynamic asymmetry of experience. Such a reformulation might help us clarifying the relation between the thermodynamic and the cosmological arrows of time. May be then that such is the mayor gain to playing the game following Price's rules, because the proposed fully temporal symmetric approach that Price has offered us does not fulfill its promise of casting overwhelmingly strong doubts over the current approaches to undermine their credibility. It still gives current approaches enough elbowroom to escape from the supposedly deathly arguments advanced from the atemporal perspective.

5. Where do we go from there?

After the previous analysis it is clear that we have left Price's view in the defensive spot. In this final section I will point out some alternative routes that could be followed for those interested in pushing forward arguments along the lines of Price's view, or those trying to correct some of the problems by restating the questions under a different light. Needless to say, this short section does not exhaust the alternatives at hand, but simply suggests some of the places were one could be interested in looking for some help.

One way of solving the narrow aiming scope problem is to "broaden the scope" of one's model. To do so is to extend the both the original questions and their interpretation context in order to include some of the alternatives previously left behind. By such and inclusive move, one gets the not small gain of having some extra help in the route for solving questions, or, in the worse case scenario, a more complete background against which one's tempting conclusions can be tested. It could be possible, for example, to decide to expand the question's horizon as to include the question about the existence of an arrow of time itself. In such a case, if there seems to be tracks leading towards the determination of such an arrow, it could be possible to follow that lead in order to explain the arrow of things in time *in terms* of the arrow of time itself. Or, moving in the opposite direction, it could be the case that what is needed is a deflated notion of the arrow of time itself *as a consequence* of the answer to the question of things in time. If it is the case that the arrow of time is disproved, then the question for the arrow of things in time would gain a new light because of, being an objective arrow, all temporal asymmetries would have to be defined *from* it, the basic one.

Two examples of this kind of question re-shaping are worth mentioning here. One could follow from an adequate interpretation of contemporary string cosmology. According to some authors (Veneziano 1999, 2000; Gasperini and Veneziano, 2003), what string analysis brings to the solution to some of the crucial problems of the standard Big-Bang model is that they allow for the inclusion of new tools. Some of those tools are a proposed new quantum of length and a new kind of inflation (the dilation-driven inflation), that help explaining the dynamics of the universe from the so-called pre Big-Bang scenario. In terms of the previous discussion, string analysis could be interpreted as a way for determining the mechanism that determined both the origin and the arrow of time. Besides its possibilities as an explanation of an arrow of time itself, this kind of analysis could eventually lead to the determination of a mechanism that explains the intriguing universe's low-entropy past. A second alternative is modeled in terms of the so-called quantum or Feynman clocks (Hitchcock, 1999), according to which rather than being a parameter in the description of "quantum systems", time is defined as a lifetime, the lifetime of unstable quantum systems. As in the case of cosmic strings, this kind of analysis could be the answer the pray of those trying to determine a mechanism from which the early universe's low-entropy would come from. These would be the favorable interpretation of the new, expanded, questions.

However, there is also the no so favorable interpretation of analyses like these. It could be possible to interpret both the string and the quantum clocks models as new problems rising against an atemporal view. In such a case, both models could be said to imply that there is a place from where temporal asymmetries, physical temporal asymmetries arise, making it necessary not just to expand the question about the things in time but to reformulate it from the now naturally asymmetric universe. Of course, our current interpretation of physical laws as temporally symmetric should also have to be revised, making the few known counter-examples the norm rather than the exception.

Evidently, given the highly speculative character of these models it is still too early to take sides on this dispute, but the thing to be learned from them is that the resource to alternative questions and routes is worth exploring, even if answers are not just around the corner. Besides, the inclusion of such new models and kinds of analysis could help solving not just the limited aiming scope problem, but could also be part of the solution to the weapon inadequacy problem. Gold's universes could become cases of a broader string theory, or examples of large quantum clocks, or whatever one's favorite model indicates they are, making their use justifiable after their required contextualization in a less restricted interpretative frame.

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