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THE PSEUDO-PROBLEM OF CREATION IN PHYSICAL COSMOLOGY*

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According to some cosmologists, the big bang cosmogony and even the (now largely defunct) steady-state theory pose a *scientifically insoluble* problem of matter-energy creation. But I argue that the genuine problem of the origin of matter-energy or of the universe has been fallaciously transmuted into the pseudo-problem of creation by an external cause. A fortiori, it emerges that the initial "true" and "false" vacuum states of quantum cosmology do *not* vindicate biblical divine creation ex nihilo at all.

1. Introduction. Various writers confuse the genuine question "Does the physical universe have a temporal *origin*, and—if so—what does physical cosmology tell us about it?" with the quite different pseudo-problem "Was there a *creation* of the universe, and—if so—what light can science throw on it, if any?" Thus, the cosmologist Hermann Bondi (1961) tells us that in "theories of creation in the past only", such as the big bang cosmogony, "the problem of the origin of the universe, that is [sic], the problem of creation is . . . being handed over to metaphysics" (p. 143). As Bondi sees it, the steady-state theory propounded by himself and Thomas Gold in 1948 brings "the problem of creation . . . within the scope of physical inquiry" (p. 140), if only because it postulates *continual* "creation" such that "no events in the past are required that have

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no counterpart now" (p. 152). Therefore, Bondi claimed heuristic scientific superiority for the steady-state theory vis-à-vis its big bang rival:

> the hypothesis of continual creation is more fertile in that it answers more questions [about the origin of matter] and yields more . . . results that are, at least in principle, observable. To push the entire question of creation into the past is to restrict science to a discussion of what happened after creation while forbidding it to examine creation itself. (Bondi 1961, p. 152)

In diametrical opposition to Bondi, the physicist Herbert Dingle rejects as perpetually miraculous the violation of matter-conservation by the "continual creation" of new hydrogen atoms in the steady-state theory. And he sees that violation as overtaxing our credulity even more than does biblical creation out of nothing: "It [the Bondi and Gold theory] exempts us from having to postulate a single initial miracle on condition that we admit a continuous series of miracles" (quoted in Loren Eiseley 1953, p. 81). But, as against Dingle, the physicist Philip Morrison opines that it is the big bang theory, rather than its steady-state rival, which purportedly requires a greater reliance on supernatural miracles (Morrison 1953, p. 14).

The physical cosmologist Jayant Narlikar is instructively articulate in his confusion of the question of the origin of the universe with the pseudo-problem of its creation. And having conflated these two different questions, he feels entitled to complain that "most cosmologists turn a blind eye" to the latter:

> The most fundamental question in cosmology is, "Where did the matter we see around us originate in the first place?" This point has never been dealt with in the big bang cosmologies in which, at $t = 0$, there occurs a sudden and fantastic violation of the law of conservation of matter and energy. After $t = 0$ there is no such violation. By ignoring the primary creation event most cosmologists turn a blind eye to the above question. (Narlikar 1977, pp. 136–137)

Narlikar had set the stage for this formulation of his question as follows:

> So we have the following description of a big bang Universe. At an epoch, which we may denote by $t = 0$, the Universe explodes into existence. . . . The epoch $t = 0$ is taken as the event of "creation". Prior to this there existed no Universe, no observers, no physical laws. Everything suddenly appeared at $t = 0$. The "age" of the Universe is defined as the cosmic time which has elapsed since this event . . . .
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> Although scientists are not in the habit of discussing the creation event

> or the situation prior to it, a lot of research has gone into the discussion of what the Universe was like immediately after its creation. (Narlikar 1977, p. 125)

During the past three decades, the astronomer Bernard Lovell (1961, 1986) has given an explicitly theological twist to the most fundamental cosmological questions by making two major claims: (1) There is an inescapable problem of creation in both the steady-state and big bang cosmologies, but neither of them is capable of offering a scientific solution to it, and (2) a satisfactory explanatory solution "must eventually move over into metaphysics for reasons which are inherent in modern scientific theory" (1961, p. 125) by postulating *divine* creation. As Lovell sees it, "the major issue" between the competing steady-state and big bang models of the universe is "whether creation is occurring now and throughout all time in the past and in the future, or whether the fundamental material of the universe was created in its entirety some billions of years ago" (pp. 118–119). As for the big bang theory, he declares explanatory bankruptcy. Having assumed that in the classical, pre-quantum versions of this theory, one can meaningfully speak of "the time before the [big bang]" (p. 99), he feels entitled to reason that "One must still inquire . . . how the primeval gas [of the big bang] originated. Science has nothing to say on this issue" (pp. 98–99). And why does he think that science is thus silent? Because the purported creation of matter at the "definite moment" of the big bang is "beyond human investigation" (p. 117). Yet, in his view, the supposed problem of creation "can tear the [human] individual's mind asunder" (p. 125) by its gnawing, inescapable intellectual challenge. Therefore, Lovell repeatedly chides those whom he calls "materialists" for indifference, neglect or evasion of the problem (pp. 112, 122, 125).

But what of the steady-state theory? Though Lovell (1961) endorses Bondi's investigative tribute to it vis-à-vis its big bang rival, he contends that nonetheless it too "has no solution to the problem of the creation of matter" (p. 117), because it provides no "information about the nature of the energy input which gave rise to the created [hydrogen] atom" (p. 124). Yet Bondi explicitly denies that there is any "energy input" in the sense of the principle of energy-*conservation*, which is denied by the steady-state theory. As he put it (1961, p. 144): "It should be clearly understood that the creation here discussed is the formation of matter not out of radiation but out of nothing". And, as will emerge in section 3.1, the crucial point will turn out to be that, in the steady-state theory, such *non*-conservative matter accretion is claimed to transpire *without any kind of external cause*, because it is held to be cosmically the spontaneous, natural, unperturbed behavior of the physical world!

I shall argue that the genuine problem of the origin of the universe or of the matter in it has been illicitly transmuted into the pseudo-problem of the "creation" of the universe or of its matter by an external cause.

At present, the big bang theory is in vogue, whereas the Bondi and Gold steady-state theory is largely defunct on empirical grounds. Indeed, as will be noted in section 4, the so-called "inflationary" early expansion, grand unified theories, and quantum cosmology have modified these earlier twentieth-century cosmologies. Yet it will be instructive philosophically to examine Lovell's argument for divine creation in the context of the earlier two rival theories despite their replacement by the current models. As it will turn out, the philosophical issues have remained essentially the same, although the technical details have changed considerably. Thus, my thesis will be two-fold: If the big bang theory—as modified by quantum theoretical considerations governing two vacuum states close to the big bang phase (Hawking 1988, chap. 8)—is true, it provides no support at all for Augustine's old philosophical doctrine of divine creation out of nothing ("ex nihilo"). And if, alternatively, the steady-state theory had been true, it would have provided no support for the claim that the *non*-conservative matter accretion asserted by it requires an *external cause* such that God is busy creating hydrogen atoms around the clock through all past and future eternity. By the same token, if there were non-conservative energy formation in an "inflationary" universe, while the energy-*density* remains constant, no *external*, let alone supernatural, cause would be warranted. In the case of the big bang theory, the creationist reading of it is, of course, not just that the big bang itself followed upon a state of so-called nothing. Instead, this transition could not have occurred quite naturally but required an *external cause* supplied only by God. On that view, ever since then, God has been thus unemployed, as it were, for about 12 billion years, because the big bang model of the general theory of relativity features the conservation-law for matter-energy, which obviously precludes any non-conservative formation of physical entities.

Most recently, however, the plasma cosmology originally developed by Hannes Alfven, which assigns a critical cosmic role to hot, electrically charged gases, has posed a major challenge to the gravity-dominated big bang cosmology (*The New York Times,* February 28, 1989, p. C1). By featuring a universe that has *existed forever,* without any beginning, plasma cosmology altogether obviates even the temptation to invoke divine creation ex nihilo. Such preclusion of creation will become important, if plasma cosmology turns out to supplant the big bang theory in response to recent observational findings that presumably contradict some of the latter's evolutionary tenets.

As I shall endeavor to show in detail, the question of creation is just

as ill-posed in the context of the recent rival physical cosmologies as was the following sort of problem, which agitated philosophers until the middle of the eighteenth century: Why do ordinary material objects (for example, tables) not simply vanish into nothingness? As Philip Quinn has remarked, there were thinkers until at least the eighteenth century (for example, Jonathan Edwards) who took this question very seriously. Thus, in René Descartes' "Meditation III", he simply assumed, at least tacitly, that when a physical system is closed, it will simply *not* obey matter-conservation spontaneously and quite naturally *without* external intervention. Having made that assumption, he was driven to suppose that an *external cause* supplied by God's activity was required at every instant of time to prevent matter from *lapsing into nothingness*. Ironically, whereas Lovell calls God to the rescue as the cause of the continual non-conservative hydrogen production in the steady-state universe, Descartes assigns that same indispensable causal role to the deity just to keep contingently existing material objects from vanishing into thin air:

> It is as a matter of fact perfectly clear and evident to all who consider with attention the nature of time, that, in order to be conserved in each moment in which it endures, a substance has need of the same power and action as would be necessary to produce and create it anew, supposing it did not yet exist, so that the light of nature shows us clearly that the distinction between creation and conservation is solely a [conceptual] distinction of the reason [rather than of ontological causation]. (Descartes 1967, p. 168)

Bernard Lovell's recent paper "Reason and Faith in Cosmology" (1986) is a technically up-dated concise version of the philosophical argument that he had developed in more detail in his earlier book (1961), which was based on his 1958 lectures over the BBC entitled "The Individual and the Universe".

Just what are the (tacit) assumptions that inspire Lovell's and Narlikar's particular questions? And are these assumptions warranted in the contexts of the theories to which they address their questions? I shall contend that they are *not*! And if not, then there is no basis for Lovell's claim that, since neither the big bang nor the steady-state theory answer his creation questions, they are unsatisfactory without divine creation. Indeed, as we shall see, his questions rest, in each case, on assumptions that are *denied* by precisely the theories to which he is addressing them. And instead of justifying his presupposed assumptions against these denials, he simply takes them for granted without argument. In this way, he assumes rather than shows that good theories need to answer the questions he addresses to them.

After all, a question cannot be regarded as a well-posed challenge,

merely because the questioner finds it psychologically insistent, experiences a strong feeling of puzzlement, and desires an answer to it. This fact is completely obvious in the case of asking a man when he last beat his wife. If, in fact, he does not beat his wife, then it is not a well-posed question to ask him whether or when he stopped beating her. And if the question is nonetheless put to him, and he denies beating her at all, it is illegitimate to accuse him of *evading* the question or of indifference to it. It would be legitimate to challenge the man's denial of wife-beating by offering evidence that he does beat her after all. Such evidence would legitimate the question. Thus, the debate on whether the man has answered the question is pointless, until the underlying assumption of wife-beating is validated. Similarly, if—as we first learned from the chemist Lavoisier—there is indeed matter-conservation (or matter-energy conservation) in a closed finite system on a macroscopic scale *qua spontaneous, natural, unperturbed behavior of the system*, then Descartes was *empirically* wrong to have assumed that such conservation requires the intervention of an *external cause*. And, if he is thus wrong, then his claim that external divine intervention in particular is needed to keep the table from disappearing into nothingness is based on a false presupposition. More generally, if the presupposition of a philosophical or scientific question is false, then the question is at best misleading and at least ill-posed or pointless.

Thus, I hope to show by an analysis of the particular assumptions which inspire Lovell's major questions that they are ill-posed *in just this way*. It will then be seen how he used these misguided questions to give an altogether unwarranted *theological* twist to the rivalry between the steady-state and big bang theories of cosmogony. In particular, as we shall see, Lovell's aforecited statement of "the major issue" between them as one of the *timing* of creation is *not at all* a philosophical refinement or deepening of the question whether the big bang or the steady-state cosmology is true.

2. The Traditional Creation Argument. In order to deal with the recent creation issue in physics, I must first offer an analysis of an old argument for divine creation or so-called first cause that all of us have encountered in the history of philosophy quite independently of sophisticated astronomical theories. It is a version of the "cosmological argument" for the existence of God that is both familiar and most germane to our concerns. There are, however, various other versions (see Rowe 1975 and Craig 1979). And I do *not* claim that my charge of pseudo-problem applies necessarily to all of the questions addressed by these other versions. Thus, I am disregarding the view of *timeless* causation set forth by Augustine in Book XI of his *Confessions,* which was accepted

by subsequent medieval theists, but which I find either unintelligible or incoherent.

The relevant creation argument proceeds from the premise that there is a question as to where everything came from, or of "*how*" the world came into being, or as to who or what caused everything. Thus the question more or less tacitly assumes some sort of temporal beginning for the physical universe, preceded *temporally* by a supposed state of nothingness. And the aim of the argument is to show that we cannot understand the supposed beginning or origin of the world without the assumption that there was a creation out of nothing by a creator. More specifically, the argument claims to establish the necessity for postulating creation by starting out with the premise that things have "causes" in the senses granted by common sense or ordinary science, or even by the sceptical common sense of a hard-headed engineer. Thus, the starting point is the following premise:

"Everything has a cause" to the extent to which causes are acknowledged in explanations of ordinary experience or of scientifically explained phenomena.

From the premise that everything has a cause, the following conclusions are then claimed to follow:

The physical universe *as a whole* had a beginning a finite time ago as a result of an act of creation out of nothing by a single, conscious external CAUSE or agent. And that external cause or creator is then claimed to be the personal God of the biblical theistic tradition.

Let me now comment on the basic premise of the argument. Fortunately, our purposes do not require the ambitious attempt of giving an adequate analysis of the concept or concepts of cause as used in the explanations of ordinary or natural experiences. Instead, our examination of the argument from creation requires only that we attend to certain relevant aspects of that concept of cause.

Note first that there are a vast number of cases of causation by physical forces and, more generally, of causally connected natural events *in which no human or other conscious agents are involved.* Earthquakes and the melting of snow on uninhabited mountain tops in the spring are causal chains of events, but no conscious agents are involved. Similarly for the freezing of a lake, for example. But there are *other* cases such as the production of statues, cakes, and dresses, in which conscious fashioners like sculptors, bakers, homekeepers, and seamstresses *are* causally involved as agents. What will be important for the argument, however, is that in many instances of causation, there simply is no involvement of conscious agents.

Secondly, consider cases of causation which do involve the intervention of conscious fashioners or agents, such as the baking of a cake by

a person. In such a case, the materials composing the cake owe their particular state of being in cake-form partly to acts of intervention by a conscious agent. But clearly, the very existence of the atoms or molecules composing the cake cannot be attributed to the causal role played by the activity of the agent. Thus, even if we were to assume that agent-causation does differ interestingly from event-causation, we must recognize that ordinary agent-causation is still only a *transformation* of matter (energy).

Let me now point out a whole series of fallacies, divided into groups, which the defender of the old creation hypothesis commits in deriving his conclusions from his stated premise. I am going to discuss a whole series not in order to employ "overkill" on the argument, but because I regard all of these fallacies to be quite instructive for our purposes in their own right.

Group 1. Even for those cases of causation which involve conscious agents or fashioners, the premise does not assert that they ever create anything *out of nothing*; instead, conscious fashioners merely TRANSFORM PREVIOUSLY EXISTING MATERIALS FROM ONE STATE TO ANOTHER; the baker creates a cake out of flour, milk, butter, etc., and the parents who produce an offspring do so from a sperm, an ovum, and from the food supplied by the mother's body, which in turn comes from the soil, solar energy, etc. Similarly, when a person dies, he or she ceases to exist *as a person*. But the dead body does not lapse into nothingness, since the materials of the body continue in other forms of matter or energy. In other words, all sorts of organized wholes (for example, biological organisms) do cease to exist only *as such* when they disintegrate and their parts are scattered. But their parts continue in some form.

Since the concept of *cause* used in the conclusion of the argument involves creation *out of nothing*, we see that it is plainly different from the concept of cause in the premise. And for this reason alone, the conclusion does not follow from the premise deductively. Nor is it even supported by it inductively. Indeed, *if* the principle of conservation of energy or mass-energy were to have unrestricted validity, there could *not* have been any temporal process of creation *out of nothing*, since there could then not have been any *time* at which the amount of matter-energy was less than now. But let us note that even an unrestricted conservation principle does not rule out a cosmological model featuring a first moment of time, that is, a model featuring *an instant that has no temporal predecessor*. Why not? Because the conservation of matter or energy requires only that *at all existing times*, the amount of matter-energy has to be the same. Such conservation does *not* require that every instant have a temporal predecessor. Indeed, one of the big bang models does feature a first in-

stant along with energy conservation, *if* one can include the so-called singularity in its space-time.[1]

Furthermore, we saw that only some cases of causation involve conscious agents. Hence it again simply does not follow from the premise, nor is it supported by the premise, that prior to the evolution of conscious organisms on earth or elsewhere, a supposed first state or any other state of the total physical universe should be attributed to the intervention of a conscious agent.

Worse yet, even if some conscious agency or other were needed in every individual case of causation in daily life and science—which it is not!—it would hardly follow that there is some *one* single conscious agency which was required causally for the occurrence of the supposed first state of the *total* physical universe. This inference commits the elementary fallacy of "composition" and is just as invalid as the following argument, which derives a false conclusion from a true premise: since every human has a mother, there is some one woman who was everyone's mother. (Formally speaking, this inference fallaciously commutes a universal quantifier with an existential one.)

Group 2. As we know, the big bang theory of cosmogony, which I shall discuss in section 3.2, relies on specific observational evidence to justify its postulation of a finite cosmic past of the order of 12 billion years, such that there simply did not exist any instant of time *before* then. For now, I need to emphasize, however, that there is nothing at all in the concept of causality as such which warrants the claim that all causal chains must ultimately originate in the finite past from a cause that is *itself uncaused.* The gratuitous assertion that causality as such requires such an uncaused cause induces the conclusion that the universe *must* have had a first instant of time, rather than featuring a past in which *every* instant had a temporal predecessor. But causality as such is fully compatible logically with *physical* causal chains which extend infinitely into the past (both ordinally and metrically), instead of having a common temporal origin in a bounded finite past.[2]

[1]Hawking and Ellis (1973, p. 3) give a brief, non-technical characterization of the concept of singularity as follows: "One can think of a singularity as a place where our present laws of physics break down [because important physical quantities are ill-defined or infinite there]. Alternatively, one can think of it as representing part of the edge of space-time, but a part which is at a finite distance instead of at infinity". Thus, at this "edge", the world-lines representing the space-time careers of mass-points, photons and other elementary physical entities originate or come closer together. For a more technical account, see Hawking and Ellis (1973, chap. 8), and Torretti (1983, Section 6.4). But, when we discuss big bang models below, we shall emphasize Torretti's important caveat regarding the inclusion of a first event in the space-time.

[2]A past that is devoid of any first instant of time is *ordinally infinite*, because every instant of it has a temporal predecessor. But such a past need *not* be of infinite *duration*,

The belief that the existence of causes for physical events requires a bounded past can originate fallaciously in several ways. Let us consider some of the most likely sources of this error. One such source is the *psychological* experience of time on which people draw, when they are presented with the following hypothesis: for any physical state whatever, there is at least one earlier physical state that is its (partial or total) cause. When a person thinks of the ever earlier causal antecedents *one-by-one*, that person soon experiences thought-fatigue. People just tire of thinking about ever earlier events. As we know, since each act of thought requires a minimum positive amount of time, it is impossible to review the members of an infinite set in thought one-by-one in a finite time (Grünbaum 1968, pp. 52, 67–68). In this way, thought-fatigue may fallaciously induce the conclusion that physical causal chains cannot possibly extend into an unbounded past, and that physical causation occurred only over a bounded past, so that there had to be a first moment of time. This fallacy gains added plausibility from an unconscious appeal to our memory, which contains only finitely many bits. But scientific understanding can do much better than such intuitive, *experiential* picturing of the past.

Another way in which people are tempted to insist on a bounded past involves the commission of a fallacy similar to the one illustrated by my earlier trivial example of motherhood. The reasoning starts out from the claim that such macroscopic objects as the earth, trees, people, mountains, and individual stars are first fully formed as such by causal processes from earlier, more primitive states. Thus such macro-objects *each* have their own respective beginnings in time in at least the following sense: for each of them, there is a time such that it did *not* exist in its final form before then, but did exist as of then or since. Incidentally, without additional theory, the correctness of this claim of temporal origin is by no means obvious in regard to all elementary particles, for example, *some* of which might conceivably have existed in their present form throughout all past time. But let us grant the claim for macro-objects. Since there may well be infinitely many of them, it then still does not follow that there must have been a *single time* such that all such objects whatever in the universe originated at or since that time.

This conclusion of a bounded past *would* follow, if the number of macro-objects in the universe were *only finite*, because a finite number of them must have originated at only finitely many times. But the defender of the inference has offered no reason for assuming that there are only finitely many macro-objects in the world! And even if there were, this

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since it could be *metrically* finite in years or other units of time. In a metrically infinite past, the number of units of time is infinite.

would not preclude that these finitely many objects could have originated in their usual form as a result of an infinitude of prior transformations, from matter or energy existing earlier in other forms *during an unbounded past*! For example, in the case of the so-called "pair creation" of a particle and its anti-particle, such as a positron and an electron, their rest-mass formation *as such* occurs by conversion of other forms of energy such as a gamma ray into them.

Besides, if literally *everything*—including the universe as a whole—has a cause to which it owes either its state-of-being or even its very existence, it becomes imperative to ask for the *cause* of God's state-of-being or even existence. Why should He be an uncaused cause? As Schopenhauer has observed, those who try to exempt God from their universal causal assertion treat causation like a hired carriage that is dismissed upon reaching its desired destination.

Group 3. At this point, the argument is sometimes abandoned in favor of claiming that creation out of nothing "*passes all understanding*" and that scientific theories of cosmogony leave much to be desired in the way of providing answers to well-conceived questions. To this I say: if the creation hypothesis is indeed beyond human understanding, then it cannot even be meaningfully *taken on faith* without evidence, and it becomes completely hopeless to try to give a causal argument for it. After all, if the hypothesis itself is beyond human understanding, then even the person who is willing to believe it on faith admits that he or she does not know what is to be believed. Our human species may well be limited by intrinsic intellectual horizons of some sort, just as theoretical physics, for example, cannot be understood by dogs. Yet the fact remains that one can meaningfully believe only a claim whose *content* one understands, even if one is willing to believe without evidence on sheer faith. If the belief-content is incomprehensible, what is it that is being believed?

Therefore, if creation out of nothing (ex nihilo) is beyond human understanding, then the hypothesis that it occurred *cannot explain anything*. Even less can it then be required to fill explanatory gaps that exist in scientific theories of cosmogony. Indeed, it seems to me that if something literally passes all understanding, then nothing at all can be said or thought about it by humans. As Wittgenstein said: Whereof one cannot speak, thereof one must be silent. Dogs, for example, do not bark about relativity theory. Thus, any supposed hypothesis that literally passes *all* understanding is simply meaningless to us, and it certainly should not inspire a feeling of awe. To stand in awe before an admittedly incomprehensible hypothesis is to exhibit a totally misplaced sense of intellectual humility! It is useless to reply to this conclusion by saying that the creation hypothesis may be intelligible to "higher beings" than ourselves,

if there are such. After all, it is being offered to *us* as a causal explanation!

So much for the reasons which lead me to regard the *traditional* first cause version of the "cosmological" argument for divine creation as multiply unsound. We are now ready to examine Lovell's attempt to base a new creation argument on the two most influential physical cosmologies of the twentieth century: the steady-state theory, on the one hand, and the "big bang" cosmogony, on the other.

3. The New Creation Argument

3.1. The Alleged Philosophical Defects of the Steady-State Theory. First, I need to comment on the unfortunately misleading uses of the words "creation" and "annihilation", which are carried over from theology into the contemporary literature of physics and philosophy of science. The semantic caveat I shall issue will apply to both of the received rival twentieth-century cosmologies, though not to the new rival plasma cosmology.

The word "creation" suggests a creating *agency* as well as a *process* in which something new is being produced. And the traditional theological assertion of divine creation out of nothing makes two further claims: (1) Before the created objects existed, the *only* entity that existed was God. In short, there was nothing besides God. (2) God was the agency responsible for the change from the so-called state of "nothing" to the state in which other sorts of entities existed. These notions are conveyed by the theological overtones of the term "creation". In English at least, this term is also used in other contexts in which it conveys the formation of something new, but need not suggest that the new object came from "nothing". But especially in the description of processes that conform to energy-*conservation* laws, the use of the terms "creation" and "annihilation" can be very misleading.

Take, for example, the phrases "pair creation" and "pair annihilation", which are familiar from the theory of particle reactions. In that theory, these phrases are employed to describe energy-conserving processes featuring the *inter-transformation* between radiation and a particle-pair consisting of one kind of particle and its anti-particle. Thus, when an electron and a positron collide, their rest-mass is *converted* into two photons of gamma radiation. While the rest-mass of these photons may well be zero, this gamma radiation is obviously much more than just "nothing". Nevertheless, even the distinguished philosopher of physics Hans Reichenbach wrote (1956, p. 265) that the particle and its anti-particle disappear "into nothing". Evidently, the phrase "pair annihilation" obscures the fact that the energy of the original positive rest-mass of the particles reappears in the resulting gamma radiation, although the term "annihilation-*radiation*"

is not similarly misleading. Corresponding remarks apply to the transformation of gamma radiation into an electron-positron pair: such pair-production is certainly not a case of pair-"creation" *out of nothing*.

This energy-conservation in the theory of particle reactions contrasts sharply with the explicit postulation of its *violation* in the now abandoned steady-state cosmology of Bondi and Gold. Unfortunately, as we recall, Bondi himself (1961, p. 144) uses the term "creation" misleadingly to describe this denial of energy-conservation in that cosmology: "It should be clearly understood that the creation here discussed [in the context of the steady-state theory] is the formation of matter not out of radiation but out of nothing". Alas, the term "creation" suggests misleadingly that Bondi was postulating the operation of a creator or creating *agency*. But, more fortunately, he goes on to use the much better term "formation". In the Bondi and Gold theory, the formation of new matter cannot be conservative, because they assume that the *density* of matter is constant over time even as the universe is *expanding*, that is, their theory features the conservation of density but *not* of matter. But I urge that this violation of matter-energy conservation be described by means of such words as "matter-increase", and "accession or accretion of matter", rather than by the term "creation".

As indicated in the Introduction, the current observational credentials of the steady-state cosmology are generally held to be poor. Yet, the steady-state theory has the merit of making many daring predictions which can be and, to some extent, have been tested. For example, it demands that the thermonuclear reactions in ordinary stars should be able to produce the heavy elements such as uranium out of what was originally hydrogen. And, indeed, this demanding prediction was very fruitful for the development of the theoretical understanding of nuclear reactions in stars. As another example, the theory predicts that the age distribution of the galaxies should be *uniform* for distant galaxies no less than for near ones. There seems to be an emerging consensus among astrophysicists that the theory is not viable for reasons of the following sort: (i) If the red shift from quasars is indeed a bona fide Doppler shift, then the presumed known distribution of quasars is actually contrary to the theory, and hence counts as refuting evidence against it. (ii) There is the evidence of the 3°K microwave background radiation which, though not necessarily contrary to every version of the theory, is fairly hard to accommodate in it (Peebles 1971, p. 24; Weinberg 1972, pp. 617–618). Yet that radiation was predicted by Gamow's version of the big bang cosmogony. Thus, given the availability of a rival *evolutionary* cosmogony, the number of adherents of the steady-state theory is dwindling rapidly to the point that now "only few will still defend it" (Rindler 1977, p. 202). But earlier a somewhat less pessimistic note was sounded by Weinberg (1972 pp. 464, 617–619).

And, as John Leslie has pointed out to me, most recently Narlikar (1988, pp. 219–225) has claimed that the currently popular so-called "inflationary" model of the universe is an up-dated form of Fred Hoyle's version of the steady-state theory, as distinct from the Bondi and Gold original with which we have been concerned. The affinity between the new inflationary and old steady-state theories derives from the fact that the new theory features the conservation of *energy density* as the universe inflates very rapidly. This feature is the counterpart of the conservation of *matter density* in the old steady-state versions.

To gain perspective on Lovell's (1961, p. 117) philosophical complaint that the "steady-state theory has no solution to the problem of the creation of [new] matter", let us first look at the lesson that can be learned from the history of science in regard to the evidential warrant for postulating *external causes* for the behavior of physical and biological systems (Grünbaum 1973, pp. 406–407).

According to Aristotle, an external force is needed as the cause of a sublunar body's non-vertical motion. In his physics, the demand for such a disturbing external cause to explain such motion arises from the following assumption: When a sublunar body is not acted on by an external force, its *natural*, spontaneous unperturbed behavior is to be at rest at its "proper place", or—if it is not already there—to move vertically toward it. Yet, as we know, Galileo's analysis of the motions of spheres on inclined planes led him to conclude that the empirical evidence speaks against just this Aristotelian assumption. As Newton's First Law of Motion tells us, uniform motion never requires any external force as its cause; only accelerated motion does. Any of us who sat helplessly in a car while it was gliding along with essentially constant velocity on a wet road while hydroplaning can appreciate that Galileo and Newton were right. But, if so, then the Aristotelian demand for an *explanation* of *any* non-vertical sublunar motion *by reference to an EXTERNAL, perturbing force* begs the explanatory question by means of a false underlying assumption, rather than asks a well-posed legitimate question as to the "why" of uniform non-vertical sublunar motion. By the same token, Galileo and Newton could only shrug their shoulders or throw up their hands in despair, if an Aristotelian told them that he has a solution to the "problem" of the *external* cause of such uniform motion, whereas they do not. It would, of course, be legitimate for the Aristotelian to *try* to offer empirical evidence that Newton's First Law is false despite Galileo's observations on an inclined plane. But begging the question hardly constitutes such evidence.

I claim that an Aristotelian who would reason *like Lovell* could just as well say the following: If a sublunar body moves non-vertically while *not* being subjected to an external physical force, then we must explain this motion—even if it is uniform—as the result of external *supernatural* di-

vine intervention. Let me justify this claim.

Just as Galileo and Newton rejected, on empirical grounds, the Aristotelian idea of rest or vertical motion as the naturally inevitable, unperturbed state of sublunar bodies, so also Bondi and Gold rejected matter-conservation on the huge cosmological scale as the inevitable natural career of externally undisturbed physical systems. Instead, as we recall, they postulated *density*-conservation in an expanding universe, which requires non-conservative matter accretion. And just as it is a matter of *empirical* fact whether uniform motion requires a force as its external cause, so also is the question whether the natural, spontaneous, unperturbed behavior of physical systems conserves the quantity of matter *or* rather its density. After all, our scientific conceptions as to which state of affairs is the spontaneous, natural and unperturbed one are no better than the scope of their supporting evidence. And, as the history of science shows all too clearly, as our evidence grows, so also these conceptions need to be changed by stretching our intellectual horizons.

If matter-conservation is indeed the natural, unperturbed course of things, even on a cosmological scale, then the steady-state theory is physically false. On the other hand, if large-scale *density*-conservation is the spontaneous, *unperturbed*, natural state, as a matter of empirical fact, then Lovell is not entitled to his stubborn dogmatic insistence that, *in every theory*, *matter*-conservation *must* be held to be the natural state! Yet just that insistence is the basis for his demand for an external supernatural cause to explain the matter-*increase* required by density-conservation in an expanding universe. Thus, as we saw in section 1, Lovell complains (1961, p. 124) that the steady-state theory makes no provision for "the energy *input* which gave rise to the created [hydrogen] atom" (my italics). No wonder, therefore, that, in his view, the *non*-conservative matter-production postulated by Bondi and Gold poses a "problem of creation" so acute that it "can tear the individual's mind asunder". To prevent such mental disintegration, he urges that "we move over into metaphysics" (p. 125) and characterize the matter-increase causally as a miracle by saying that "the creation process is a divine act which is proceeding continuously" (p. 117). Thus, in that sense, Lovell is prepared to accept the steady-state cosmology if observation were to confirm it empirically. Ironically, he overlooked that Descartes had claimed divine intervention to explain matter-*conservation*, after assuming a state of nothingness to be the unperturbed natural state of the world. In a steady-state world containing humanoids who live long enough to observe its matter-accretion many, many times, it would seem quite natural to them.

We see that the hypothesized matter-increase in a steady-state universe is turned into a divine miracle only by the gratuitous, dogmatic insistence on matter-conservation as *cosmically* the natural state, *no matter what the*

empirical evidence. Those who share Lovell's view of miraculousness cannot justify a criterion of "naturalness" that would turn the continual accretion of new matter into something "outside the natural order" instead of just being itself a part of that very order. I therefore conclude that Herbert Dingle's rejection of matter accretion as miraculous was ill-founded.[3] Thus, Lovell, the theist, and Dingle, the atheist, made identically the same mistake of thinking that the matter-increase would be miraculous, although they made opposite uses of that mistake in their attitude toward the steady-state theory. Philosophically, they are brothers under the skin in this context. Thus, both Dingle and Lovell overlook the following key point: *Just as a theory postulating matter-conservation does not require God to prevent the conserved matter from being annihilated, so also the steady-state theory has no need at all for a divine agency to cause its new hydrogen to come into being*!

The argument that I have developed on the basis of the history of physics from Aristotle to Bondi and Gold could likewise be based on the history of inquiry into the natural possibility of the spontaneous, unperturbed generation of living substances from inorganic materials. After Pasteur's work led to the denial of that possibility in an oxidizing atmosphere, Oparin and Urey asserted it for a reducing atmosphere *over much longer time periods* (Grünbaum 1973, pp. 571–574).

3.2. The Big Bang Theory. Let us now turn first to the alleged problem of "creation" posed by the pre-quantum version of the big bang theory, as treated by Lovell, Narlikar and even Bondi. When that theory is being contrasted with its steady-state rival, it is often called "evolutionary". And it tells us that, before the chemical elements were formed, an explosion of primeval matter resulted in the present expansion of the universe. That explosion is called "the big bang". It may perhaps still be an open question whether the big bang might be somehow accommodated in a mathematically meaningful fashion in an Einsteinian universe such that the big bang is *not* a singular boundary of space-time. In one such sketchily envisioned model, the big bang would have been preceded by an infinite sequence of prior contractions and expansions, like those of a musical accordion. But quite apart from current technical doubts about the eternally oscillating model of the universe, it does not even provide a *point of departure* for the argument from creation ex nihilo. Therefore, I shall now consider just the particular models which at first glance *seem*

[3]I pointed out the pitfalls of the miracle concept in this context in a letter in *Scientific American*, December 1953. In a private communication to me (dated December 11, 1953), Professor Bondi wrote that, in his view, my point in the letter "was in great need of being stated". And he added: "Naturally I found it particularly enjoyable that you discussed the matter with reference to an unsound criticism of our [Bondi & Gold] theory".

to warrant the sort of questions asked by Narlikar and Lovell.

These models have been claimed to allow two cases: Let me discuss them separately. But I must note at once the caveat issued by Torretti (1979, pp. 328–329; 1984, p. 197; 1983, pp. 210–219) that only the *second* of these cases is a bona fide one of general relativity, whereas the first one is not. I nonetheless deal with the latter as well, because Narlikar and others have invoked it to claim, as we saw, that $t = 0$ is a bona fide instant at which "the primary creation event" actually occurred (Narlikar 1977, pp. 136–137).

Case (i) features a cosmic time interval that is *closed* at the big bang instant $t = 0$, and furthermore, *this instant had no temporal predecessor*. In this case, $t = 0$ was a singular, temporally first event of the physical space-time to which all of the worldlines of the universe converge. This means that *there simply did not exist any instants of time before* $t = 0$! But it would be (potentially) misleading to describe this state of affairs by saying that "time began" at $t = 0$. This description makes it sound as if time began in the same sense in which, say, a musical concert began. And that is misleading, precisely because the concert was actually preceded by actual instants of time, when it had *not yet* begun. But, in the big bang model under consideration, there were no such earlier instants before $t = 0$ and hence no instants when the big bang had not yet occurred. Lovell (1961, p. 106) is quite unaware of these facts when he speaks mistakenly of a "metaphysical scheme before the beginning of time and space". Similarly, there is no basis for Narlikar's (1977, p. 125) lament that "scientists are not in the habit of discussing . . . the situation prior to it [the big bang]".

To suggest or to assume tacitly that such prior instants existed after all is simply incompatible with the physical correctness of this model and thus implicitly denies its soundness. Since Aristotle believed that a first instant of time is *inconceivable* (*Physics*, Book VIII, 25lb), he implicitly denied even the logical possibility of the model, and therefore also its physical possibility. It is now clear that the physical correctness of this model is also implicitly denied by anyone who asks any of the following questions: "What happened *before* $t = 0$?", "What *prior* events CAUSED matter to come *into* existence at $t = 0$?" or "What *caused* the big bang to occur at $t = 0$?" In just this vein, Lovell (1961, pp. 98–99) asks "how the primeval gas originated" and then complains that "Science has nothing to say on this issue". But each of these questions presupposes that $t = 0$ was preceded by other existing moments of time. Yet just this assumption is denied by the very model to which these questions are being addressed!

Therefore, we can now draw the following major conclusions: If Nar-

likar and Lovell take the given big bang model to be physically true, then the questions they have addressed to it are illegitimate, because then these questions are based on a false presupposition. Of course, they are indeed entitled to reject the model by giving cogent reasons for postulating the existence of times *before* $t = 0$. But, failing that, it is altogether wrong-headed for them to complain that—even when taken to be physically adequate—this model fails to answer questions based on assumptions which it denies as false. As we saw, Newton's laws of motion cannot be expected to answer a question calling for the specification of an external cause (force) of uniform motion. And a man who never beats his wife cannot be expected to answer the question: "When did you start or stop beating her?"

This question-begging presupposition of instants before $t = 0$ is also made in another form by asking in the context of the *pre*-quantum models: "How did the matter existing *at* $t = 0$ come *into* being?" The model to which this is addressed features the *conservation* of matter-energy. Thus, it asserts that, at all existing instants of time, the total matter-energy content of the universe was the same. To ask how this matter came *into* existence in the first place is to presuppose not only earlier moments of time, but also the *non*-existence of any matter at those supposed earlier times. Yet precisely these presuppositions are denied by the matter-conservation asserted by the model. Therefore, Narlikar (1977, pp. 136–137) was simply dead wrong when he wrote: "in big bang cosmologies . . . at $t = 0$, there occurs a sudden and fantastic violation of the law of conservation of matter and energy". Even the term "sudden" tacitly trades on times prior to $t = 0$. And these illegitimate ways of begging the question generate the so-called "problem of creation"! By the same token, it was wrong for the physicist Orear (1963, p. 243) to say that the big bang model features "sudden creation".

Besides Narlikar and Lovell, even Bondi (1961, pp. 74, 140) thought that there is a problem of creation in the big bang model of general relativity, though not in his own steady-state model. But the big bang model simply denies that any matter at all comes *into* existence *non*-conservatively. It appears, therefore, that, with respect to the big bang theory, Bondi fell into the same error as Lovell and Narlikar. But so did the atheistic British astrophysicist Bonnor (1964, pp. 111–112), who rejects the model of Case (i) partly because he mistakenly believes that it supports a theological interpretation of cosmogony.

Recall that the oscillating "accordion" universe mentioned at the start of this section 3.2 is irrelevant to our concerns, since it does not even provide a point of departure for the creation ex nihilo argument.

I should emphasize that if, as in the version of quantum cosmology outlined in section 4 below, the "big bang" is no longer held to comprise

all early past time ($t \geq 0$) but to start later, then *it may well no longer be misguided* to ask "what caused the big bang?", as in Davies (1984, chap. 12). But, in that quantum version, general relativity turns out to tell us *why* there is an "inflationary" expansion, thereby obviating any explanatory resort to an external divine cause!

Case (ii). This subclass of big bang models differs from those in Case (i) by excluding the mathematical singularity at $t = 0$ as not being an actual moment of time. Thus, their cosmic time interval is *open* in the past by lacking the instant $t = 0$, although the duration of that past interval in years is finite, say 12 billion years or so. But just as in Case (i), no instants of time exist *before* $t = 0$ in Case (ii). And despite the equality of finite duration of the time intervals in the two models, the crucial difference between Case (ii) and Case (i) is the following: In Case (ii), *there is no first instant of time at all*, just as there is no leftmost point on an infinite Euclidean line that extends in both directions. And in both Case (i) and Case (ii), the non-existence of time *before* $t = 0$ allows that matter has *always* existed, although the age of the universe is finite in either case. And this assertion is true because, in this context, the term "always" refers to all actual past instants of time.

Nevertheless, even in Case (ii), the finite age of the universe has tempted some people to make the tacit false assumption that there were moments of time after all *before* the big bang, an assumption incompatible with both models. And once this question-begging assumption is made, the door is open for all the same illegitimate, ill-posed creation questions that I undermined à propos of Case (i).

We are now ready to see that despite the replacement of the classical big bang theory by quantum cosmology, the philosophical issues with which we have been concerned, as well as their resolution, remain essentially the same.

4. Quantum Cosmology. In a very recent paper, Weisskopf (1989) gives an account of quantum cosmogony that links up with the above classical story of the big bang expansion of the universe. Relying on that account, we note first that there are two sorts of vacuum (p. 36): The "true" and "false" ones respectively. The former features empty space and "energy fluctuations", though it is devoid of matter and energy proper. The false vacuum, on the other hand, contains energy *without* matter. Referring to the initial true vacuum state, Weisskopf (p. 36) recalls the biblical statement "The world was without form and void, and darkness was upon the face of the deep". But, as we shall see, the clear affinity between that vague biblical statement and the assertion of an initial true vacuum in the technical sense of particle physics turns out to be *altogether unavailing*

to the proponent of divine creation out of nothing!

The initial true vacuum state does not last. There is a transition from it to the false vacuum:

> Everything, including the true vacuum, is subject to fluctuations—in particular to energy fluctuations. The field that provides energy to the false vacuum is absent in the true vacuum, but not completely. There must be fluctuations in the field. Thus, at one moment a small region somewhere in space may have fluctuated into a false vacuum. (Weisskopf 1989, p. 36)

In a follow-up letter (*New York Review of Books*, vol. 36, no. 4, March 16, 1989), Weisskopf addresses the following question posed by several readers:

> How can energy fluctuations occur in a true vacuum that is supposed to be free of energy and matter? (p. 43)

And he replies:

> I did not explain this because it would have been difficult to do so in ordinary language . . ..
>
> No doubt the statement I made, if applied to the true vacuum, contradicts the idea of total emptiness. *In this sense the common concept of a vacuum is not valid*. The recognition of fundamental fluctuations in empty space is one of the great achievements of quantum mechanics. In some special cases the existence of such fluctuations has been established by experiment. And that is the basis of the idea that indeed something can come out of nothing. (p. 43; my italics)

Thus, according to quantum theory, this sort of emergence of energy, which is ex nihilo only in a rather Pickwickian sense, proceeds in accord with pertinent physical principles, rather than as a matter of inscrutable external divine causation.

As is known from Einstein's general theory of relativity, a false vacuum "is bound to expand suddenly and explosively, filling more and more space with false vacuum". Just this "inflationary" expansion, which is far more rapid than the rates familiar from the classical conceptions of the expanding universe, "is supposed to be the Big Bang!" (Weisskopf, p. 37).

When a specified large size is attained, the inflationary explosion stops, and a true vacuum emerges but, by one microsecond thereafter, the energy contained in the false vacuum shows up as light as well as in the form of various particles and anti-particles. In this sense, a "mechanism" for matter-formation is envisioned by this current theory. Thereafter, our

universe goes into the previously familar, relatively "slow" expansion. Some 300,000 years later, atoms are formed when protons and helium nuclei capture electrons. In due course, stars are born from the hot hydrogen and helium gases, and so, subsequently, are galaxies.

For precisely the reasons I developed à propos of the classical big bang at $t = 0$, there is no warrant at all for invoking an external cause—let alone a divine one—for the initial true vacuum. Hawking (1988) reaches the conclusion that there is no problem of creation, because at that stage, the very distinction between space and time becomes mushy, as does the notion of an initial singular instant of time. A fortiori, there is no warrant for seeking an external cause of any sort for effecting the various successive transitions from the true vacuum to the false one, then to the "inflationary expansion", and finally to the more familiar slow expansion that features the formations outlined above. After all, all these transitions are matters of natural physical laws.

In his 1986 paper, Lovell referred to an updated big bang model that features an initial quantum vacuum state, followed by the expansion. And he said in effect: If we call $t = 0$ a state of "nothing", then this model provides a scientific justification of Augustine's theory of creation out of nothing. But in the discussion after his oral delivery of the paper at a 1986 Locarno congress, I offered my arguments above against his reasoning: Why, I asked, should the transition from the vacuum state to the expansion require any *external cause* at all, let alone a divine one? I was delighted that, in Lovell's reply, he then expressed agreement with me (Lovell 1986, p. 109).[4]

More generally, I conclude that neither the big bang cosmogony nor the steady-state cosmology validates the traditional cosmological argument for divine creation. But, as we see, that argument dies hard.

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[4]For discussion relevant to this debate, the reader is referred to the papers by Bondi, Bonnor, Davies, Ellis, Gale, Gamow, Linde, McMullin, Narlikar, Rees, and Tryon in Leslie (forthcoming 1989), which will also contain a reprint of this paper.

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