ADOLF GRÜNBAUM

CREATION AS A PSEUDO-EXPLANATION IN CURRENT PHYSICAL COSMOLOGY*

1. INTRODUCTION

In his posthumously published *The Direction of Time* (1956, p. 133), Hans Reichenbach wrote: "At the present state of cosmology, it is very difficult to come to a conclusion concerning time as a whole". Yet in that work, he did rely on his "hypothesis of the branch structure" (chap. III, sec. 16) to offer a cosmological examination of temporal anisotropy in the context of (classical) statistical mechanics. Elsewhere (Grünbaum, 1967, pp. 168–170), I have offered an appreciative critical appraisal of his proposed extension of his hypothesis of the branch structure to cosmology. But unfortunately, Reichenbach did not live to witness the elaboration of cosmic physical models during the latter half of the twentieth century that are very much concerned with "time as a whole".

Indeed, some of these cosmologies have ushered in various attempts to enlist them as support for theological creationism. For example, in a famous 1951 address to the Pontifical Academy of Sciences, Pope Pius XII saw the big bang cosmology as calling for a necessary creator *ex nihilo* (Isham, 1988, p. 378). And the Benedictine priest Stanley Jaki (1980, pp. 85–86) opines:

> . . . on account of the universal relevance of creation, there ought to be an intimate connection between the fate and fortune of science and the Christian dogma of creation. Indeed, such a connection is all too well attested by a history of science free of the shackles of the blind rationality of logical positivism and of the subtle irrationalism of a psychologism and sociologism erected into epistemology and metaphysics.

For historical reasons, the term "creation" is laden with the notion of a creating agency or cause *external* to the created objects. In this important respect, this word differs from the neutral term "origination." Moreover, the terms "nothing" or "from nothing" as used in conjunction with "creation" carry the connotation of the traditional theological notion "*ex nihilo*". Alas, the recent literature on some

Erkenntnis **35**: 233–254, 1991.

versions of quantum cosmology contain inappropriate uses of these locutions which may suggest that this theory abets creationism. For example, such physicists as Hartle and Hawking (1983) and Vilenkin (1983) speak misleadingly of certain primordial physical states as "nothing", even though these states are avowedly only "a realm of unrestrained quantum gravity", which is "a state with no classical spacetime" (Vilenkin, 1983). By the same token, in his essay "Creation of the Universe as a Quantum Process", the English physicist Isham (1988, p. 401) characterized Hartle and Hawking's (1983) version of quantum cosmology as featuring "creation from nothing". Indeed, he adds: "The creation from nothing is precisely that".

On the other hand, some opponents of creationism have illicitly rejected particular cosmological models *a priori*, in the mistaken belief that these physical models either lend credence to divine creation *ex nihilo*, or at least fail to answer allegedly legitimate questions posed by creationists. Thus, John Maddox (1989, p. 425), the editor of *Nature*, judged the big bang cosmogony "philosophically unacceptable," claiming that "creationists . . . have ample justification in the doctrine of the Big Bang", because this doctrine is allegedly vitiated by "the philosophical difficulty that an important issue, that of the ultimate origin of our world, cannot be discussed". In due course, I shall challenge Maddox's assertions fundamentally. But, it behooves me to register a two-fold *caveat* at the outset: 1. Suppose that – contrary to actual fact – the best model of recent physical cosmogony *were* evidentially supportive of divine creation *ex nihilo* à la Augustine. In that counterfactual eventuality, it would be an impermissible apriorism to reject the model for that particular reason, as some atheists have done. 2. On the other hand, posit that, in the context of the Big Bang model, Maddox's particular construal of the question of "the ultimate origin of the world" turns out to be a *pseudo-problem*, as indeed it will. Then his question is simply pointless. And, in that case, the import of his question surely does not license his conclusion that "creationists...have ample justification in the doctrine of the Big Bang".

In advance of considering particular cosmologies, let me note that the invocation of a divine creator to provide *causal* explanations in cosmology suffers from a fundamental defect vis-à-vis scientific explanations: As we know from two thousand years of theology, the hypothesis of divine creation does not even envision, let alone specify, an appropriate *intermediate* causal *process* that would *link* the presence of the

supposed divine (causal) agency to the effects which are attributed to it. Nor, it seems, is there any prospect at all that the chronic inscrutability of the putative causal linkage will be removed by new theoretical developments. In sharp contrast, the discovery that "an aspirin-a-day" keeps many a heart-attack away has been quickly followed by the quest for a specification of the mode of action that mediates the prophylaxis afforded by this drug against coronary infarcts. Similarly for therapeutic benefits from placebos wrought by the mediation of endorphin-release in the brain and by the secretions of interferon and of steroids. In physics, there is either an actual specification or at least a quest for the *mediating causal dynamics* linking presumed causes to their effects. In the case of laws of coexistence or action-at-a-distance, there is a specification of concomitant variations in the sense of John Stuart Mill. Yet despite the failure of theology to provide just such a dynamical linkage, Newton invoked divine intervention in the belief that it could plug explanatory lacunae which his physics had left unfilled.

In the face of the inherently irremediable dynamical inscrutability of divine causation, the resort to God as creator, ontological conserver of matter, or intervener in the course of nature is precisely a *deus ex machina* that lacks a vital feature of causal explanations in the sciences. The Book of Genesis tells us about the divine word-magic of creating photons by *saying* "Let there be light". But we aren't even told whether God said it in Hebrew or Aramaic. I, for one, draw a complete *explanatory* blank when I am told that God created photons. This purported explanation contrasts sharply with, say, the story of the formation of two photons by conversion of the rest-mass of a colliding electron-positron pair. Thus, so far as divine causation goes, we are being told, to all intents and purposes, that an intrinsically elusive, mysterious agency X inscrutably produces the effect. And the appeal to the supposed divine attributes of omnipotence, omniscience and omnibenevolence merely baptizes this cardinal explanatory lacuna.

Thomas Aquinas recognized, to his credit, that divine causal explanations are problematic by being global in this way, although he thought he could neutralize his own initial objection to them by his famous "Five Ways". As he put the explanatory challenge: "it seems that everything we see in the world can be accounted for by other principles, supposing God did not exist" (*Summa Theologica*, Part I, 1.6. Third Article, Objection 2.)

So much for a general preliminary *caveat* against the tacit misassimi-

lation of purported divine causation in cosmology to causal explanations in the natural sciences.

In the present paper, I aim to show that pseudo-explanations offered in response to pseudo-problems vitiate current attempts to harness the influential cosmological models of recent decades in support of theological creationism. Indeed, it will turn out that none of these models pose any sort of challenge to atheism. As we know, the notion of pseudo-problem figured prominently in the philosophical iconography of logical empiricism. Though much of positivist philosophy of science is deservedly superseded, I shall argue that its notions of pseudo-problem and pseudo-explanation are fundamentally illuminating in the philosophy of cosmology. Currently, the Big Bang theory, in some version of quantum cosmology, is largely in vogue. The original steady-state cosmology of Bondi and Gold (and of Hoyle) has become defunct on empirical grounds. Yet there are dissenting voices: Last year, five astrophysicists (Arp *et al.*, 1990) argued that the Big Bang model is unsatisfactory, and one of them (Narlikar, 1991) dealt with the question "What if the big bang didn't happen?"

Despite the recent modifications of the original rival big bang and steady-state cosmologies, it will be philosophically instructive to examine creationist arguments in the context of these original theories before turning to quantum cosmology. As it will turn out, the philosophical issues have remained essentially the same, although the technical details have, of course, changed considerably.

2. THE PSEUDO PROBLEM OF CREATION IN THE PRE-QUANTUM 20TH CENTURY COSMOLOGIES

A. *The Alleged Philosophical Defects of the Pre-Quantum Big Bang Cosmogony*

According to the physical cosmologists Narlikar, Lovell, and Bondi, a problem of socalled "creation" is posed by a pre-quantum version of the big bang theory. When that theory is being contrasted with its steady-state quondam 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 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 big bang models that, at first glance, seem to warrant the sort of questions asked by Narlikar and Lovell

These models have been claimed to allow two cases, which I shall discuss separately. But I must note at once the caveat issued by Torretti (1979, pp. 328–329; 1983, pp. 210–219; 1984, p. 197) that only the *second* of these cases is a bona fide one of general relativity, whereas the first one is not (see also Tipler, 1987, and Barrow and Tipler, 1986, pp. 442–443). I nonetheless deal with the spurious case as well, because J. Narlikar and others have invoked it to claim that there is a bona fide instant $t = 0$ at which "the primary creation event" actually occurred (Narlikar, 1977, pp. 136–137).

Narlikar is instructively articulate in his *confusion* of the question of the origin of the universe with the alleged 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 purportedly most fundamental of all questions:

> 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 occurrs 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. . . .
>
> 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)

Now let me be more specific as to the sorts of big bang model that Narlikar and other creationists have invoked. They fall into two classes.

Case (i) features a cosmic time interval that is allegedly *closed* at the big bang instant $t = 0$, and furthermore, *this instant had no temporal predecessor*. In this case, which figures in Narlikar's complaint, $t = 0$ was a singular, temporally first event of the physical space-time to which all of the worldlines of the universe converge. This means, I repeat, *that there simply did not exist any instants of time before* $t = 0$! It would be (potentially) misleading to describe this state of affairs by saying that "time began" at $t = 0$. How so? 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 putative 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. Narlikar and Lovell (1961, p. 106) were apparently quite unaware of these facts. Thus, as we saw, Narlikar (1977, p. 125) deplored that "scientists are not in the habit of discussing . . . the situation prior to it [the big bang]". And Lovell assumed that one can meaningfully speak of "the time before the [Big Bang]" (p. 99), such that "one must still inquire. . . how the primeval gas [of the Big Bang] originated". Thereupon he joins Narlikar in a philosophical jeremiad and says: "Science has nothing to say on this issue" (pp. 98–99).

To suggest or to assume tacitly that instants existed after all before the big bang is simply *incompatible* with the physical correctness of the putative big bang model at issue, and thus implicitly denies its soundness. Aristotle believed that a first instant of time is *inconceivable* (*Physics*, Book VIII, 251b). But such a moment is quite conceivable, and the verdict as to its actual existence must be reserved to the mathematics of our best, empirically tested, physical theories. Yet, in effect, Aristotle had implicitly denied even the logical possibility of the putative big bang 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 addresses any of the following questions to it: "What happened *before* $t = 0$?", "What prior events *caused* matter to come *into* existence at $t = 0$?", "What prior events caused the big bang to occur at $t = 0$?" As Barrow and Tipler (1986, p. 442) point out, the question "what happened before $t = 0$?" makes just as little sense as

to ask, in the case of a universe featuring an *infinite* past, "what happened before the Universe began?"

Of course, Narlikar and Lovell are indeed entitled to reject the given big bang model by trying to give cogent reasons for postulating a rival model featuring times *before* $t = 0$. But, failing that, it is *altogether wrongheaded* for them to complain that – even when taken to be physically adequate – the putative big bang model *fails to answer questions* based on assumptions which it denies as false.

Maddox (1989, p. 425) contends that the big bang "is an effect whose cause cannot be identified or even discussed". Thence he concludes that the big bang model is beset by "the philosophical difficulty that an important issue, that of the ultimate origin of our world, cannot be discussed". But far from being important, I claim, this issue is a pseudo-problem, which is generated by Maddox's *illicit insistence* on characterizing the putative initial event at $t = 0$ as "*an effect*" of a prior cause. He is presumably *not* invoking the very questionable notion of simultaneous causation of the big bang by another event. Therefore, his designation of the hypothesized initial event as an "effect" requires the existence of an *earlier* cause of this purported effect. And this existential claim, in turn, entails the assumption – within the context of the assumed model – that there is at least one instant *before* $t = 0$ *after all*. Evidently, this presupposition saddles the model with a temporal inconsistency, engendered at the outset by Maddox's question-begging insistence on daubing the cataclysmic event at the putative $t = 0$ as "an effect".

Evidently the elusiveness of the phantom earlier cause is due to its sheer non-existence in the face of the gratuitous demand that it must exist nonetheless at instants *before* $t = 0$. Precisely the hypothesis that $t = 0$ simply had no temporal predecessor obviates the misguided quest for the elusive cause. Hence, if the big bang is taken to have occurred at the putative $t = 0$, that *initial* event is causally *sui generis*: It just cannot have any cause at all in the universe of the given model. After all, events do not qualify *a priori* as caused *simpliciter* independently of the space-time structure to which they belong. Neither can all events be decreed *a priori* to be the effects of earlier causes. Indeed, it is no more legitimate to legislate *a priori* the (temporal) structure of space-time and the existence of causes in it, than to decree by fiat the properties of, say, photons.

Evidently, it is imperative to distinguish the sound question "Does

the career of the universe have a temporal beginning?" from Maddox's quite different alleged problem "If the universe did have a bounded past of finite duration, what was the cause of its initial event at $t = 0$? He takes the latter query to be the "important issue. . . of the ultimate origin of our world". But absent the phantom cause or "ultimate origin," the craving for the causal explanation of the classical big bang at the putative instant $t = 0$ is a seductive pseudo-problem, rather than a riddle eluding scientific solution, let alone a mystery calling for theological resolution. Clearly, to obviate an issue of causation as spurious is not tantamont to failing to come to grips with it. After all, a question cannot be regarded as a well-posed challenge to a theory merely because the questioner finds it *psychologically* insistent, and finds the answer to it elusive after introducing a temporal inconsistency into the theory *a priori*. If the presupposition of a philosophical or scientific question is presumably false, then the question is at best misleading, and at least ill-posed or pointless.

Relatedly, the presupposition of instants before $t = 0$ has also served to beg the question of energy conservation in the context of the putative big bang model, which does feature the *conservation* of matter-energy. Such conservation requires that, at all existing instants of time, the total matter-energy content of the universe is the same. But it *allows* a bounded, finite past. To ask how matter or energy came *into* existence in the first place at $t = 0$ is to presuppose not only earlier moments of time, but also the *non*-existence of any matter at those supposed earlier times. *Yet precisely the latter presupposition is denied by the matter-conservation that is asserted by the model* (Barrow and Tipler, 1986, p. 443). 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 socalled "problem of creation"!

More generally, the terms "creation" and "annihilation" can each be especially misleading in descriptions of processes that conform to energy-conservation laws. 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 intertransformation 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, emitted in two opposite directions. While the rest-mass of these photons may well be zero, this gamma radiation is obviously much more than just "nothing". Nevertheless, even 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*.

I should emphasize that if, as in one of the versions of quantum cosmology to be discussed below, the "big bang" is no longer held to comprise *all* of the earliest instants of past time, but to start as a later inflation, then it may well no longer be misguided to ask "what caused the big bang?", as in Paul Davies' book (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 creative cause!

Apart from Maddox's philosophical objections to the putative big bang model featuring an initial instant, he expects that scientific evidence will turn out to justify the abandonment of the model. But I claim that, insofar as both its classical and quantum versions become unacceptable, they will do so *only* on scientific, rather than on philosophical grounds. For example, the very recently discovered "great wall" and "great attractor," the socalled "dark matter", the newly observed most distant and oldest quasars (Wilford, 1990), or the role played by plasma in cosmic evolution (Peratt, 1990) pose a theoretical challenge that the big bang framework may, in due course, perhaps be unable to meet.

Yet, in Lovell's case (1961,1986), cosmological questions take on a quite sweeping form. During the past three decades, he 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" (1961, p. 125) by postulating divine creation. This brings us to the *second* class of general relativistic big bang models that have been claimed to warrant the sort of questions asked by Narlikar and Lovell.

Case (ii). This relativistically bona fide subclass of pre-quantum 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 prior to that time interval 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. Since here as elsewhere, the term "always" refers to all actual past instants of time, the nonexistence of time before $t = 0$ in either Case (i) or Case (ii) allows that matter has *always* existed, despite the finitude of the age of the universe in both sets of models.

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).

In a very recent paper, Hawking (1987) very briefly expressed the sort of view I advocate here when he wrote:

> In general relativity, time . . . does not have any meaning outside the spacetime manifold. To ask what happened before the universe began is like asking for a point on the Earth at 91 north latitude; it just is not defined. Instead of talking about the universe being created, and maybe coming to an end, one should just say: The universe is. (p. 651)

The French astrophysicist Jean-Marc Levy-Leblond (1989) noted correctly that general relativity theory excludes an initial instant t_0 from the set of bona fide physical instants. And thus he points to the relativistically bona fide status of Case (ii), as against the impermissibility of the initial instant t_0 in Case (i). Levy-Leblond then argues against Maddox that the big bang universe "need not be as 'philosophically unacceptable' as he [Maddox] thinks". Assuming that there is no final future crunch, Levy-Leblond then emphasizes that the cosmic time-

interval of the Robertson–Walker spacetime metric is *open* in both directions ($t_0 < t < \infty$) but patently does not extend before t_0. Relying on an *a priori* prejudice, however, Levy-Leblond finds it philosophically discomfiting that even though the past on this open interval is ordinally unbounded, the age of the big bang universe in the given metric is finite, presumably somewhere between 12 and 20 billion years.

Thus, citing Misner (1969), he aims "to send back the birth of the Universe [metrically] to (minus) infinity where, or rather *when* it seems to belong". Hence he was pleased to introduce a new linear time metric, which confers an infinite duration on the ordinally unbounded past of the big bang universe. True, this alternative time-metrization is quite legitimate. And, interestingly, it is physically realized, as Levy-Leblond explains, by a clock geared to the expansion of the universe. But just why must the birth of the universe "belong" into a past of metrically infinite duration? Levy-Leblond reasons that *because* "on the linear scale. . . never did the big bang begin", its "philosophical status does not seem that disquieting". But the philosophic malaise experienced by those who shrink *a priori* from a metrically finite age of the universe is baseless. Therefore the ability to allay this discomfiture does not add merit to the remetrization. *Pace* Maddox and Levy-Leblond, the big bang model featuring the finite age of the universe on the standard cosmic time-scale is not philosophically disquieting at all, and should not be, either causally or temporally, even if its time-interval were to contain an instant t_0 having no temporal predecessor. It is the *a priori* philosophical aversion for a bounded, metrically finite past that tacitly but unwarrantedly plays into the hands of the creationists (Grünbaum, 1990).

False or unwarranted underlying assumptions can vitiate not only questions, but also characterizations of cosmological models that employ at best inappropriate or misleading vocabulary. Thus, when speaking of a pre-quantum big bang model of the expanding universe featuring an initial zero radius, Isham (1988, p. 392) says: "This is essentially the sense in which space and time can be said to 'come into being' at the point of creation". And Vilenkin (1982) spoke of a quantum model featuring an initial minimum radius as having been "created from nothing" at the minimum radius. But Hawking (1987) rightly exposes the dubious underlying assumption:

> However, the use of the word "create" would seem to imply that there was some concept of time in which the universe did not exist before a certain instant and then came into

being. But time is defined only within the universe, and does not exist outside it. (pp. 650–651)

Surprisingly, Hawking (p. 651) even credits St. Augustine with the recognition of just this restriction by quoting Augustine's assertion that "time itself was made by God". Augustine made this claim to undercut the premise of a challenger who had asked him "What did God do before He made Heaven and Earth?" The frivolous, apocryphal answer to this question reportedly was that God was busy preparing hell for those who would ask such a question. Isham (p. 387) sees Augustine's notion of the divine creation of *both* time *and* matter as a "profound" answer to the challenger's question as to God's activity before He created heaven and earth. But, to my mind, when Augustine tells us that "time itself was made by God", the locution "was made" is subject to precisely the objection that Hawking justly raised against the word "created". I therefore consider this Augustinian assertion to be incoherent, and moreover as unhelpful to Hawking's well-taken *caveat* against Vilenkin. Moreover, I consider the notion of simultaneous causation, as applied to the purported *creation of time*, either unintelligible or, at best, incoherent.

Yet some Catholic theologians, including Aquinas, have interpreted Book XI of Augustine's *Confessions* as enunciating the doctrine of *timeless* causation as follows: At any time whatever, the existence of time itself and of the world are entirely dependent on God for their very being. Let me stress, however, that, since it is not relevant to current physics, I shall not be concerned at all with this *atemporal* metaphysical version of Augustine's creation *ex nihilo*. Suffice it to say, however, that I find this version quite obscure, if not incoherent. And, in any case, I know of no cogent argument for it.

Having reported Pope Pius XIIth creationist gloss on the big bang cosmogony, Isham (1988) elaborates:

Perhaps the best argument in favour of the thesis that the Big Bang supports theism is the obvious unease with which it is greeted by some atheist physicists. At times this has led to scientific ideas, such as continuous creation or an oscillating universe, being advanced with a tenacity which so exceeds their intrinsic worth that one can only suspect the operation of psychological forces lying very much deeper than the usual academic desire of a theorist to support his/her theory. (p. 378)

The advocacy of an oscillating universe by the atheistic British physicist Bonnor (1964) is a case in point, since Bonnor rejected a big bang

model featuring a finite past in the belief that it lends support to divine creation. But, as I have argued, Bonnor's belief is fundamentally mistaken.

Recently, plasma cosmology (Peratt, 1990) has posed a major challenge to the gravity-dominated big bang models by assigning a critical cosmic role to hot, electrically charged gases. The plasma model evolves without any beginning, being metrically infinite in both time-directions on the standard cosmic scale. But this feature does not make the plasma universe *philosophically* preferable to any of its big bang rivals, although it does, of course, obviate even the temptation to resort to creationism. The merits of the competing claims of the plasma and big bang models turn instead on their scientific credentials, which include the adequacy with which they fit observational findings. A recent survey of astrophysical opinion (Wilford, 1990) suggests a preference, in some quarters, for exploring the role of plasmas in cosmic evolution, but only within the big bang framework, rather than as an alternative.

Elsewhere (Grünbaum, 1989, Sec. 2, pp. 378–384), I have argued that the *traditional* first cause argument for divine creation – in the versions relevant to the concerns of this paper – is multiply unsound. But here, I shall contend further that atheists have nothing to fear from *any* of the twentieth century cosmologies.

B. *The Alleged Philosophical Defects of the Bondi and Gold Steady-State Theory*

In the Bondi and Gold theory, the formation of new hydrogen atoms violates matter-conservation, because they assume that the *density* of matter is constant over time (steady state) even as the universe is *expanding*. Thus, their theory features the conservation of density but *not* of matter. Yet I urge that this violation of matter-energy conservation be described by means of such words as "accession or accretion of matter", rather than by the term "creation". By the same token, I deplore the use of the term "creation" throughout Isham's (1988) paper, which is entitled "Creation of the Universe as a Quantum Process". Unfortunately, Bondi himself (1961, p. 144) uses the term "creation" misleadingly to describe this denial of energy-conservation in his 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 "crea-

tion" 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".

The astronomer Lovell (1961, p. 117) asks, in effect: What is the external cause of the new hydrogen atoms that come into being in the Bondi and Gold universe, in violation of matter-energy conservation? And Lovell complains that the "steady-state theory has no solution to the problem of creation of [new] matter". To gain perspective on this complaint, 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 a causal explanation of *any* non-vertical sublunar motion *by reference to an EXTERNAL, perturbing force* is predicated on 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 in

the absence of any external physical force, then we must explain this motion – even if it is uniform – as the result of external supernatural intervention. Let us apply these considerations to Lovell's philosophical complaint against the steady-state theory.

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 an issue 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 large-scale physical systems conserves the quantity of matter *or* rather its density in an expanding universe. 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 the history of science shows all too clearly that, 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 in an expanding universe is indeed 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 after all! Yet just that insistence is the basis for his demand for an external supernatural cause to explain the steady-state theory's matter-increase, which is required by the postulated *natural* density-conservation in an expanding universe.

Thus, Lovell begs the question by postulating energy-*conservation*, when he 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 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 seems to have overlooked that Descartes, in Meditation III (1967, p. 168), had claimed that divine intervention explains ordinary matter-*conservation*, upon 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*. But 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. By the same token, I conclude that Herbert Dingle's rejection of matter accretion as supernaturally miraculous was ill-founded. Thus, Lovell, the theist, and Dingle, the atheist, made identically the same mistake of thinking that the matter-increase would be super-naturally 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. In sum, 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 – pace Descartes – 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 generation of living substances from inorganic materials. After Pasteur's work during a cosmically tiny time period 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).

So much for the steady state theory. 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.

C. *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, let us note first that there are two sorts of socalled vacuum (p. 36): The 'true' and 'false' ones respectively. The socalled "true" sort is constituted by space that differs from being totally devoid of matter and energy only to the extent of allowing energy fluctuations. The socalled false vacuum, on the other hand, contains energy without matter. Referring to the initial true vacuum state, Weisskopf (p. 36) poetically recalls the biblical statement "The world was without form and void, and darkness was upon the face of the deep". But any affinity between that vague biblical statement and the assertion of an initial true vacuum in the technical sense of particle physics will now turn 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. (p. 36)

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

> 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)

More emphatically, Barrow and Tipler (1986, p. 440) issue the following salutary *caveat*: "the modern picture of the quantum vacuum differs

radically from the classical and everyday meaning of a vacuum – nothing." And furthermore, they rightly point out:

> It is, of course, somewhat inappropriate to call the origin of a bubble universe in a fluctuation of the vacuum "creation *ex nihilo*", for the quantum mechanical vacuum is not truly 'nothing'; rather, the vacuum state has a rich structure which resides in a previously existing substratum of space-time, either Minkowski or de Sitter space-time. (p. 441)

Thus, according to the pertinent quantum theory, the emergence of energy by fluctuation is *only metaphorically ex nihilo*, and proceeds in accord with pertinent physical principles, rather than as a matter of inscrutable external divine causation.

As Weisskopf points out, it is known from Einstein's general theory of relativity that 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).

For precisely the reasons I developed a 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. *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 formation of photons and various particles of matter. After all, all these transitions are matters of natural physical laws. 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.

In a 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 the vacuum state 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 a concise version of some of my arguments above against his reasoning: Why, I asked him, 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 his reply, Lovell then expressed full agreement with me (Lovell, 1986, p. 109).

Let me conclude by taking issue with Isham's gloss on the Hartle and Hawking account of quantum cosmology. Isham (1988, Sec. 5.1 and 5.2, pp. 398–401) considers a space-time different from the pre-quantum conical one of classical general relativity, "because the classical solution to Einstein's equations. . . is itself singular and ill-defined" (p. 398) at the vertex of the cone. And he explains the motivation for the choice of an alternative space-time: "Had this [classical] procedure worked it would have described the creation of the universe from an initial 'point'. However, we are interested in creation from 'nothing', which suggests. . . a spacetime. . . whose boundary is just a *single* three-dimensional space" (p. 398). His accompanying figure representing the latter is a bowl whose rim stands for the single three-dimensional space that is avowedly the *only* boundary of the space-time.

How then does Isham manage to have the bowl space-time originate "from nothing"? It would appear that he does so by sheer verbal fiat (p. 401, item (ii)):

> The initial space from which the universe "emerged" can be defined to be that part of the boundary of the four-dimensional space which is *not* part of the (later) three surface [boundary]. But this is the empty set, which gives a precise mathematical definition of the concept of "nothing"! (p. 401, item (ii))

Then Isham adds pointedly (p. 401, item (iv)): "The creation from nothing is precisely that".

But note that, as Isham himself had told us, the bowl space-time is one "whose boundary is just a single three-dimensional space", i.e. the rim of the bowl. What then is temporally "initial" about an empty set, generated by the following stipulative definition: The "initial" space is that portion, if any, of the space-time boundary which is definitionally *excluded* from the *only* boundary possessed by the space-time? Apparently, the empty set in question is verbally labeled to be "initial" by mere definitional fiat.

But let us suppose, just for the sake of argument, that there is an initial state that qualifies as "nothing" in virtue of being the empty set. In that putative case, the bowl universe described by Isham could in fact be said to have *originated* from nothing. But that is still a very far cry from having been *created* out of nothing, since the purported creation has hardly been shown to be creation by an agency or external

cause! Yet Isham insists on saying (p. 401): "The creation from nothing is precisely that", although I gather from him (private communication) that he does not claim to have supported *divine* creation *ex nihilo* in this way. By the same token, I deplore the assertion by Barrow and Tipler (1986, p. 440) that "Clearly, a true 'creation *ex nihilo*' would be the spontaneous generation of everything – space-time, the quantum mechanical vacuum, matter – at some time in the past". Having adopted this misleading usage of the term "creation", Barrow and Tipler claim entitlement to say that if the model of our Case (ii) were correct, "we would truly have a creation *ex nihilo*" (p. 442).

It would appear that, more appropriately, Isham recognizes the slide to a Creator as being just *psychologically* motivated:

> one might consider. . . the eradication of the conical singularity in the [pre-quantum] conventional Big Bang picture. . . . There is no doubt that psychologically speaking, the existence of this initial singular point is prone to generate the idea of a Creator who sets the whole show rolling. The new theories would appear to plug this gap rather neatly. (pp. 404–405)

I must applaud Isham's professed rejection of the philosophical or theological misappropriation or twisting of scientific results when he says (p. 378): "there is a regrettable, but recurrent, tendency for the results of science to be mis-stated and mis-used in the propagation of world views that are not in themselves scientific". Alas, despite his avowed contrary intention (private communication), Isham's own gloss on the Hartle and Hawking space-time as featuring "creation from nothing" may well be read as a case in point. After all is said and done, the notion of temporal creation *ex nihilo* dies hard.

If Hans Reichenbach were with us today, he would, I believe, share my view that creationist interpretations of contemporary physical cosmologies offer *pseudo*-explanations, rather than a philosophical deepening of cosmological understanding.

ACKNOWLEDGMENT

I appreciate the helpful comments on a much earlier version of this paper made by Richard Gale, Allen Janis, John Leslie, and Roberto Torretti.

NOTE

*This paper is based on the author's invited presentation to the Centenary Symposium in Memory of Hans Reichenbach, held on April 2,1991 at Boston University and at Harvard University.

REFERENCE

Arp, H. C., Burbidge, G., Hoyle, F., Narlikar, J., and Wickramasinghe, N. C.: 1990, 'The Extra-Galactic Universe: An Alternative View', *Nature* **346**, 807–812.

Barrow, J. D. and Tipler, F. J.: 1986, *The Anthropic Cosmological Principle* Oxford University Press, New York.

Bondi, H.: 1961, *Cosmology*, 2nd ed., Cambridge University Press, New York.

Bonnor, W.: 1964, *The Mystery of the Expanding Universe*, Macmillan, New York.

Davies, P. C. W.: 1984, *Superforce*, Simon and Schuster, New York.

Descartes, R.: 1967, *Meditation III*, in: E. S. Haldane and G. R. Ross (eds.), *Philosophical Work by Descartes*, Vol. 1, Cambridge University Press, New York.

Grünbaum, A.: 1967, 'The Anisotropy of Time', in: T. Gold (ed.), *The Nature of Time*, Cornell University Press, Ithaca, New York.

Grünbaum, A.: 1973, *Philosophical Problems of Space and Time*, 2nd ed., Reidel, Dordrecht and Boston.

Grünbaum, A.: 1989, 'The Pseudo-Problem of Creation in Physical Cosmology', *Philosophy of Science* **56**, 373–394. Reprinted in Leslie (J.), (ed.), *Physical Cosmology and Philosophy*, Macmillan, New York, 1990, pp. 92–112. A German translation appeared in Bohnen, A. and Musgrave, A. (eds.), *Wege der Vernunft*, J.C.B. Mohr, Tübingen, 1991, pp. 164–191.

Grünbaum, A.: 1990, 'Pseudo-Creation of the Big Bang', *Nature* **344**, 821–822.

Hartle, J. B. and Hawking, S. W.: 1983, 'Wave Function of the Universe', *Physical Review* **D28**, 2960–2975.

Hawking, S. W.: 1987, 'Quantum Cosmology', in: S. W. Hawking and W. Israel (eds.), *Three Hundred Years of Gravitation*, pp. 631–651, Cambridge University Press, Cambridge.

Hawking, S. W.: 1988, *A Brief History of Time*: *From the Big-Bang to Black Holes*, Bantum Books, New York.

Isham, C. J.: 1988, 'Creation of the Universe as a Quantum Process', in: R. J. Russell *et al.* (eds.), *Physics, Philosophy and Theology*: *A Common Quest for Understanding*, Vatican Observatory, Rome.

Jaki, S.: 1980, *Cosmos and Creator*, Scottish Academic Press, Edinburgh.

Levy-Leblond, J.-M.: 1989, 'The Unbegun Big Bang', *Nature* **342**, 23.

Lovell, A. C. B.: 1961, *The Individual and the Universe*, New American Library (Mentor Book MD330), New York.

Lovell, A. C. B.: 1986, 'Reason and Faith in Cosmology'. Italian translation: 'Ragione e Fede in Cosmologia', *Nuova Civilta Delle Macchine* **4**, Nos. 3/4 (15/16), 101–108.

Maddox, J.: 1989, 'Down with the Big Bang', *Nature* **340**, 425.

Misner, C. W.: 1969, 'Absolute Zero of Time', *Physical Review* **186**, 1328–1333.

Narlikar, J.: 1977, *The Structure of the Universe*, Oxford University Press, Oxford.

Narlikar, J.: 1988, *The Primeval Universe*, Oxford University Press, Oxford.
Narlikar, J.: 1991, 'What if the Big Bang Didn't Happen?', *New Scientist*, 2 March, pp. 48–51.
Peratt, A. L.: 1990, 'Not With a Bang', *The Sciences* Jan./Feb., pp.24–32.
Reichenbach, H.: 1956, *The Direction of Time*, University of California Press, Berkeley.
Tipler, F. J.: 1987, 'Achieved Spacetime Infinity', *Nature* **325**, 201–202.
Torretti, R.: 1979, 'Mathematical Theories and Philosophical Insights in Cosmology', in: H. Nelkowski, *et al.* (eds.), *Einstein Symposium Berlin*, pp. 320–335, Springer, New York.
Torretti, R.: 1983, *Relativity and Geometry*, Pergamon Press, New York.
Torretti, R.: 1984, 'Kosmologie als Zweig der Physik', in: B. Kanitscheider (ed.), *Moderne Naturphilosophie*, pp. 183–201, Königshausen and Neumann, Würzburg.
Vilenkin, A.: 1982, 'Creation of Universes from Nothing', *Physics Letters* **117B**, 25–28.
Vilenkin, A.: 1983, 'Birth of Inflationary Universes', *Physical Review* **D27**, 2848–2855.
Weisskopf, V.: 1989, 'The Origin of the Universe', *Bulletin of the American Academy of Arts and Sciences* **42**, 22–39. Reprinted in *The New York Review of Books* **36**, No. 2, 10–14.
Wilford, N. W.: 1990, 'The Big Bang Survives an Onslaught of New Cosmology', *The New York Times*, Jan. 21, Section E, 5.

Dept. of Philosophy
University of Pittsburgh
2510 Cathedral of Learning
Pittsburgh, PA 15260
U.S.A.