Time before Time: How to Avoid the Antinomy of the Beginning and Eternity of the World

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1. A universe with or without a beginning

Although modern physical cosmology has been able to emancipate itself considerably from its philosophical predecessors, it is still occupied with some of their fundamental questions (cf. Kanitscheider 2002). One of them is the problem of the finiteness versus infiniteness of time and space. The philosophical implications of current scientific approaches to these problems and the Big Bang, should they turn out to be true, are far-reaching; and they are based on many (partly speculative) premises as well as concepts, which are not always sufficiently clear in scientific practice. Therefore these approaches are also an interesting subject of reflections for philosophers of science (cf. Bartels 1996).

Immanuel Kant (1781/1787), in his *Critique of Pure Reason*, argued that it is possible to prove *both* that the world has a beginning *and* that it is eternal (First Antinomy of Pure Reason, A426f/B454f). As Kant believed he could overcome this "self-contradiction of reason" ("Widerspruch der Vernunft mit ihr selbst", A740) by the help of what he called "transcendental idealism", the question whether the cosmos exists forever or not has almost vanished in philosophical discussions. This is somewhat surprising, because Kant's argument is quite problematic (cf., e.g., Heimsoeth 1960, Wilkerson 1976, Smith 1985, Wike 1982, Schmucker 1990, Falkenburg 2000). In the twentieth century, however, the question became once again vital in the context of natural science, culminating in the controversy between Big Bang and Steady State models in modern physical cosmology (Kragh 1996). In recent years, it has reappeared in the framework of quantum cosmology (Vaas 2001b & 2002a), where, on the one hand, there are Instanton models that assume an *absolute beginning of time* (Vilenkin 1982 & 1984, Hawking & Hartle 1983, Hawking & Turok 1998), while other scenarios suppose that the Big Bang of our universe was only a *transition from an earlier state* (Linde 1983 & 1994, Blome & Priester 1991, Khoury *et al.* 2001, Steinhardt & Turok 2002), and that there are perhaps infinitely many such events.

General Relativity breaks down at very small spatio-temporal scales and high energy densities. This is why quantum cosmology is needed. But in contrast to the framework of General Relativity, which is theoretically well understood and has been empirically confirmed quite marvelously, the current approaches in quantum cosmology, string theory, etc., are still quite speculative, controversial, and almost without any empirical footing yet. Although it is on a much more sophisticated and abstract level, this situation somewhat resembles the pre-Socratic discussions of natural philosophy. This is a further reason why conceptual analysis and philosophical investigations of assumptions and implications in general might be useful here – both within and beyond physics.

This paper has two goals: First, a conceptual clarification of the term "Big Bang" shall be made, drawing a four-fold terminological distinction which helps to classify different cosmologies and avoid confusion. Second, a proposal for a solution of Kant's First Antinomy of Pure Reason within a framework of metaphysical realism is suggested, which is compatible with some modern cosmological scenarios.

2. Different notions of "Big Bang" and "universe"

"Big Bang" is an ambiguous term, which has lead to many misunderstandings and prejudice. One should draw a distinction between at least four logically different meanings: (1) the hot, dense early phase of our universe where the light elements were formed, (2) the initial singularity, (3) an absolute beginning of space, time, and energy, and (4) the beginning of our universe, i.e. its elementary particles, vacuum state, and perhaps its (local) space-time.

That our universe originated from a Big Bang in the sense of (1) is almost uncontroversial. (2) is the relativistic cosmology's limit of backward extrapolation where the known laws of physics break down. Different models of quantum and string cosmology try to overcome this limit, and (3) and (4) classify their different scenarios. Those characterized by (3) might be called *initial cosmologies*; they postulate a very first moment (cf. Grünbaum 1991, Smith 2002). Those characterized by (4) are *eternal cosmologies*; there are different kinds of them – namely *static*, *evolutionary* (with cumulative change), and *revolutionary* (with sharp phase-transitions) ones – both in ancient and in modern cosmology. And they could have either a linear or a cyclic time. The option (4) also allows the possibility that our universe neither exists eternally, nor that it came into being out of nothing or out of a timeless state, but that space and time are not fundamental and irreducible at all, or that there was a time "before" the Big Bang – "Big Bang" in the sense of (1) –, as well as that there are other universes.

There are different meanings of the term „universe“, e.g.: (1) Everything (physically) in existence, ever, anywhere; (2) the observable region we inhabit (the Hubble volume, roughly 27 billion light years in diameter), plus everything that has interacted or will ever interact with this region; (3) this region plus everything that has interacted with it by now, or will at least do so in the next few billion years; (4) any gigantic system of causally interacting things that is wholly (or to a very large extent) isolated from others; (5) any system that *might* well have become gigantic, etc., even if it does in fact recollapse while it is still very small; (6) other branches of the wavefunction (if it never collapses, cf. Vaas 2001c) in unitary quantum physics, i.e. different histories of the universe or classical worlds which are in superposition; (7) completely disconnected systems consisting of universes in one of the former meanings, which do or do not share the same boundary conditions, constants, parameters, vacuum states, effective low-energy laws, or even fundamental laws, e.g. different physically realized mathematical structures (cf. Tegmark 2003). Nowadays, the term „cosmos“ or „multiverse“ or „world“ (as a whole) might be used (and will be used here) to refer to Everything in Existence, while „universe“ permits to talk of several universes within the multiverse. In principle, these universes might or might not be spatially, temporally, dimensionally, and/or mathematically separated from each other.

3. A possible solution for Kant's First Antinomy

Kant's First Antinomy makes the error of the excluded third option, i.e. it is not impossible that the universe could have *both* a beginning *and* an eternal past. If some kind of metaphysical realism is true, including an observer-independent and relational time, then a solution of the Antinomy is conceivable. It is based on the *distinction between a microscopic and a macroscopic time scale*. Only the latter is characterized by an asymmetry of nature under a reversal of time, i.e. the property of having a global (coarse-grained) evolution – an arrow of time (Zeh 2001, Vaas 2002b, Albrecht 2003) – or many arrows, if they are independent from each other. (Note that some might prefer to speak of an arrow *in* time, but that should not matter here.) On the microscopic scale, however, only local, statistically distributed events *without* dynamical trends, i.e. a global time-evolution or an increase of entropy density, exist – if the system is in thermodynamic equilibrium (e.g. there is a huge degeneracy of microscopic states identifiable with the same coarse-grained state) and/or in an extremely simple meta-stable ground state. Some still speculative theories of quantum gravity permit the assumption of such a global, macroscopically time-less ground state (e.g. quantum or string vacuum, spin networks, twistors). Due to accidental fluctuations, which exceed a certain threshold value, universes can emerge out of that state. Due to some also speculative physical mechanism (like cosmic inflation) they get – and, thus, are characterized by – directed non-equilibrium dynamics, specific initial conditions, and, hence, an arrow of time. (It could be defined, for instance, by the cosmic expansion parameter or by the increase of entropy.)

It is a matter of debate (cf., e.g., Price 1996, Vaas 2002b) whether such an arrow of time is 1) irreducible, i.e. an essential property of time (e.g. Maudlin 2002), 2) governed by some unknown fundamental and not only phenomenological law (e.g. Penrose 1989, Prigogine 1979), 3) the effect of specific initial conditions (cf. Albrecht 2003, Schulman 1997, Zeh 2001) or 4) consciousness (if time is in some sense subjective, e.g. Kant 1781/1787) or 5) even an illusion (e.g. Barbour 2000); many physicists favour special initial conditions, though there is no consensus about their nature and form. But in the context at issue it is sufficient to note that such a macroscopic global time-direction is the main ingredient of Kant's First Antinomy, for the question is whether this arrow has a beginning or not. Surprisingly, quantum cosmology offers a possibility that the arrow has a beginning and that it nevertheless emerged out of an eternal state without any macroscopic time-direction. (Note that there are some parallels with a theistic conception of a creation of the world here, e.g. in the Augustinian tradition which claims that time together with the universe emerged out of a time-less God; but such a cosmological argument is quite controversial, especially in a modern form, cf. Craig & Smith 1993, and of course beyond the scope of this paper.) So this overcoming of the First Antinomy is not only a philosophical possibility but is already motivated by modern physics. At least some scenarios of Quantum Geometry (Ashtekar 2002) and String Cosmology (Gasperini & Veneziano 2003, Vaas 2003) can be interpreted as examples for such a local beginning of our macroscopic time out of a state with microscopic time, but with an eternal, global macroscopic timelessness.

Note that this kind of solution bears some resemblance to a possibility of avoiding the spatial part of Kant's First Antinomy, i.e. his claimed proof of both an infinite space without limits and a finite, limited space: The Theory of General Relativity describes what was considered logically inconceivable before, namely that there could be universes with finite, but unlimited space (Einstein 1917), i.e. this part of the Antinomy also makes the error of the excluded third option. This offers a middle course between the Scylla of a mysterious, secularized "creatio ex nihilo", and the Charybdis of an equally inexplicable eternity of the world.

In this context it is also possible to defuse some explanatory problems of the origin of "something" (or "everything") out of "nothing" as well as a – merely assumable, but never provable – eternal cosmos or even an infinitely often recurring universe (cf. Nozick 1981 & 2001, Parfit 1998). But that does not offer a final explanation or a sufficient reason, and it cannot eliminate the ultimate contingency of the world.

4. Outlook

It seems unlikely that philosophical considerations alone can answer the question whether there was a beginning of the universe or not, and in what sense. It is also premature, however, to ignore such questions, e.g. for Kantian reasons. On the other hand, it is not to be expected that some unambiguous empirical results (e.g. from the gravitational wave background, dark matter relics, or some traces in the cosmic background radiation) will ever solve these questions. But empirical research might at least constrain cosmological theories which could and should be based on current and/or future and more advanced fundamental theories of forces, particles, space and time, e.g. M-theory or Quantum Geometry. It is an open question whether the dream of such a "final theory" (Weinberg 1992) or "Theory of Everything" (Barrow 1991) will ultimately explain the origin of our universe (or even the whole multiverse) and address the finiteness or infinity of space and time – or even reduce space-time to something more fundamental. But extrapolating from the scenario of eternal inflation (Guth 2000, Vilenkin 2000), and contemporary approaches to quantum gravity, it seems almost inevitable that the origin of our universe was *not* a unique event, and that other universes also exist (Linde 1994, Smolin 1997, Vaas 1998, Tegmark 2003). This not only has important implications for observational (or anthropic) selection effects (Barrow and Tipler 1986, Kanitscheider 2001, Vaas 2000) and our place in nature (Knobe, Olum & Vilenkin 2003, Vaas 2001a), but also for the question whether the whole cosmos or multiverse is past-eternal or not (Borde, Guth & Vilenkin 2003). If the proposal of this paper is correct, both options could be true in some way.

Acknowledgments: Though they are of course not responsible for the proposals I offered here, I'd like to take this opportunity to thank Abhay Ashtekar, Hans-Joachim Blome, Maurizio Gasperini, Alan Guth, Bernulf Kanitscheider, Claus Kiefer, Andrei Linde, Wolfgang Priester, Paul Steinhardt, Neil Turok, Gabriele Veneziano, Alex Vilenkin, and H. Dieter Zeh for discussions, kindness, and patience. And, as ever, I am grateful to André Spiegel for his suggestions and improvements.

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