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MULTIVERSES - WHAT IS THE DIFFERENCE THAT MAKES THE DIFFERENCE?

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Abstract: *A critical interdisciplinary analysis of the causes for imperfection and discrepancy in the created and tested concepts about the Universe is made. Possible future attempts are commented.*

МУЛТИВСЕЛЕНИ - КОЯ Е РАЗЛИКАТА, КОЯТО ПРАВИ РАЗЛИКАТА?

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Абстракт: *Представен е критичен интердисциплинарен анализ на причините за и несъответствие в създаването и използването на основни концепции за Вселената. Обсъждат се възможни бъдещи опити.*

The title opens up both conceptual and empirical problems which in part have to do with language, and perhaps the limitations of the human mind. A usual approach to the behaviour of highly a complex (hierarchic) system starts with modelling it as isolated and symmetric to time reversal. Any emergence of the "arrow" of time is ascribed to making the system open to their surrounding. And all kinds of classical models for open systems are based on the assumption that this coupling is weak. If the coupling becomes stronger and stronger we run into serious trouble due to the requirement of the continuity of both time and space dimensions.

With regard to cosmology we live at a very privileged time. Previously, when we learned about bold revolutionary paradigm changes, in which our fundamental ideas about nature underwent radical revisions, the drama had already taken place in the distant past. Today, however, we have the rare opportunity of witnessing at first hand a profound transformation in our basic understanding of how nature is structured. This ongoing change of cosmological paradigms from a "small" finite cosmos to an infinite fractal cosmos began about three decades ago and is in full swing at present. The new general paradigm that cosmologists and natural philosophers have arrived at by several different routes is an infinite fractal hierarchy that has "universes" within "universes" without end. Parts of the Universe may be created or annihilated, or may undergo expansion or contraction, but overall the infinite fractal hierarchy remains eternal and unchanged as a whole, and therefore it is without temporal limits. There is no limit to size scales. In the infinite fractal paradigm there is no class of largest objects that would cap off the cosmological hierarchy; the hierarchy is infinite in scale. This fact removes one of the more suspect aspects of the old paradigm. When humans do appear to be at the center of things, we should strongly suspect that some form of bias is leading us astray.

We humans taxonomize because our brains like to organize and categorize things. We perceive cause-and-effect relationships because they are products of our evolution and are critical to our survival. But if we step outside of that human bias for a moment and try and observe nature from nature's point of view, we see that these taxonomies and evolutionary processes are more our creation than nature's.

Although different universes, or multiverses, may each have their own distinct physical parameters, constants and even dynamics, nevertheless they must obey some form of the Second Law of

Thermodynamics, otherwise such thought experiments are to be discounted, and any physical system that violates SLT is to be interpreted is not real, or at least that not all the variables are known. Memory and entropy are deeply related aspects of each other, in much the same way that various forms of energy are related and can be converted into one form or the other without loss. Any system converting entropy into memory, or memory into entropy, which also involves choice, thus contributes to running the system, we characterizes as having intelligence or consciousness. If such a system is the universe itself, or multiverses, we say cosmic consciousness is involved in the operation of the cosmology.
How is it that the math that so wonderfully exactly describes the world we can see allows infinities? Is our universe just one among an ensemble of many? Just an infinitesimal part of an elaborate structure, which consists of numerous universes, possibly an infinite number of universes, sometimes referred to as multiverses? With so many possible types of multiverses to choose from, which one can we legitimately select to develop a cosmology that parallels the thought experiment of James Clerk Maxwell and his intelligent demon? We must rely on various observations to guide us, and when those are not available, to be guided by sound reason.
Physics is the art of approximations, a device we have to describe the world we measure. Sometimes, however, we get carried away, and ascribe reality to what are, in essence, thinking tools. This may sound heretic, but it seems that the universe is one of these thinking tools. Physics gets really weird as soon as we go beyond Newtonian physics**,** a priori weird, it is what we observe. The universe is stranger than we imagine, it may even be stranger than we can imagine.
“Science advances funeral by funeral” said Max Planck. The scientific endeavour usually takes place in the form of research programs rather than in respect of single hypotheses or theories. And refutations are not a straightforward sign of empirical progress, and this is because research programs grow in a permanent ocean of anomalies- data are theory-dependent, they might simply be false or interpreted wrongly. Theories are often ahead of data and should not been thrown away too quickly. Testability, a sophisticated falsificationism, referring to a struggle between theories and data interpretation is important, but not necessarily at least at the initial stages of theory building. It is reasonable to keep the theory for a while, especially its "hard core" (at least if there is no alternative or an experimentum crucis is very rarely accomplished). Instead of killing the theory, the "protective belt" of auxiliary hypotheses should be modified first. Of course this effort to save the core could lead to immunization strategies which would in the end expel the theory from science. Furthermore, falsification is often difficult to achieve because core commitments of scientific theories are rarely directly testable and predictive without further assumptions. Therefore, ad hoc hypotheses to save a hard core could led to program degenerations especially if they are problem shifts not pointing to other fruitful areas.
"Why is there something rather than nothing?" asked Leibniz. Cosmology provides a lot of examples for the complex interplays between competing theories, data acquisition and interpretation, immunization, and even paradigm changes. The most prominent were geocentrism versus heliocentrism, metagalaxy versus island universe, and steady state versus big bang. Universe versus multiverse seems to be the next challenge in this direction.
In contemporary science, besides for the discussed aspects of cosmology that are common to available observations, there are some relevant features including among others: evolution of systems at multiple levels; hierarchies of complexity, from quantum to cosmos; networks of relationships at multiple levels; importance of both reduction (exclusive focus on efficient cause) and emergence with both bottom-up (efficient causality) and top-down causation provide examples of emergent processes; dualities without dualism arising from modern physics [e.g., both continuity and quantization; both symmetry and asymmetry, both particles and fields; fine-tuning of physical systems; ultimate limitations of physical cosmology. These common features are characteristics of some firmly established components of modern science (quantum theory, nonlinear dynamics, etc.) and appeal to less established theories in physical cosmology is generally not needed. Science is constituted by methodology and not by any particular content or results. For metaphysics and philosophical cosmology, the focus can remain on consistency and coherence, albeit with ultimate grounding in experience with a concern for applicability. However, in physical cosmology and science more broadly, linkages to observation and experiment are essential.
Although complexities have arisen with all efforts to distinguish proper scientific propositions from non-scientific propositions, some helpful concepts have been developed, principally falsification (hypotheses should be falsifiable in principle) and Ockham’s razor (keep hypotheses as simple as possible). It is often assumed that scientific methodology is fully characterized by the hypothetical-deductive framework. In cases where very large datasets are available, some scientific problems may be more clearly resolved by deployment of the observational-inductive approach rather than by the theory-oriented hypothetical-deductive approaches that are currently prominent in physical cosmology. Frontline physics is not as unique and reliable as the multiply tested physics of every-day life. The

further the frontline advances towards unreachably large, or unresolvably small separations, or timescales, the more plausible assumptions have to replace redundant experience, and hasty interpretations can lead astray.
Though the demarcation criteria for science have sometimes been criticized and are somewhat fuzzy indeed, it is usually rationality that rules. But this is of course the main source of the controversies. How can we know, if for a successful research program in cosmology there are only some popularly established criteriaan corresponding answers as: many applications? -no; novel predictions?- perhaps yes, partly; new technologies?- definitely not (yet); answering unsolved questions?- yes; consistency?- hopefully; elegance?- depends on taste; simplicity?- often yes; explanatory power/depth?- certainly yes; unification of distinct phenomena?- yes indeed; truth?- nobody knows.
Why is that which is, the way it is? These question is among the most fundamental (meta)physical mysteries currently debated in cosmology. The multiverse hypothesis represents, at least in part, an attempt to answer them. The central tenant of the multiverse hypothesis (henceforth called M) is that our universe is just one among an ensemble, an infinitesimal part of an elaborate structure which consists of numerous universes, possibly an infinite number of universes. Thus M has been conceptualized and described by a variety of terms including "many worlds", "parallel worlds", "parallel universes", "alternative universes", "alternative realities", "alternative dimensions", "quantum universes", and so on. Some of these "universes" could have a physics or chemistry completely unlike our own, and this has led to additional questions, such as: is our universe fine tuned for life, and if so, why? No approach can possibly provide an exhaustive or ultimate answer to these questions, and neither does M seek to do that. But if empirically confirmed in some way, or rigorously derived theoretically, M would be one of the most radical and far-reaching insights in the history of science. M could well be a derivative of the ultimate *explanans*. Possibly, precisely because of these exciting prospects, M is controversial and under attack not just from sceptical scientists, but theologians and critical philosophers of science. This is not surprising and, indeed, it is to be appreciated because extraordinary claims which have the potential to overturn and usher in a new world scientific order, require extraordinary evidence. And considerable evidence remains to be discovered**.**
The term "universe" (or "world"), as it is used today, has many different meanings such as:
(1) Everything (physically) in existence, ever, anywhere, in totality. According to this defintion there are no other universes.
(2) The observable region of the cosmos that we can observe and which we inhabit plus everything that has interacted or will ever interact with this region.
(3) Any gigantic system of causally interacting things that is wholly (or to a very large extent, or for a long time) isolated from others; sometimes such a locally causally connected collection is called a multi-domain universe, consisting of the ensemble of all sub-regions of a larger connected spacetime, the "universe as a whole", and this is opposed to the multiverse in a stronger sense, i.e. the set of genuinely disconnected universes, which are not causally related at all.
(4) Any system that might well have become gigantic, etc., even if it does in fact recollapse while it is still very small.
(5) Other branches of the wavefunction (if it never collapses) in unitary quantum physics, i.e. different histories of the universe or different classical worlds which are in superposition.
(6) 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
Therefore, "multiverse" (or "world" as a whole) can be used to refer to everything in existence (at least from a physical point of view), while the term "universe" can refer to one of several universes (worlds) within the multiverse. In principle, these universes mostly conceived in the meaning of (2), (3), or (4) might or might not be spatially, temporally, dimensionally, causally, nomologically and/or mathematically separated from each other. Thus, sharp boundaries do not necessarily exist between them. One might call the whole set of different universes the multiverse.
In an infinite fractal hierarchy there is no center of the Universe whatsoever, nor is there any preferred reference frame or scale. Why are fractal hierarchies so ubiquitous in nature? By studying empirical phenomena within the observable universe, how much will we be able to learn scientifically about the parts of the Universe that lie beyond our observational limits? But it could be true that there are even different sets of totally spatiotemporally and strictly causally separated multiverses, e.g. different bunches of chaotically inflating multiverses. In that case it remains useful to have a term with a still broader meaning, namely ‘omniverse’ or ‘cosmos’. Thus, omniverse or cosmos could be taken as the all-embracing term for everything in existence which might or might not be the set of different multiverses, while the multiverse refers to and consists of different universes which are not separated in every respect. Although most believe that multiverse classifications should be abstract enough to include all possible cosmological scenarios, there is no general agreement as to exactly what that should be. For example, it has been suggested that the multiverse should be categorized with regard

to separation/distinction of the different universes. Even if all dimensionless constants of nature could be reduced to only one, a pure number in a theory of everything, its value would still be arbitrary, i.e. unexplained. No doubt, such a universal reduction would be an enormous success. However, the basic questions would remain: Why this constant? Why this value? If infinitely many values were possible, then even the multitude of possibilities would stay unrestricted. If there were just one constant (or even many of them) whose value can be derived from first principles, i.e. from the ultimate theory or a law within this theory, then it would be completely explained or reduced at last. But what would such a spectacular success really mean? First, it could simply shift the problem, i.e. transfer the unexplained contingency either to the laws themselves or to the boundary conditions or both. This would not be a Pyrrhic victory, but not a big deal either. Second, one might interpret it as an analytic solution. Then the values of the constants would represent no empirical information; they would not be property of the physical world, but simply a mathematical result, a property of the structure of the theory. This, however, still could and should have empirical content, although not encoded in the constants. Otherwise, fundamental physics as an empirical science would come to an end. But an exclusively mathematical universe, or at least an entirely complete formal description of everything there is, derivable from and contained within an all-embracing logical system without any free parameter or contingent part, might seem either incredible (and runs into severe logical problems due to Kurt Goedel's incompleteness theorems) or the ultimate promise of the widest and deepest conceivable explanation. Empirical research, then, would only be a temporary expedient like Ludwig Wittgenstein's famous ladder: The physicist, after he has used empirical data as elucidatory steps, would proceed beyond them. "He must so to speak throw away the ladder, after he has climbed up on it."

That there is no contingency at all seems very unlikely. So why are some features realized but not others? Or, on the contrary, is every feature realized? Both questions are strong motivations for M. The strongest version of M is related to the principle of plentitude or principle of fecundity (advocated e.g. by Richard Feynman, Dennis Sciama). According to this principle everything is real, if it is not explicitly forbidden by laws of nature, e.g. symmetry principles. The question remains: What is forbidden, i.e. physically or nomologically not possible and thus not "allowed" by natural laws? This is a slippery slope. There are or could be at least three main reasons for assuming the existence of other universes: empirical evidence, theoretical explanation, and philosophical arguments. These three reasons are independent from each other, but ideally entangled. As far as there is at least some connection with, or embedding into a theoretical framework of physics or cosmology, M is part of the scientific endeavour, not only of philosophy. This is also the case in the absence of empirical evidence, if a theoretical embedding exists. And philosophical arguments might at least motivate scientific speculation. There is an important distinction: Scientific laws on the one hand must be falsifiable. In science verification is obviously extremely important. But falsification is not sufficient to disprove an idea in controversial and hypothetical situations even if there are concise predictions. That is, "absence of evidence is not evidence of absence." So what is missing here? It is theoretical embedding. To be reasonably part of science, hypothetical universal existence statements must not only be verifiable, they must also be part of a sufficiently confirmed or established scientific theory or theoretical framework. Statements about the existence of other universes are not like statements about scientific laws. The latter must be falsifiable, while the former should be taken as universal existential statements which cannot be falsified, but must be verified. So ultimately a multiverse scenario might only be accepted, strictly speaking, if there is empirical evidence for it, i.e. observational data of another universe or its effects. A weaker argument for M would be if a falsifiable, rigorously tested theory predicts the existence of other universes, and this theory is well established according to the usual scientific criteria. Still weaker are philosophical reasons. Whether they could suffice if they are stronger than alternative statements is a controversial issue and lies at or beyond the boundaries of physics and cosmology.