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THE CONCEPT OF UNIVERSE FROM A METATHEORETICAL POINT OF VIEW

How many universes are there? - This question seems absurd. For, it might be said, the universe is, by definition, all there is; and if this definition is accepted, then it is clear that there can be at most one such thing called "universe"; for, if there were at least two universes, say *U* and *U'*, then there would be a thing in *U* which is not in *U'*, and therefore *U'* would not be all there is, contrary to the assumption. So, there is at most one universe.

However, on a closer look, things don't appear as simple as this simple argument suggests. The characterization of the universe as "all there is", comes from an intuitive, presystematic idea; and as soon as we analyze it carefully or try to provide a formal explication of it, matters appear to be more complicated. Indeed, the apparently obvious existence and uniqueness of the universe may become shaky. A systematic and plausible explication of the intuitive idea may lead to a conclusion opposite to the intuitive assumption: that there is no universe at all, or else that there are several universes, even a variable number of them.

Some authors tend towards the first alternative mentioned. A recent example is Van Fraassen [1995]. At the beginning of his essay, Van Fraassen is quite definite about the issue: "there is no reason to think that there is even such a thing as the (real, actual) world" (*op.cit.*, p. 139). Later on in the essay, he seems to water down his definitely negative attitude towards "the world";[1] he admits that one could after all make sense of the expression "the world" as a kind of **schematic term**, which can be filled in in different ways according to different needs and contexts. Now, the approach I'll offer in the present essay resembles, to a certain extent, Van Fraassen's suggestions in the later part of his article; however, as we shall see, the line of the argument and the concrete content given to the general idea will appear to be quite different.

Before we really start looking for the universe, let us make some remarks intended to avoid some possible *parti-pris* from the very beginning. First, when we examine the question of the existence and uniqueness of the universe as the totality of all there is, we should be quite flexible as to the way this totality should formally be built out of what there is, at least in a first move. That is, we should not restrict ourselves to the assumption that the universe should be conceived, for example, as the **mereological** aggregation (much less the **spatiotemporal** mereological aggregation!) of existing

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[1] Van Fraassen uses the term "world" in his context; I prefer to use "universe" for reasons that will become apparent below. However, the intuitive idea behind both terms and their (possible) explications are pretty much the same.

things rather than as a **set-theoretical** construction out of them or some other thing. The concrete formal way to conceive the totality called "universe" should be left open at the start; whether set theory, or mereology, or something else is the best **technical** tool to explicate the structure of that totality should come out rather as a result and not as a presupposition of our analysis.

Second, when we say that the universe is the totality of all there is, we should mean the totality of all there **really** (and not just possibly) is. If we think that Don Quixote is a possible person but that he never really existed, then Don Quixote is **not in** the universe; he is not a part, element, aspect or whatever of the totality we want to call "the universe". From this it follows that the possibility of a plurality of universes we will envisage here is not to be understood as the plurality of **possible worlds** (which is trivially given if you believe in the metaphysics of modal logic and trivially nonsensical if you don't believe in it). The universe we are talking about is the **real** one, the totality of all there **actually** is. Nor are we talking about a plurality of universes in fictional contexts, nor about metaphors - we are talking about the totality of what **literally** is. Don Quixote might be a very apt metaphor - still, he is **not** in the universe.

This said, however, it does not imply that we are presupposing a particular constitution for all the things that are in the universe. In particular, we are not presupposing that all there is must be a (direct or indirect) object of our sense experience, much less (again) that only spatiotemporally localized entities really exist. If we think that the number π really exists, then π is **in** the universe; if we think that archangel Michael really exists, then archangel Michael is **in** the universe. The reflection upon the possible constitution or constitutions of things in the universe should be undertaken **after** the primary question about the existence and uniqueness of the universe has been decided.

Having made these preliminary remarks of a negative kind, let me now put my cards on the table and tell what my own positive assumptions are. Though they are of a methodological or metaphilosophical kind, they have, as we shall see, some substantial consequences about the way we should conceive the universe, and in particular about whether we should envisage the existence of one, none, or many universes[2]. The premises of my argument are these.

(1) Whether or not we assume that there are purely "a priori" or "analytical" questions, the issue we are discussing here is certainly not of this kind. It certainly depends on "conceptual analysis" but not only on that; it also depends on (meta-)empirical facts about the structure and content of our knowledge.

(2) If there is a universe, then it should be something we can **speak about**, at least in very general terms in an approximate way. Let's rule out the idea of a completely ineffable universe - whatever the Wittgenstein of the **Tractatus** might have contended.

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[2] In the following, "universe" should always be understood in the sense of "real, actual, literal universe".

(3) The most adequate way to speak about anything (again, in a more or less general, approximate way) is the **scientific** way. So, if we think we can and should speak about the universe, let us do it from a perspective which is as close as possible to the bulk of really existing science.

I will not argue for these three assumptions. They seem to me obvious. At least, I'll take them for granted here. Let's assume, then, without further ado, that the universe, if it exists, is something we can talk about from a scientific, hypothetical, non-analytical perspective. Now, the rest of my argument depends on a further assumption for which I'll argue a bit more because it is, perhaps, not so obvious as the other three, and because it leads to the very core of my argument.

(4) Whenever we undertake the examination of anything in a scientific way, we necessarily have to do it from a definitely **theoretical** perspective. This is a necessary (though generally not sufficient) condition of scientific examination of things. No doubt, there are theories without science, but there is no genuine science without theory. A "direct encounter" with the object of examination, without the intervening medium of that sort of conceptual systems we usually call "theories", is a privilege apparently granted to mystics and ethnomethodologists only; the scientific investigation of anything presupposes the use of more or less well-articulated theories. Of course, this is not to say that any scientific activity is reducible to the construction and application of theories; science consists of more sorts of things than theories: it also includes methods, devices, observations, experiments, institutions, budgets, and what not... However, all of this makes (scientific) sense only within the implicit or explicit framework of some theory or theories. Whenever we claim the real existence of a given object, or we analyze it by means of systematic observations, devices, laboratories, etc., we do it from the perspective of one or several definite theories. In science, there is no ontology without theory. Here, I cannot argue for this thesis in detail; I have provided some arguments for it in Moulines [1994a] and [1994b]. For the present purposes, it suffices to recall two fundamental insights which make up the core of those arguments and which are widely acknowledged, explicitly or implicitly, in present-day analytical philosophy. The first of these insights is what might be called the "Fundamental Ontosemantical Principle". Its most popular formulation is due to Willard Quine: "To be is to be the value of a bound variable". The other basic insight may be described as the "Principle of the Theoretical Contextuality of Being": the bound variables Quine speaks of do not appear isolated or as single variables; nor do the statements where those variables occur - at least in the case of a scientific discourse, which is what matters now. Bound variables and scientific statements containing them get their meaning only within a wider and more complex conceptual frame; and this frame is settled precisely by the sort of entity we call "a theory" (or "a family of theories"). Whatever there is that it is, it must be - at least if we want to speak about it within a scientific discourse - the value of bound variables occurring in the basic statements - fundamental laws or axioms - of one or several scientific theories. Therefore, the notion of a scientific theory becomes crucial when discussing what it is that is all

there is. Ontology appears to depend on metascience - on the metatheory of scientific theories.

Now, for our purposes we need not get into the details of a metatheoretical analysis. We need only to take notice of the following insight. In present-day philosophy of science there exist different proposals as to what is the best explication of the notion of a scientific theory. But, in spite of the divergences in many other respects, most of these metatheories agree in that an essential element for the determination of a theory is the class of its **models**. To determine a theory is to determine its models. This is all we need to know at present. And what is a model? We know it from formal semantics: a model is a **structure** satisfying certain axioms (roughly speaking, the theory's basic laws). And what is a structure? This we know from set theory: a structure is a finite sequence of sets of objects and of relations defined on those sets, i.e. an entity of the form

$$< D_1, ..., D_m, R_1, ..., R_n >,$$

where $$R_i \subseteq D_{j1} \times ... \times D_{jk}.$$

When one of these structures is a model of a given theory *T* we say that the sets D_i are the **basic domains** of *T*. The elements of these sets are all *T* speaks about. They are *T*'s ontology. If you literally believe in *T*, then you literally believe in the reality of the elements of these sets. They are all there is according to *T*. However, we should be a bit more cautious in our wording here. According to *T*, all there is, is what is in the sets D_1,...,D_m, **but** these objects are not lying around amorphously - they are related to each other by R_1,..., R_n; that is, according to *T*, all there is, is in the D_i as articulated by the R_j. *T*'s reality is an **articulated** reality.

Now, the reality given in this way is, in most cases, not what we immediately experience; the phenomena we are confronted with in our experience **usually** are not so nicely articulated as to appear immediately having the form

$$< D_1, ..., D_m, R_1, ..., R_n >;$$

phenomena are usually much clumsier, fuzzier, more chaotic than that; and some people think that this is what "real reality" looks like; they would say that the model $< D_1, ..., D_m, R_1, ..., R_n >$ is an "idealization" or "approximation" of **real phenomena**. Other people, quite on the contrary, would stick to the etymology of "phenomena" and claim that they are mere appearances, which are "saved" by the neat entities postulated by the theory; the latter are the "real reality" behind the phenomena allowing them to be "saved"; in that case, the "real reality" is $< D_1, ..., D_m, R_1, ..., R_n >$.

Anyway, for the rest of our discussion, we need not take a stance on this controversy, which is as old as philosophy. All we need to assume here is that, if we literally believe in *T*, then we believe that there is an intimate, endurable, "essential" connection between the range of phenomena investigated by *T* and the models associated with *T*. Whether or not the phenomena have the primary ontological status and the models the secondary one, or the other way around, if we literally believe in *T*, we believe that the models adequately "represent the facts", as they appear through the phenomena perceived. In that case, those phenomena justify us in assuming that what there really is, is contained in the D_i as articulated by the R_j.

At this point, however, we should remember that, from a formal point of view, the relations R_j are nothing but subsets of the Cartesian products of the D_i; so that, after all, what is real **and** articulated in a certain way, is already contained in the array D_1x...xD_m. From this point of view, then, it is a natural way of speaking to say that this array is precisely the theory's **universe**.

Now, this certainly represents quite a deviation from the intuitive ideas we associate with the ordinary term "universe". However, the deviation is **not** just metaphorical and is perfectly justified: remember that we decided to speak about all there is from a scientific perspective and this means within a theory's frame. And, for the theory, all there is, is given by arrays of elements of D_1,...,D_m. So, it is not a fancy of mathematicians to call the set of such arrays "a universe". This is the best explication formal thought has so far provided of the intuitive notion of universe. It has, of course, some epistemological and ontological consequences worth considering. Let us explore them.

A first remark to be made is that, strictly speaking, not all sets on which the primitive relations are defined will really be considered "basic" and therefore constituting the theory's universe. In "mathematized" theories, i.e. in theories where at least some of the primitive relations are metrical functions, each model will contain, in addition to the "real" basic domains, some "**auxiliary**" **sets** settling the range of the metrical functions. Typical examples are the set of real numbers or the set of three-dimensional real vectors. Now, unless we are hard-nosed Platonists in the philosophy of mathematics, it would not be adequate to take such auxiliary sets to be part of the theory's universe. And even if we are Platonists in the philosophy of mathematics, we need not be such when examining ontological issues in empirical science. For, clearly, in empirical theories the "ontological commitment" associated with such things as real numbers, real vectors, complex numbers, and the like, is much weaker than the one associated with the basic domains. Auxiliary sets are there not to commit ourselves to what "really exists" but only to help to express the relations defined on what there really exists. These relations could, in principle, be established in purely qualitative terms. Science without numbers is possible, as Hartry Field has convincingly argued. Of course, this would be extremely impractical but we are discussing here matters of principle, not of practice. Moreover, most metrical functions playing a central role in science (mostly in physics, but increasingly also in the social sciences) can be more or less easily (and, at any rate, **systematically**) reconstructed as **representations** into the real numbers of underlying qualitative structures, where all relations are defined on "real" basic domains[3]. So, to establish those relations we need not assume the "reality" of real numbers. Consequently, Quine's slogan "To be is to be the value of a bound variable" has to be interpreted in a more restrictive way: if the bound variables run over the set of real numbers, or similar mathematical constructions, then their values should not be considered as part of all there is according to a scientific theory - **unless the theory is really intended to be about them.**

So, the array of the basic domains of a theory's model, and only it, constitutes the universe. **The** universe? We have *prima facie* no good reason for using the definite article here. For different theories will usually be determined by different arrays of basic domains, and even within one and the same theory the basic domains might differ. So, at least on a first move, the model-theoretical explication of the intuitive idea of the universe destroys its essence - uniqueness. Perhaps this essence may be reconstructed after a closer analysis but this will not be a trivial endeavour anyway. To give the issue a concrete form let us first consider some examples.

A highly respected theory about what there is, is Newtonian particle mechanics. In a standard model-theoretical reconstruction of it, its models appear to have the form:

$$< P, S, T, IR, IR^3, s, m, f >$$ [4],

where P is a set of particles, S is physical space, T is time, IR is the set of real numbers, IR^3 the set of three-dimensional real vectors, and s, m, f are the metrical functions position, mass, and force, respectively. Clearly, what this theory assumes as the "real furniture of the world" is given by the sets P, S, and T: particles, places, and times. This is the universe of Newtonian particle mechanics.

Now, there was a time (around the middle of the 18th century) where many more or less cultivated people in Western Civilization believed that Newtonian mechanics **literally** represented the ultimate word about the constitution of **the** universe. That is, they believed that, not only mechanical phenomena, but also electrical, optical, chemical, physiological, even social phenomena could be conceived as models of Newtonian mechanics. Some went so far as trying to represent love as the result of interacting particles in space and time[5]. But this was a long time ago. Today, we have learnt to be more cautious about such sweeping ontological claims drawn from scientific theories. The reason is that we know there are lots of other well-functioning scientific theories besides Newtonian mechanics having quite different arrays of basic domains. Let us indicate just a few examples. In a model-theoretical reconstruction of equilibrium thermodynamics we will not have particles, places, and instants but rather (equilibrium) states as basic entities in the models; in stoichiometry, we will have a set

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[3] To show this systematically is the main gist of the colossal endeavour of Krantz, Luce, Suppes, and Tversky in their *Foundations of Measurement.*

[4] See, for example, Balzer/Moulines/Sneed [1987], Ch. I.7.

[5] An example is the book *Newtonianismo per le dame* by F. Algarotti, of 1737, cited in Schneider [1988], p. 155.

of chemical substances and a discrete time as basic domains representing chemical reactions; in a quite different field - microeconomics -, it will be most plausible to take sets of economic agents and goods as basic domains to model economic processes...[6] The zoo of the ontology of existing scientific theories is quite variegated. Is this zoo **the** universe? Before we tackle this question let us note a further factor for variegation in model-theoretical ontology.

The variety of universes in the model-theoretical sense doesn't just come from the variety of different existing scientific theories. One and the same theory may also refer to different "real" universes. We will have this situation whenever a scientific theory whose empirical claims are taken literally is **non-categorical**. Remember that we call a theory "categorical" when all its models are mutually isomorphic. In this case, all corresponding basic domains in the different models have the same cardinality and the corresponding relations are established in the same way in the corresponding domains. That is, if D_i is a domain of model x and D'_i is a domain of model x', and φ is a bijection between D_i and D'_i, we will have, for any basic relation (say R_j in x and its corresponding R'_j in x') that, for any $a, b \in D_i$, if $a\, R_j\, b$, then $\varphi\,(a)\, R'_j\, \varphi\,(b)$. In such a case, since we don't know anything about the elements of D_i and D'_i and their relationships but what the theory's axioms tell us about them, it is plausible to say that both models x and x' represent exactly the same facts and that their difference is just notational or symbolic but not substantial. That is, for categorical theories, it is plausible to claim that the multiplicity of their models is not a "real" multiplicity after all but just a set of notationally different ways of representing one and the same reality. In this case, we are entitled to say that there is just **one universe** referred to by the theory.

However, as it is well-known, most scientific theories - especially those taken literally - are non-categorical: their models are not mutually isomorphic. In these cases, each model, if taken literally, has to be viewed as representing different facts, even if the theory says always the same things about these different facts. Then, there is no plausibility anymore in the claim that the universe $D_1 \times ... \times D_m$ of model x and the universe $D'_1 \times ... \times D'_m$ of model x' are actually one and the same universe. So, even within the frame of one single theory we would have a multiplicity of universes.

There are only two conceivable ways to restore the uniqueness of the universe within a single theory: either to select just one privileged model and claim that this is the only "real" model of the theory and that therefore only its basic domains constitute the "real" universe; or to accept the multiplicity of models as real but to assume some substantial (ontological) connections between their respective basic domains producing a kind of "second-order" unity out of first order diversity.

The first alternative is not plausible for most empirical theories, especially those of physics. Take the example of Newtonian particle mechanics again. This theory has a

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[6] The detailed model-theoretical reconstruction of these examples is provided in Balzer/Moulines/Sneed [1987], Ch. III.

lot of quite different models which are intended as literal (though more or less idealized or approximative) representations of real facts: models on a galactic scale, on a planetary scale, on a terrestrial scale, etc. There is absolutely no reason to privilege any one of them. The same is true of the vast majority of other scientific theories.

The second alternative is much more plausible. It is the one envisaged by the structuralistic approach in the metatheory of science. According to structuralism, a characteristic of most scientific theories, especially of physics, is that they include, besides the usual fundamental laws determining each model axiomatically, a set of so-called "constraints", as a kind of "second-order axioms": their role is to bind the theory's different models though not amalgamating them into one single model. These constraints have also been called, in the structuralistic literature, "cross-connections" or "internal bridges" within a theory. Typical examples (and the most frequent ones) are so-called "identity constraints" - those stipulating the value-identity of two corresponding functions of two different models given the identity of the arguments: if x and x' are two different models of the same theory and there is an object a appearing in a certain D_i and in another D'_i, then, for given metrical functions f_j and f'_j also appearing in the respective models, we will typically require that $f_j(a) = f'_j(a)$.[7] Clearly, such identity requirements make models **cohere** into a higher-order model-theoretical unity. Identity constraints represent the most notorious, though not the only, kind of constraint having this effect; invariance principles and so-called "extensivity constraints" play a similar role. The upshot of this discussion is this. **If** we assume that **all** models of a given theory intended as real are interwoven by such constraints, then it is quite clear that, in spite of the irreducible multiplicity of models, their respective basic domains cohere constituting a superior conglomerate. It is difficult to represent this conglomerate symbolically, at least if we restrict ourselves to standard model theory. Nevertheless, it is clear that we can talk about this conglomerate as **the** (real) universe of the theory in question. So, we would have the unity of the universe restored after all (at least in the case of "friendly" physical science). However, this unity would be less "monolithic" than the one envisaged by the intuitive idea and it would depend on the contingent model-theoretical structure of the theory in question.

It goes without saying that a more serious menace to the idea of a unique universe doesn't come from the multiplicity of non-isomorphic models in a theory but from the multiplicity of theories. **There are** very many different, non-equivalent scientific theories. This is a contingent fact too, but of such an obvious nature that it almost has the force of an analytical truth. And since many of these theories will appear to have quite different arrays of basic domains, the hope of getting a unique universe out of them seems to have to be abandoned forever.

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[7] **Most** metrical functions in **most** physical theories will satisfy some identity constraint. But there are exceptions. And, in the social sciences, the "exceptions" appear to be rather the rule. For more details on the notion of a constraint, and the different types and examples of constraints, see Balzer/Moulines/Sneed [1987], especially Ch. II.2.

Nevertheless, this need not be the last word. We have to examine the issue more carefully. Two points can be made to keep our hopes alive. (The two points are related, as we shall see.) First, even if there are many different theories, surely not all of them can play the same role in determining what there really is. Secondly, the multiplicity of theories by itself is still not a knock-down argument against the unique universe. We have already seen that there is a mechanism of bridges between models ("constraints") which is able, in principle, to restore the unity of the universe within a theory in spite of a genuine multiplicity of models. Perhaps, it could be hoped, there is an analogous mechanism of bridges between **theories** enabling us to restore the lost unity of the universe.

Let us begin with the second point. According to the structuralist metatheory there are indeed such intertheoretical bridges playing an essential role in the configuration of the structure of science. They have even been given a proper name ("links") and have been defined formally.[8] It is a central tenet of structuralism that considering scientific theories as conceptual monads would give a completely distorted picture of the structure of science. Most scientific theories are essentially linked to each other. "Essentially" means here that they would not be able to "live" (i.e. to be understood and applied) unless at least some of their companions are taken into account. Links play a similar role for the coherence of theories within a global picture of science as constraints for the coherence of models within a theory.

However, at this point we have to water down the expectations of the "universe-unitarian". There are different types of intertheoretical links and some of these types have certainly nothing to do with the idea of unifying the basic domains of different theories - they rather have to do with the fact that the values of some function in one theory are set in a relationship (for some particular applications) with the values of some other function(s) in some other theory.[9] The only kind of links having a relevance for the issue at stake here are so-called "ontological reductive links". This is not the place to analyze them in detail. This has been done elsewhere[10]. The only thing we need to know for the present purposes is the general characterization of an ontological reductive link in terms of basic domains. Take two theories T and T' with their respective basic domains $D_1 \ldots D_m$ and $D'_1 \ldots D'_m$; we say that there is an ontological reductive link of T to T' if there is at least one D_i which is a (proper or improper) subset of a D'_j, or else D_i can be defined as an **echelon set** over an array of $D'_{j1}, \ldots, D'_{jk}$.[11]

When a theory T has an ontological reductive link to a theory T', the first is, in a quite precise sense, ontologically dependent on the second. The universe of the first

[8] Cf. Balzer/Moulines/Sneed [1987], Ch. II.3. and Ch. VIII. See also Moulines/Polanski [1996].

[9] A first attempt at a systematic typology of intertheoretical links has been made in Moulines [1992]; the connections between the different types is investigated in Moulines/Polanski [1996].

[10] See Moulines [1984], where also paradigmatic examples of ontological reductive links are examined; in this article, it is also argued that all ontological reductive links may be subsumed under the same general scheme.

[11] An echelon set is a set (or a relation) constructed out of some basic set(s) by repeated application of the set-theoretical operations of Cartesian product and power-set construction. The notion goes back to Bourbaki [1968]. For more details see Balzer/Moulines/Sneed [1987], Ch. I.2 and Moulines [1984] p. 65 and ff.

one is (at least in part) the same as, or a coarser version of, the universe of the second. Then, for the purposes of a general ontology, we may concentrate on the second theory and forget about the first one. So, if we want to know what the universe is, we should concentrate our attention to theories not reducible to other theories in the sense just explained. There must be such theories. For it is highly plausible to conceive ontological reductive links formally as reflexive, antisymmetric, and transitive relations; further, we know that there is only a finite number of theories (this is, again, an "almost analytic" metatheoretical statement); then, if all theories were ontologically reducible to other theories, they would crumble into just one theory: there would be just one theory in the world - which is plainly false.

Let us call such theories, which undoubtedly must exist, "fundamental theories" (abbreviated as "f-theories"). More precisely, an f-theory is a scientific theory *T* fulfilling the following properties:

(f-1) At least some of *T*'s models are intended to be taken literally, i.e. as (approximately) accurate representations of facts;

(f-2) there are good reasons to believe in *T*'s truth or factual adequacy; or, more precisely, there are good reasons to believe that *T*'s literally intended models are good representations of some facts (*T* is at least "well-confirmed");

(f-3) there is no other theory satisfying conditions (f-1) and (f-2) to which *T* has an ontological reductive link.

The universe, if there is such a thing, will be the universe of one or several f-theories. The question about the uniqueness of the universe becomes a question about f-theories and their properties and relationships. What can we say in general about them? Since we already know there must be some f-theory, there are *a priori* only four possibilities to consider:

(A) There is just one f-theory and it is categorical.

(B) There is just one f-theory and it is not categorical.

(C) There are several f-theories and they are mutually compatible.

(D) There are several f-theories and they are incompatible.

Let us see what the ontological consequences of each one of these alternatives are. Plainly, only the first one would give us an absolute guarantee of the uniqueness of the universe. If (A) were the case, all admissible scientific theories but one would be reducible to a privileged theory, or else they should be regarded as more or less useful fictions not intended literally to represent facts. We would then have a single theory about all there is and a single model corresponding to the whole of reality; or, more exactly, all the theory's models would just be notational variations of one and the same representation of all real facts. Its basic domain(s) would be **the** universe.

In alternative (B), we would also have just one privileged theory but with genuinely different models. In this case, as we suggested above, we could assume a unique universe only in case that plurality of models were tightly intertwined by so-called "constraints" (second-order "axioms"). The issue about the uniqueness of the universe would then be a highly contingent matter - metatheoretically contingent upon the concrete structure of the particular theory we have privileged as the most fundamental one. Moreover, the universe's uniqueness would be in this case a matter of degree - as odd as it may sound. For it would depend on the nature, strength, and generality of the model-binding constraints.

Let's consider now alternative (C). In this case, we have a set of f-theories which don't contradict each other but are not mutually reducible either. What happens then with our idea of a single universe? To simplify the discussion take the simplest possible case: we have only two theories T_1 and T_2 such that:

(C-1) T_1 does not imply the negation of T_2[12];
(C-2) T_1 is not reducible to T_2, nor is T_2 to T_1.

Let us suppose further, to make the case for uniqueness as strong as possible, that T_1 and T_2 are both categorical, or, at least, that for some good reason we privilege a single model in each theory. Then we may say that T_1 is the theory about universe U_1 (as the Cartesian product of the basic domains of the privileged model) and T_2 the theory about universe U_2. Under the conditions (C-1) and (C-2) above, we should assume that $U_1 \neq U_2$; since, otherwise, T_1 would negate T_2, or be reducible to T_2 (or vice versa), or else we could put together the axioms of T_1 and T_2 and have them satisfied in the single universe $U_1 = U_2$, so that we would just have a single theory T_3 with a single universe; that is, we would be brought back to alternative (A). So, U_1 and U_2 must be really different. Can we in such a case still assume the uniqueness of the (real) universe? One might argue that this is still possible: just take the set-theoretical union of U_1 and U_2 and call this thing "**the** universe". This set would indeed cover all there is[13]. One could then go one step further and argue as follows: strictly speaking, it is true that we have two really different theories T_1 and T_2 (which cannot be put together into a coherent conjunction T_3), each one having its own universe - U_1 and U_2, - T_1 being in charge of U_1 and T_2 being in charge of U_2; but since T_1 and T_2 are compatible, what

12 If, as good structuralists, we don't conceive of a theory as a conjunction of statements but rather as a structure composed of classes of models and similar structures, then the intuitive idea behind condition (C-1) should be reworded into something like: (C-1') the so-called "central empirical claim" of T_1 does not imply the negation of the central empirical claim of T_2 - where "central empirical claim" has a precise, technical sense within the structuralist metatheory. But we need not enter into these technicalities in the present context.

13 Instead of taking the set-theoretical union, one could also take the mereological aggregation in case one prefers mereology to set theory to deal with the universe; however, the line of reasoning and the difficulties it encounters could easily be transposed from the first version to the second.

this means is that we have divided the single "real" universe U_1 and U_2 in two parts for purposes of theoretical investigation.[14]

However, the question immediately prompted by this strategy of "division of labor" is this: What reason do we have to think that the union $U_1 \cup U_2$ is a universe, more specifically **the** universe (as the totality of all there is) we want to speak about? Without further argument we have no good reason to take this for granted. Indeed, the mere formal construction of $U_1 \cup U_2$[15] does not necessarily lead to ontologically relevant consequences implying that there is, **in fact**, a single universe. To make this point clear let's take a drastic example. Imagine that in our time of post-modern tolerance, a (Friedmanian) economist and a (Lefèvrian) theologian meet and start a friendly conversation about "the state of the world". The economist speaks about economic agents and money, the theologian about souls and the devil. After a while, they see that they have some difficulty in understanding each other, since their theories deal with quite different things; they part company, but before that, for the sake of a truly ecumenical spirit, they decide that, contrary to appearances, they were both talking about one and the same world after all: the universe constituted precisely by economic agents, money, souls, and devils. Would this be a genuine way out of the impasse created by the disparity of the universes they were talking about? I don't think any genuine universe-unitarian would be satisfied with such an *ad hoc* solution. Besides being a courteous diplomatic gesture, the proposal made by the economist and the theologian would not change an iota in the disparity of their universes. For a genuinely common universe to come out of their conversation, at least some non-trivial connections between the objects of both domains should be established. In a word, there should be a theory dealing with the mutual relationships between economic agents and souls, money and the devil. This is just a corollary, applied to a concrete example, of the combination of the two basic principles we have taken as premises of our discussion: the Fundamental Ontosemantical principle and the Principle of the Theoretical Contextuality of Being.

Generally speaking, given two compatible but independent theories T_1 and T_2 with their respective universes U_1 and U_2, we shall be able to speak of one common universe U constructed out of U_1 and U_2 only if U is the universe of a third theory T_3 to which T_1 and T_2 may be reduced. In this situation, however, alternative (C) would dissolve again into alternatives (A) or (B). If we want to assume (C) as a real alternative, then there is no good reason to assume a single universe as well; quite the contrary, we would have every reason to speak of a irreducible multiplicity of universes.

This conclusion is still more evident in the case of alternative (D). The existence of several, **mutual incompatible** f-theories is the best argument we can think of for the

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[14] I think that this view of the matter is more or less (sub)consciously taken for granted by many present-day physicists when talking about "our present knowledge of the universe": there is a part of it called "microcosmos", which is taken charge of by one fundamental theory (quantum field theory), and another part called "macrocosmos", which is the business of another fundamental theory (general relativity theory).

[15] or its mereological counterpart.

non-uniqueness of the universe. This is, again, a straightforward corollary of the two principles mentioned above.

The upshot of the discussion up to this point is this. The uniqueness of the universe would be guaranteed only in case (A). Alternatives (C) and (D) speak clearly against the uniqueness idea. In case (B), the issue remains as an open question, depending on the concrete structure of the f-theory assumed as literally true.

The four alternatives discussed so far and their ontological consequences come out of an analysis of formal possibilities given *a priori*. The question now is: Which one represents the global structure of present-day scientific knowledge? Or, to be more cautious: Which one is the **most plausible** representation of scientific knowledge?

It doesn't seem to me that we need to engage in a difficult metascientific analysis to see that alternatives (A) and (B) are out of the question. There is no single f-theory about all objects we take as real - much less a categorical f-theory. This is certainly a matter of empirical fact about our scientific culture, but it is so well-entrenched in it that, again, it almost has the strength of a conceptual truth. One may argue about the adequacy of alternative (C). But the most plausible picture of present-day scientific knowledge is, no doubt, case (D). It is already almost a truism for reasonably cultivated people (or it is at least an essential component of the world view of reasonably cultivated people) that we have at least two fundamental **and** incompatible theories: general relativity theory and quantum field theory. They may "collaborate" locally to solve some specific problems, for example in astrophysics; but this is like to collaboration between the Soviet Union and the Anglo-Saxon powers during the Second World War: it is purely opportunistic and it just temporally covers a quite fundamental dissent that sooner or later will come to the surface with full force. Their basic concepts and principles, as well as the intuitive image of reality provided by general relativity and quantum field theory are to a high degree incompatible; only few pairs of theories in the course of the history of science have been so opposite as these two. And in spite of tremendous efforts made by some of the most brilliant physicists of the 20th century, the situation has remained practically the same as it was 60 years ago.

Many physicists and some philosophers who favour the One-Universe idea are fully conscious of this situation but consider that it is not so bad for "unitarianism" as it seems. They argue more or less like this. After all, we should be happy that we have reached a situation where there are only two f-theories; moreover, as we have said above, this is the most plausible picture of **present-day** scientific knowledge; but this can change very soon: with a little additional effort we may somehow marry the two quarrelling theories or invent a third theory which will incorporate both of them as "approximations". Then we would have **the** ultimate theory with its ultimate universe which would then be precisely **the** universe. Often, some historical examples are remembered apparently going in the same direction: it is said that, by his particle mechanics, Newton managed to "unify" (that is, to reduce to his own theory) the previous theories of Kepler, Galileo, and Descartes, which were clearly different, if not incompatible; or, 200 years afterwards, Maxwell managed to incorporate optics, electricity and magnetism into his own electrodynamics. So, the argument runs, why should not a new "Newton/Maxwell" come along and "unify" general relativity and quantum field theory?

It is undeniable that this vision of ultimate unification has been tremendously stimulating for the development of physics in the 20th century. In recent years, attempts at constructing an adequate "great unified theory" (GUT) and still more the theory of "superstrings" represent simply the last link in a long chain of similar efforts. Nevertheless, stimulating visions are one thing, the hard facts of life quite another. As critical analysts of the present situation in science, we have to take notice of the fact that the doctrine of only two f-theories and their probable unification looks rather like a great myth. On a closer look, it totters even within physics alone. If we take seriously the notion of a fundamental theory as defined above (and I know of no better explication), then one has to admit that fundamental theories pullulate in present-day particle physics. Indeed, even if we are ready to admit that, instead of speaking of quantum field theory, we can speak of **electroweak theory** (as the "unification" of quantum electrodynamics and the theory of weak interaction) as a **single** f-theory, we come across other, independent particle theories of which nobody has so far shown that they are reducible to the electroweak theory. Furthermore, none of the wider unifying theories proposed so far (like the theories of supersymmetry or of superstrings) can be said to have been empirically confirmed - so that, according to condition (f-2), they are not f-theories. As it is laid out in Salam [1989], the experimental difficulties are so enormous that we will have to wait still for a long time to test them in a decisive way.

Moreover, even if we forget about the jungle of particle physics and do (hypocritically) so as if all theories of particle physics were actually reducible to the electroweak theory (or its substitute), we cannot just forget about the third big frame theory (besides general relativity and quantum field theory) in physics: thermodynamics. Curiously enough, this blossoming branch of physics tends to be neglected when the issue of the unification of physics is at stake. Apparently, it is taken for granted that the whole of thermodynamics has been reduced to something else. However, this again has many features of a myth. It is already quite problematic to claim the reducibility of **equilibrium** thermodynamics to statistical mechanics and from this to quantum mechanics. The ergodic hypothesis, which is always mentioned in this context and which was used by Boltzmann and Ehrenfest for their famous derivation of the principles of equilibrium thermodynamics from statistical mechanics, is demonstrably false. Other hypotheses purporting to play the same role as the ergodic hypothesis have been devised (at least for ideal gases - non-ideal gases are discretely forgotten); but there are still strong divergences as to which are the most plausible ones. A particularly careful analyst of this matter, Lawrence Sklar, has recently summarized the state of the issue in these words: "There is as yet no real agreement about which idealization is the correct one to use in trying to represent thermodynamic behavior in terms of microscopic dynamical behavior and probabilities"[16].

[16] Cf. Sklar [1992], p. 137.

But even if we presuppose some of the present versions of statistical mechanics as the reducing theory for equilibrium thermodynamics, a little reflection shows, as Sklar himself points out, that the genuinely statistical principles assumed to make the reduction work are alien, and in a sense even contrary to, mechanics both in its classical and (still more so) in its quantum version. Therefore, even if we considered that equilibrium thermodynamics has actually been reduced to statistical mechanics, we would get in the final analysis another f-theory different both from quantum field theory and general relativity.

If we change from equilibrium thermodynamics to the thermodynamics of irreversible processes (a very lively branch of present-day physics), the situation becomes even more depressing for the unitarian. We find here a family of mathematically well-articulated and empirically well-confirmed theories; but the reduction of any of them to statistical mechanics - whether quantized or not - seems to have been postponed *ad calendas graecas*...[17]

If we get out of physics, the landscape becomes still more hopeless for the unitarian. We often hear that all chemical theories have successfully been reduced to physical theories (mainly thermodynamics and quantum mechanics); but it is not at all clear that, in most cases, the alleged reduction is really much more than "hand-waving". In biology, there have undoubtedly been some partial reductions of genetics to chemistry; but the theory of evolution and etology stubbornly resist any kind of serious "chemistrification". When we enter the vast field of the social sciences, the metatheory of the unique universe goes completely bankrupt: it becomes obvious that the best psychological, linguistic, economic, and ethnological theories (many of them more or less well-mathematized and with an acceptable empirical basis) are not reducible to physiology or biology, whatever the fans of socio-biology might contend.

In sum, if we take a reasonably careful look at the global picture of science, we'll notice that it contains some "regions" of the (C)-type, whereas some other are clearly of the (D)-type. At any rate, from a sufficiently general perspective, we see nothing here that speaks for the idea of a unique f-theory with a unique universe.

At this point, the unitarian may try to get out of this depressingly pluralistic landscape by changing of strategy in his/her argumentation. He/she may move from a synchronic to a diachronic way of arguing and reply in the following manner.[18] The plurality of universes provided by f-theories is a feature of scientific knowledge **in the present times** but is not an eternal truth. Quite the contrary - the unitarian may claim - there are good reasons to suppose that this situation will change in the future **because** scientific development essentially has the structure of a convergent process. Therefore,

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[17] See, for example, Cohen [1973]. This essay is already (by usual standards in physics) a bit old, but I haven't found any more recent examination of this issue which could compete with it in stringency.

[18] Indeed, this strategic move represents just a generalization of the characteristic unitarian response to the general relativity vs. quantum theory case as sketched above.

the ontological disparity of theories will gradually diminish; and therefore, f-theoretical uniqueness, which also implies ontological uniqueness, will be reached in a future stage of scientific development, which might be closer than we think. Then, all theories of the social sciences will have been reduced to biological theories, all biological theories to chemical ones, all chemical ones to physical ones, and in physics finally they will have managed to construct the everlasting, real GUT, with just one literal model.

A somewhat watered-down, more cautious version of this doctrine is what has been called "convergentism" and has its roots in Charles Peirce's philosophy of science. The Peircean convergentist doesn't necessarily assume that the unitarian paradise will ever be reached in this earthly life, but he/she contends that, for the present purposes, it is enough to assume that science may be diachronically characterized as a process **tending** towards that ideal form; it gets ever closer to uniqueness though perhaps it will never reach it completely. The unique theory with its unique model would then be an ideal limit to which the series of historically given theories converges.

Now, the crucial question is: What reasons can the convergentist give for his/her eschatological view of scientific development? If we leave transcendental, i.e. metaphysical arguments out of consideration (and the tenor of his essay is that we should admit only scientifically founded arguments in this discussion), then the only good (meta-)empirical reasons the convergentist may have should be of a **historical** nature: if we examine the history of science from its beginnings 2,500 years ago to the present times, we should notice that from an initial situation of extreme disparity in the modelling of reality, science has gradually proceeded to stages of successively diminishing divergences. The evolution of the set of f-theories and their models could then be graphically represented as a "damped harmonic oscillator".

Is this the truth of the matter? It doesn't seem so. Truly, in the dawn of the scientific spirit, as we understand it today (that is, in the times of the Pythagoreans and Pre-Socratics), the most disparate and incompatible theories about all there is pullulated. However, a couple of centuries afterwards, the first great synthesis was established - the Aristotelian synthesis or, to be more precise, the Aristotelian-Ptolemaic synthesis. It convinced the vast majority of learned people with scientific interests and, for many centuries, it was really a "theory about everything", like the ones present-day physicists dream of. It was the most embracing, lasting f-theory that has ever existed. Then, with the emergence of the impetus theory, which actually was incompatible with it, the Aristotelian-Ptolemaic synthesis became increasingly shaky. Later on, the calendar problem and the invention of the telescope, among other things, eventually made it crumble away. To this, a period followed - between the end of the 16th century and the beginning of the 18th century - of extreme diversity of theories and models. Let's remember just a few of them: Copernicus' quasi-Aristotelian but anti-Ptolemaic universe; Tycho Brahe's half-Ptolemaic universe; Kepler's geometric-cosmological mechanics; Galileo's Platonic cinematics; Van Helmont's universe of chemically active spirits; Descartes' continuous universe of collisions and vortices; Leibniz's universe of spiritual monads and forces... and finally Newton's discrete universe of particles in a vacuum with a physically investigable God pushing them once and again when they get tired. As we all know, in this war of all against all which characterized the Scientific Revolution of the 17th century and which was much longer (though less cruel) than the coeval Thirty Years War, it was Newtonian mechanics which eventually triumphed over all others - temporally. For roughly a century, people got again almost a "theory of everything", though it never attained the totalizing character of the Aristotelian-Ptolemaic synthesis. (Remember that Newtonians soon had to concede that optics and chemistry escaped them.) The 19th century witnessed again an explosion of disparate and incompatible theories. Even if we restrict our attention to the domain of physico-chemical disciplines, we contemplate, besides the orthodox and stubborn Newtonian universe, Young's universe of waves, Laplace's caloric fluid, Faraday's mysterious fields, Ostwald's all-pervading energy, and, why not, the impressionistic world of pure sensations proposed by Ernst Mach, who then was a quite influential authority, determined to reduce physics to psychophysiology, and not the other way around. Towards the end of the 19th century a great little synthesis was achieved by Clerk Maxwell but it was soon to be buried under the frightening heterogeneity of universes offered by the first and second theories of relativity as well as the first and second theories of quantum phenomena... and all the rest that came later on.

In sum, the history of the universes of physics (to say nothing of the other disciplines) appears indeed to have the structure of an oscillator - but not of a "harmonic", much less of a "damped" oscillator... The diachronic perspective is of no more help to the idea of the unique universe than the synchronic one.

Do we have to regret this situation? The dream of the ultimate theory of everything with its big and united universe, has its origin, like the dream of a World State, in a noble ideal. This ideal has guided the most strenuous efforts of a dozen generations of physicists since the 17th century. One could almost say that the faith in this ideal defines modern physicists as a professional group. With few exceptions (the most notorious in the 20th century probably being Pierre Duhem, Erwin Schrödinger and Günther Ludwig), the process of socialization of physicists is such that, whoever doesn't show an irrevocable faith in the Advent of the Universal Theory, tends to be seen by the rest of the group as a renegade. Nevertheless, as critical "meta-physicists" we need not have this faith. We may acknowledge that the pursuit of this goal has been a positive stimulus for the progress of human knowledge in general; but, at the same time, we may also note that the faith in the Advent of the Universal Theory has not had, so far, any rational grounding; and, what is more important, we also have to ask ourselves whether the dream of the Unique Theory of the Unique Universe, like the dream of the World State, in case it were effectively realizable (and I see no a priori reason why it should not be), would not have the inherent risk of becoming a nightmare. Could it be that the continuous efforts to dominate every corner of reality by means of a single model, like the effort to dominate every corner of the planet by means of a single government, would lead to the death of human spirit?

Anyway, there is no reason to sound the alarm prematurely. Whatever noise the trumpets of the superstring theory or similar theories may make, the plain fact is that, at least for the time being, the supermarket of science contains ever more theories with ever more universes. As unprejudiced consumers we should rejoice over it.

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