Is there "Ultimate Stuff" and are there "Ultimate Reasons"?

David Rousseau[a*] & Julie Rousseau[b]

[a] *University of Wales, Trinity Saint David, Ceredigion, United Kingdom, & Centre for Systems Philosophy, Surrey, United Kingdom.*

[b] *Centre for Systems Philosophy, Surrey, United Kingdom*

1. Introduction

The pre-Socratic philosopher Parmenides famously argued that the world must have always existed, on the basis that it cannot have come out of nothing. The form of his argument implies that he held a view we recognise today as *the Principle of Sufficient Reason* (PSR). PSR encapsulates the idea that there is (at least in principle) a complete explanation for the existence of every thing, and likewise for the occurrence of events, the progression of processes, and the truth of true propositions. If PSR is true then the world would be fully comprehensible.

That said, Parmenides's 'solution' actually violates PSR, since we cannot understand how something can have always existed any more than we can understand an arbitrary origin. From this it looks as though both possibilities are ruled out if we insist on PSR, generating what I will call the Parmenides Dilemma.

A perceived weakness in Parmenides's argument is that he (apparently) had no compelling reason for assuming PSR, but only adopted it on the basis of a rationalistic intuition. However, if we give up PSR then we have to adopt either Mysterianism, (under which aspects of how the world is, or works, are in principle incomprehensible, and hence represent "brute facts") or Theism (in which the powers of God are invoked in explanations). Rationalists typically resist both Mysterianism and Theism, and hence still feel the force of the quandary raised by the Parmenides Dilemma today.

2. The modern answer to Parmenides's question

The modern view of the origin of the world is very different to Parmenides's. We are now convinced that our physical world had a first moment, and that the physical matter in it arose from another kind of concrete matter called the quantum vacuum (QV). In modern theory the QV replaces the ancient notion of space as being "emptiness" or "the void". The ancient idea of a void is presently represented by *abstract* space – something that can be described in geometrical (or more accurately *topological*) terms but which is only a conceptual thing and hence it has no causal powers. The QV, in contrast, is a kind of space that does have causal powers, and having causal powers is what distinguishes "concrete" things from "abstract" ones. The QV's topological properties derive from the distribution of its parts, which are typically called 'virtual particles'. They are called *virtual* because they exist in a special way that resembles but is unlike how physical particles exist. However, virtual particles *are* concrete, and hence as objectively real as physical particles are. Rather than the ancient dichotomy of matter and void modern science now postulates two related kinds of matter, namely 'physical matter' and 'spatial matter'. What

* email: david.rousseau@systemsphilosophy.org

makes them both kinds of *matter* is that they both have energy, but they are different *kinds* of matter because of how their energy manifests.

The notion of 'energy' is widely held to be mysterious (e.g. Feynman, 1989, p. 4.2), but as Mario Bunge has so clearly explained, the term "energy" merely represents the ability of a concrete thing to change, and the extent to which it can change is represented by the "amount of energy" it has (Bunge, 2000). One has to be careful with terminology here because energy is a property ("the ability to change") and not a kind of stuff, even though it is often convenient to speak as if it is a sort of fluid, e.g. we talk of "flows of energy" or "exchanges of energy". Something is *matter* if the ways in which it can change are always constrained (Bunge, 2010, pp. 62, 65, 66); if something existed that was immutable, or could change in unlimited or ungoverned ways, it would be an *immaterial* substance. The ways in which things can or do change define the kinds of things they are. Therefore we could say that things are differentiated by the ways in which their energy manifests, meaning they have different kinds of properties that designate the different ways in which they can, do or resist change.

This conception of energy is crucial to understanding the nature of the QV, and how 'spatial matter' is different from 'physical matter'.

The 'virtual particles' comprising the QV are 'bits of stuff' whose physical properties are in constant flux, alternating between different values so rapidly that 'on average' regions filled with QV appear to have no properties at all. Only under special conditions such as by looking at very small portions of it over very short timescales can we see past this averaging effect, and see that there is something objective there after all. In most contexts the QV appears indistinguishable from abstract nothing, but in fact we can now begin to understand how something can appear that way and yet give rise to concrete things with persistent concrete properties: physical particles can now be understood as 'stabilizations' of the otherwise rapidly changing physical aspects of the QV. We propose that this suggests a powerful new way of understanding the notion of "having properties", in that something can be regarded as having (or not having) certain properties if it has (or does not have) them *on average*. In a dynamic and contextualized conception of reality, such as modern science is increasingly leading us to invoke, this appears to be the most appropriate way of understanding the notion of concrete properties.

This of course refines our notions of nothingness, thing-hood and kind, for now a material particular is nothing, something or specific only conditionally and temporarily, and not essentially a member of any absolute category other than being a material thing.
Note however that even under these refined concepts the QV is not a sort of 'nothing'. Even though its physical properties mostly 'average out', it has persistent spatial properties such as a metric and a topology, and these properties have casual consequences for particles moving through this space.

So the modern way of answering Parmenides's question contends that physical matter *did* arise out of space, but concedes that the physical world did *not* come out of nothing. However, despite our scientific and philosophical advances the modern answer does not escape from the Parmenides Dilemma: the QV is still something specific (*spatial* matter), and since we cannot understand *its* origin our 'explanation' still does not satisfy PSR.

3. Should we give up on the idea of fully comprehending the world?

PSR was the dominant view in philosophy and science from pre-Socratic times up until very recently. In the 1990s metaphysical philosophers, led by Peter van Inwagen, pointed out that we can only understand

what logically follows from what is logically necessary or self-evident, and if everything in the world is either logically necessary or logically entailed then we would end up with a strong from of determinism called "necessitarianism". In such a world there is no possibility of authentic happenstance, choice, creativity, or free will. This grated on most philosophers' intuitions, and so the majority view in current metaphysics is that we have to accept some brute facts in our world model (Hudson, 1997, 1999, 2008).

News of this bombshell seems not to have reached mainstream physics yet, so the situation is that philosophers now mostly favour Mysterianism, whilst scientists still mostly support the Rationalist PSR.[1] However, both positions are ultimately grounded in wishes about how we would like the world to be, rather than principled arguments grounded in empirical findings about how things are, so neither is compelling.

4. Systems Philosophy's answer to the PSR question

The philosophical debate about PSR in the 1990s apparently proceeded in ignorance of relevant insights from *Systems Philosophy* dating from the 1970s; Mario Bunge has often lamented that the systems concept has not yet reached mainstream metaphysics (e.g. Bunge, 2010, p. 75). Ervin Laszlo pointed out in his 1972 book *Introduction to Systems Philosophy* that the existence of the systems sciences, which have trans-disciplinary application, and of the General Systems Theory which unifies them, suggests that the world is ordered as a whole and hence comprehensible (Laszlo, 1972a; Rousseau, submitted). This provides an empirically grounded argument supporting the validity of PSR.

If this empirically-suggested comprehensibility entails necessitarianism then so be it, although *we* think there are good arguments and evidences suggesting that this is *not* the case. However, that is an argument for another occasion. For now we will assume PSR on the grounds that it is indicated by the findings from Systems Philosophy, and then see where it gets us in terms of thinking about the fundamentality of the QV.

5. Systems Philosophy and our picture of the world

The anti-PSR debate exposed the idea that if PSR is true then explanatory arguments must form logically coherent chains, so cannot embed any brute facts along the way. Moreover, as we work out explanations, arguing from present phenomena back to original conditions, the explanatory chains must terminate (otherwise we get an infinite regress) and must do so on self-evident or logically necessary facts (so there can be no brute facts amongst the fundamental ones). It is interesting to consider the degree to which the possibility of constructing such arguments fits our scientifically derived picture of the nature of Nature.

The Systems Sciences reveal that it is as important to understand the *organization* of the world as to catalogue its furniture. One of the central tasks of Systems Philosophy is to generalise this organizational insight by developing an 'architectural map' of the organization of nature, as a sort of skeleton that can be

[1] There is a long-standing exception amongst fundamental physicists who accept the Copenhagen Interpretation (CI) of quantum mechanics. For example, under CI the entanglement relation is incorrigibly mysterious. Recent developments in the philosophy of quantum mechanics suggest that Einstein's resistance to this Mysterianism was on the right track, and favour 'hidden variable' type models which would render the entanglement relationship comprehensible (Christian, 2011a, 2011b).

fleshed out with our discipline-specific knowledge of the world. Such a model can be useful for identifying important gaps in our knowledge, raising questions about the finality of our insights, and guiding theorizing about what lies beyond the limits of what is known.

Our current such model of the world indicates that every concrete thing is a system or part of one, where a "system" is "a whole that functions as a whole in virtue of the relationships between its parts" (Rapoport, 1986). When things are ranked in terms of their complexity they form a hierarchy in which the things in any level of the hierarchy are comprised of or arise from the things at lower levels. This pattern only fails for things in the lowest level of the hierarchy, which (as far as we know) are not composite or derivative (Boulding, 1985; Laszlo, 1972a, 1972b). We will call this systemic hierarchy the "Systems Model of Nature (SMN)", and depict it schematically in Fig 1 below.

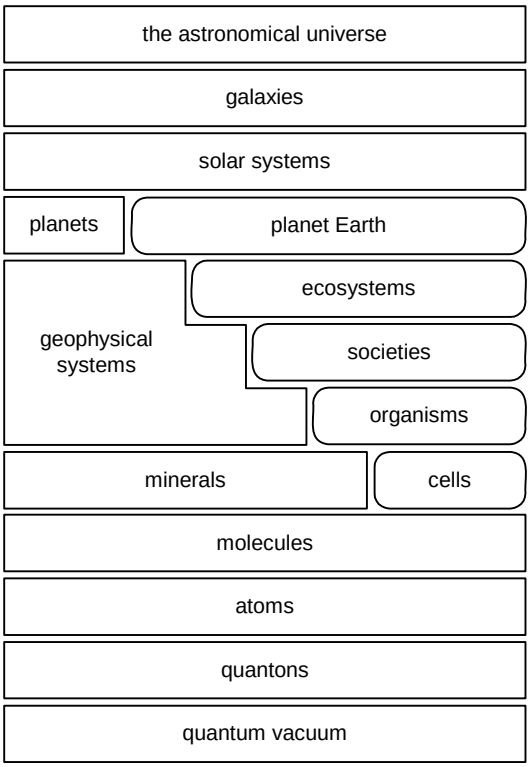

Fig. 1. Nature Modelled as a Hierarchy of Systems and Parts

According to the latest understanding of this model the properties and behaviours of composite things are determined not only by the properties of their parts (the classical reductionist model) but also by the relations between their parts (the systemic or emergentist model) and by their context, i.e. by their relations with other parts in the supra-system. This latest systems-philosophical view, according to which behaviours and properties are conditioned by an interplay of "bottom-up", systemic and "top down" processes, is called "Organicism" (Bahm, 1967, 1981).

This hierarchical model is still work in progress, but in broad terms it seems to suit the requirements for PSR-based explanations rather well. The relations between the layers appear to be rationally analyzable,

except for the transition to living/conscious systems, which is still a challenging problem. However, we cannot be sure that we have correctly identified the boundaries of the hierarchy model; the highest level of complexity for which we have objective evidence represents the astronomical universe, and the lowest level likewise represents the QV.

It has been argued that logically speaking the astronomical universe is not necessarily at the highest level of complexity in concrete reality, because 'our' universe may be a member of a multiverse. Multiverse theory is still speculative but it has some explanatory promise, e.g. in certain ways of accounting for the fine-tuning of the universal constants, or the anisotropy of the cosmic microwave background (Carr, 2007).

Likewise, it can be questioned whether there are levels below the QV. The nature of the QV does not appear self-evident or logically necessary, so if PSR is true then there might be lower levels yet to be discovered. That said, if PSR is true then there must be a bottom-most level in which things do not depend on lower-level stuff (to avoid an infinite regress), and this fundamental stuff must have at least some properties that do not depend on higher-level conditions (to avoid circularity in how the properties of things are grounded). In such a scenario the nature of the 'ultimate' stuff must provide what is *necessary* to make everything else, i.e. its properties must be sufficient to enable logical explanations of any higher level thing or phenomenon.

6. The Systems Model of Nature and the nature of scientific explanations

Explanations trace causal interactions by tracking changes from causes to effects along continuous space-time paths. These changes *must* balance out in a consistent way, otherwise the relationship between cause and effect cannot be understood but appears arbitrary. So there is a 'change-conservation principle' entailed by PSR, in which the parties to a causal exchange must each undergo some change (otherwise we would not implicate them in a causal transaction), and their respective changes must balance out exactly (otherwise we cannot claim that we have accounted for all the participants in the event). In order to do this tracking in practice we need an objective "measure of change" so we can show numerically that we have satisfied the 'change conservation principle'. As we discussed above, things' ability to change is represented by their energy, so the amount of change a material entity can undergo is designated by its "total energy", and the amount of change it undergoes in a causal interaction corresponds to "energy lost or gained". So explanations, in tracing related changes, really trace 'flows' of energy 'between' interaction partners. An explanation is thus only complete and comprehensible if in every interaction all the energy is accounted for, i.e. energy is fully conserved. So if we assume that the concrete world is understandable (PSR), then the energy conservation principle must (necessarily) be true as well.

Conservation of energy has usually been taken to be a law of Nature that has been suggested by empirical observations. However, our argument here shows instead that conservation of energy is a logical entailment of the assumption that the world is understandable and hence fully explainable.

7. In search of the bottom level

We argued in section 4 that it is reasonable to assume PSR. Combining the arguments from sections 5 and 6 we can now conclude that PSR-satisfying explanations will ultimately terminate on the facts from the lowest level in the systems hierarchy, and these facts must be self-evident or logically necessary.

In practice such explanation is so far only an ideal vision, since due to limitations in our current knowledge, technology and opportunities for investigation, we cannot say whether we have correctly identified the "ultimate" lowest level or fully inventoried it. For this reason our present best arguments terminate on empirical findings that appear as brute facts, but if we assume PSR then these are really placeholders for discoveries and explanations yet to come.

Nevertheless, knowing what we do about the structure of reality (the SMN) and how explanations work under the PSR, we can identify some of the logically necessary requirements applicable to the ultimate fundamental stuff, and consider whether the QV is a likely candidate or not.

We can start this reflection by asking the following question: what properties must the stuff in the lowest level necessarily have if we are to be able to build logical explanations from these to account for anything that can exist or happen in the concrete world?

8. Necessary characteristics of the fundamental stuff

As discussed above, all the steps of an explanatory chain satisfy logic by complying with the energy conservation principle, that is, by tracking change in a balancing way. By implication, all concrete things (i.e. things with causal powers) that can be involved in PSR-compliant explanations must have the ability to change (equivalently, have energetic properties), and do so only in a way that conserves energy. Given that science is aimed at elucidating the nature of Nature we can use this insight to define *Natural* things as things that can change but only in balancing ways. Unchanging things and things that change in inexplicable ways cannot be part of a comprehensible world, but only part of a world that contains mysterian or supernatural elements (Rousseau, 2011).

As we trace causal interactions across the different levels and entities of the natural systems hierarchy, we will typically encounter different types of energy (e.g. kinetic, chemical, elastic), and also typically see constrained conversions between types (e.g. from chemical energy to kinetic energy). The important observation is that there is always some sort of energy involved. The implication is that Natural things *always have conservative energetic properties.* By this reasoning the "ultimate stuff" *must have* energetic properties and must be subject to the principle of energy conservation.

In our earlier discussion on the nature of the QV we arrived at a new perspective on what it means "to have a property", namely that it is to have it *on average.* By implication, the ultimate stuff must have energy *on average*, so that its energy is always a positive quantity. In addition, the ultimate stuff must also have the property that it changes spontaneously – because this is the primitive existent, we cannot get things going if this stuff is not inherently dynamic (as opposed to merely changing in response to stimulus or constraint). However, these considerations do not entail any restrictions on what changes it might undergo, so in practical terms the ultimate stuff's properties can oscillate rapidly between the various possibilities, analogously to what happens in the QV.

The QV is somewhat like this, since it is both energetic and inherently dynamic. However, it also has persistent spatial properties such as extent and curvature. These are concrete properties, so that e.g. the metric of the vacuum affects the trajectory of objects moving through it, as in radiative decay where an excited electron is 'pushed' into a lower energy state. Nevertheless spatial properties appear not be primitive or absolute, since they are dynamic (for example the metric can be distorted around closely approaching conducting surfaces with various geometries (e.g. the Casimir effect) (Rodriguez et al., 2010)), and spatial matter can be converted into physical matter (e.g. electron-positron pair formation

from virtual photons in very strong electric fields (this is sometimes called "vacuum decay")). As an aside, it is also the case that physical matter can be converted into spatial matter (e.g. in the process called "black hole evaporation").

Because spatial properties are not primitive, but represent just one form that energetic properties can take, this suggests that something might exist that is analogous to the QV but that is "neutral energy", i.e. it has net positive energy but its properties oscillate rapidly between different options so that on average it is nothing in particular (at minimum neither space nor physical matter). Such a substance could be considered to be "pure energy". We postulate that such a stuff actually exists, and further propose calling this stuff "energeum". The QV is then a form of this substance in which the *spatial* properties have been stabilized, and by analogy with energeum the stuff of the QV can be called "toponium" (it has energetic and spatial (or more aptly, *topological* properties)). Likewise, physical matter can be regarded as QV in which additionally certain *physical* properties have been stabilized; by analogy with the previous naming convention we might call this stuff "mechanium" on the basis that physical properties are deterministic or stochastic in nature.

If it could be shown that energeum exists, then it would be a plausible candidate for the "ultimate stuff" in Nature (rather than just another layer below the QV) because it has the minimal properties needed to qualify as matter (it can change conservatively) but it is nothing in particular.

9. Utility of the energeum concept for physics

The existence of energeum is suggested (so far) only by analogies and extrapolations, and not by empirical evidence as such. However, it does not have to be directly observed for its existence to be inferred with a high level of confidence. In general we believe in unseen phenomena (such as quarks) because of the explanatory or predictive value they have for theories that utilize the concepts that represent them.

One way in which the concept of energeum could have practical value is in relation to the so-called "dark energy problem". The "problem" here is that the universe is expanding at an accelerating rate, the implication being that the "amount of space" in the universe is increasing (at an accelerating rate). Because space (understood as the QV) has a constant energy density, the implication is that the amount of energy present in the astronomical universe is increasing. This violates the energy conservation principle and hence PSR. One way of salvaging energy conservation is to suppose that something else exists that has energy (but as "something else" is neither space nor physical matter), and this "something else" is being converted into space (QV) at an accelerating rate. Energeum fits the bill nicely – if energeum existed it could be converted into QV without violating energy conservation (and hence PSR), since the total energy would then be a constant. If we are committed to PSR the "dark energy" phenomenon can therefore be taken as direct evidence for the existence of energeum. Absent postulating energeum dark energy is not only unexplained but violates the energy conservation principle. On this basis we suggest that energeum does exist.

10. Broader potential of the energeum concept

The energeum concept may have wider utility than as a route to explaining the dark energy puzzle.

As background, consider that the only requirements on energeum were that:

a. It has net energy "on average" (so it actually exists as a concrete thing),
b. It "normally" oscillates between all the possible properties it could have fast enough that it appears to have no properties at all, and
c. This fluxing can be stabilized under certain conditions, so that (for some time) it can manifest as some particular thing, depending on the properties that have been stabilized. Such a situation may arise on statistical grounds.

We cannot be sure as yet that we have correctly inventoried all the kinds of fundamental properties that might exist, but in principle whatever kinds practically exist will be present in the energetic flux of energeum. As yet undiscovered properties might enable the instantiation of more classes of properties than just spatial and physical ones. We suspect that such novel properties exist because some theorists (e.g. David Chalmers) have suggested that the properties of consciousness cannot be accounted for in physicalistic or topological terms, and that something else has to be present in the foundational nature of matter to support the 'special' properties that consciousness can have e.g. awareness, subjectivity, qualia, emotions, will, rationality, and values (Chalmers, 1995, p. 210). These properties have a quality called "intentionality", sometimes paraphrased as "aboutness", e.g. a desire is always *for something*. This inherently referring aspect is absent from spatial and physical properties (e.g. shape or charge), and so cannot be emergent from them in an understandable way. If we adhere to PSR this suggests that these 'consciousness-related' (or better, "psychonic") properties must derive from primitive properties of fundamental matter. Nothing in the conceptualization of energeum above precludes it from fulfilling such a role. In this case, energeum would have additional properties that can be stabilized to instantiate things that have psychonic properties. Perhaps we can, by analogy, call a substance in which psychonic properties have been stabilized "psychonium".

It is unclear whether something that has psychonic properties would necessarily have physical and spatial properties as well. However it can be foreseen that the logically possible variants would have different explanatory potentials.

In general, the energeum postulate may therefore be useful in that it provides a way of having a universe in which things can have spatial and/or physical and/or psychonic properties without there being a plurality of fundamental substances (such as in the dualism of Descartes). Instead, we have a kind of neutral monism in which we can contingently have substances that appear distinct but are in fact all within a single family of substances: the distinction between them would be empirical but not ontological, and they can all naturally interact with each other, and could even interconvert.

11. Concluding remarks

In this essay we have defended the Principle of Sufficient Reason (PSR), which encapsulates the conviction the world is in principle understandable. We did this on the basis of empirically supported philosophical insights from Systems Philosophy, and concluded that it is reasonable to continue to assume that there are, in principle, "ultimate reasons" for the existence of every thing and event.

We showed that our best model of reality is broadly consistent with the requirements for PSR type explanations, but queried whether this model is correct in positioning the quantum vacuum (QV) as the most fundamental stuff that exists in Nature. On the basis of PSR and its entailments we argued that there is a more fundamental "ultimate substance", which we dubbed "energeum", and whose minimal features we could characterise to some extent. In order to do this we had to develop a new conception of the notion of "having properties" that is inherently dynamic and conditional.

We pointed out that the dark energy phenomenon implies a violation of the energy conservation principle on a cosmological scale, and argued that postulating energeum opens up a way to resolve this conundrum in a way that complies with energy conservation.

The inherent nature of energeum makes it a candidate for a kind of "neutral monist" ultimate substance that might support the emergence not only of spatial and physical substances but also ones with psychonic properties. It therefore has the potential to bring Consciousness Studies into science in ways that are compatible with the notions of energy and the conservation of energy.

Postulating energeum as a substance that is concrete but is ordinarily 'nothing in particular' brings us a step closer to solving the Parmenides Dilemma, in that the properties of energeum are logically necessary from the standpoint of how explanations work, and it could thus be an originating substance from which the world could arise in a way that complies with PSR. However, we have created a dilemma of our own, since we have postulated a new kind of 'nothing', and now that we know about it *its* origin stands in need of an explanation.

We believe that by introducing the concept of energeum we have opened up new ways of thinking about the fundamental nature of the world and how things have arisen in Nature, and by defending PSR we have reinforced the conviction that Nature can be understood through the combination of the methods of science and philosophy, guided by the unifying structure provided by Systems Philosophy.

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