What Can It Mean to Ask, Why Is There Something Rather Than Nothing?[†]

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March 15, 2019

> Nu, even if there were nothing, you wouldn't be satisfied.
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> — Sidney Morgenbesser[‡]

> A metaphysician: one who will argue (and believe) that the claim "nothing is something" is meaningful and true, but "something is nothing" is not.
>
> — aphorism

ABSTRACT

The bald question, Why is there something rather than nothing?, is hopelessly ambiguous. One needs explicative disambiguation to render it amenable to philosophical attack. If one wants to do so in such a way that an appropriate answer must be grounded, at least in part, on scientific knowledge, then one comes to realize that one needs first to understand what one can mean by "nothing" in the context of our best physical theories. I argue that to do so requires deep and comprehensive modifications to any traditional account of the idea of "nothing".

[†] This manuscript was prepared for presentation at the symposium "Understanding Our Place in the Universe: Beyond the Legacy of Stephen Hawking" organized by the John Templeton Foundation, Mishkenot Sha'ananim Conference Center, Jerusalem, 17–19 March 2019.

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‡. In response to the question, "Why is there something rather than nothing?"; reported to me by David Malament.

Contents

1 Physics, Metaphysics, and the Question Itself

I was asked to address the question, why is there something rather than nothing? I must begin, therefore, by defending my intent to address what I see as a prior question, the one posed in this paper's title. I believe that the thematic question on its own—a deeper and more fundamental question than the one I aim to address—baldly considered, is ambiguous to the point of vacuity. To attack it directly has little, if any, hope of success. Any arguments concerning the fundamental question, therefore, must first get straight on what the question itself *can* mean, and, moreover, any subsequent arguments concerning it must have a corresponding modesty, both in assumptions and in proposed scope. It can be clarified and given concrete and substantive enough content to admit of attack only after explicative discussion of the kind I aim at here. One may therefore consider this paper as a propædeutic to an attempt to address the deeper question. (A note on terminology: from hereon when I speak of "the question", I mean the titular question I aim to address; when I speak of "the deeper question" or "the more fundamental question", I mean the thematic one for this session.)

I do not think that pure metaphysics, divorced from the input of our best scientific knowledge, can be a sound guide to answering the fundamental question, nor that it can even suffice for addressing the titular question. The idea of a necessarily existent being, for example, cannot be taken seriously, for we have no grounds for thinking that the world must respect what we view as "conceptual necessities", no matter how strong an argument to that effect looks on its face—there is no necessity out (of an argument) without necessity (having been put) in (to start with)—of necessity (!). Pure metaphysics, in the end, can give us nothing *but* arguments based on intuitions and "conceptual necessities", and that will not do for a question whose answer must at least in part be informed by the fact that something *does* exist, and what our knowledge of that something is. The best source of that knowledge, so far as the physical world goes, is physics, and so it is to our best physical theories that I will look for ways to begin to address the question. (I say more about my view of alleged "conceptual necessities" in my concluding remarks in §5.)

Before continuing, I feel I must make a remark about theology. I do not intend anything I say about metaphysics to bear on the issue of whether theology can provide knowledge of some form or can otherwise warrant belief. I do believe there are different forms of knowledge, not all scientific in content; correlatively, I do not think that all sound kinds of belief can be warranted only by scientific, or more broadly empirical, forms of investigation. If theology can provide knowledge or warrant belief—and I am too much a mitigated, unremitting skeptic to declare that it cannot—it will, I suspect, be of a kind so radically different from the scientific as to make fruitful contact between them difficult to bring about. That does not mean I think that the two cannot have a fruitful dialogue in which each may learn something of value, and even be inspired by, the other, only that I find it difficult to see how knowledge and understanding derived from either can be *grounded* in knowledge or understanding derived from the other. If there is a divine entity responsible for the creation of the universe, then either that act of creation is treatable by physical theory or not. If not, there is no more to say. If so, it seems plausible that the divine entity itself will not be representable in the formalism of the theory, only the process of creation itself, so, once again, it would seem that the physics would make no substantive contact with the *theological* facts. I therefore put theology aside for my purposes here.[1]

I first consider attempts to answer the question that look as though they may be trying to make substantive contact with physics, but in fact do not. A good example of this is van Inwagen (1996), in which he tackles exactly the fundamental question. He cloaks his arguments with formal and technical machinery and references to scientific knowledge of the world, that may all make it seem on first glance that he is attempting to address the question, at least in part, by engaging with real science in a substantive way. (For instance, he attempts to defend his use of what is essentially the principle of indifference for assigning probabilities by relying on a thought experiment based on the evaporation of black holes by the emission of Hawking radiation.) The appearance is illusory. He has no control over the technical machinery (the calculus of probabilities), and his references to science are glib, at best, and show no sign that he has understood anything of significance to the question.

Without injustice, one may sum up his argument as follows. There is one way for there to be nothing, but illimitable ways for there to be something. Given our epistemic state *vis-à-vis* the fundamental question, in particular our ignorance of whatever underlying, fundamental matters that may determine the existence of something, we ought to distribute our prior judgements of probability for each of those states of affair more or less equally. It follows that there is essentially zero probability for there to have been nothing.

There are two basic problems with the argument, one involving his use of probability in framing the question, and the other involving the representation of different ways there can be something, which in turn bears on the application of the calculus of probability to the question. I start with the first. With very little effort beyond vague gestures at what he calls the maximality and simplicity of possible physical systems, he gives no justification for assigning probabilities based on cardinality. There are well known cases in physics, however, where cardinality arguments will demonstrably give the wrong answer to the question of how to distribute probabilities over a family of possibilities. Perhaps the most well known case is the selection of a probability distribution for a system composed of a large number of discrete entities, as treated in the context of statistical mechanics. The cardinality of the set of non-equilibrium micro-states in the system's phase space is the same as that of the equilibrium micro-states, but one could hardly go more wrong than to assign the probability distribution over phase space so as to respect that fact. We know that

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[1] 1. Perhaps I have too limited a view of theology in particular, or religion in general. I would be happy to be convinced otherwise.

Lebesgue measure on the phase space of a statistical system is the right measure, not one based on cardinality, because of empirical evidence we have gathered supporting its use—because of controlled observation and experimentation on such systems. There is no *a priori* argument that Lebesgue measurement is the right one. Likewise, no *a priori* argument, divorced from scientific knowledge grounded in contact with empirical data, can determine an appropriate probability measure over *any* family of physical events. Without empirical knowledge of those systems to guide one's arguments, one can rely only on intuition or conceptual necessities.[2]

In any event, in probability one standardly represents the appropriate notion of the "size" of a class of events by the use of the mathematical structure known as a measure, even if that measure is to be determined by considerations of cardinality. This leads directly to the second problem with Inwagen's arguments. If one want to define an appropriate space of states representing all the ways that there can be something, in the sense of the entirety of a possible world, and one wants to do so in a way that conforms to our best current scientific understanding of the world *in toto*, all with the aim of assigning a probability distribution over the state space, then one should use the resources of our best theory for representing entire worlds, *viz.*, the spacetimes of general relativity.[3] Now, however, one runs immediately into what seems *prima facie* to be an insuperable obstacle: it is a theorem that there can be no appropriate, non-trivial Borel measure at all, much less a probability measure, on any non-trivial family of relativistic spacetimes (Curiel 2017). Thus, if one wants to speak of probability at all in this context, one will need some framework other than standard measure theory and the Kolmogorov axioms to do it. Inwagen's arguments are not so much wrong, therefore, as not even well posed.[4]

Both problems have their ground in the fact that the metaphysician has paid no heed to the way that concepts and tools such as probability find their warrant for application in the enterprise of science. That warrant can be had only by arguments based at least in part on evidence we have gathered about the relevant kinds of physical systems through the use of controlled observation and experimentation, which itself is predicated on the fact that there is indeed "something" to observe and experiment on, evidence that legitimizes the use of such tools through the demonstration that their application has been successful. I do not know what to make of the demand that we can meaningfully apply a tool like probability in the absence of any considerations whose warrant comes from the fruitful application of the tool in the practice of physics as it studies something.

I take the final lesson to be clear: if one wants to argue in favor of a particular way to address the fundamental question, and that way has the ambition of making substantive contact with scientific

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[2] Norton (2011, p. 410) criticizes this aspect of Inwagen's argument on interestingly different grounds, based on Norton's analysis of the way to properly represent a state of total ignorance in a probabilistic setting. In particular, Norton claims that Inwagen commits what he refers to as the inductive disjunctive fallacy. Yet another problem with Inwagen's attempt to use probabilities is that he never explains what a probability can mean in the context of a single event—the coming-to-be of the world in its entirety—that is not repeatable *in principle*. I put that aside.

[3] To require the resources of quantum theory as well would only add unnecessary technical details and conceptual intricacies with no concomitant gain in understanding, and would in particular not lessen the force of my criticism. I therefore put all such considerations aside.

[4] Inwagen published his paper in 1996, and so could not have known of the particular result I cite from Curiel (2017). Nonetheless, the problem the result addresses—the so-called measure problem in cosmology, to find an appropriate probability distribution on a non-trivial family of spacetimes—was well known, much discussed, and, most importantly, recognized as difficult and deep, going back at least to the early 1970s. If Inwagen had bothered to ask any practicing cosmologist at the time, he would have gotten an earful.

knowledge by use of sophisticated technical machinery, then one must take great care to ensure that one is in fact making real contact with science in the sense that one's use of the machinery conforms with its use in science, not merely giving the illusion that one has made such contact. One must, correlatively, have reason for confidence that one's use of the technical machinery is under control.

That lesson, however, leaves open the issue of what it may mean for a philosophical investigation to make substantive contact with scientific knowledge. In the sense relevant to my purposes here, I think that a large part of such contact must be mediated by the theories we use in physics to regiment and encapsulate our knowledge. Otherwise that knowledge cannot be made available in a form usable by philosophical argumentation. The concepts and structures that philosophy will use need not be tied to their articulation in a particular, fully fledged theory (such as general relativity). One does need, at the least, however, what one may think of as a "scientifically pre-theoretic notion", *i.e.*, a concept one has reason to believe one can articulate, explicate, and regiment in the context of a theory, and so be placed into unambiguous relation with other such concepts. Indeed, it is such scientifically pre-theoretic notions that allow fully fledged theories such as general relativity and quantum field theory to be brought into mutually fruitful relation with each other. There is, for instance, a pre-theoretic notion of stress-energy that gets explicated in precise ways in each of those two theories, and the *a posteriori* identification of those two explications grounds the formulation of a new theory, quantum field theory on curved spacetime. In the current investigation, therefore, it behooves us to look to our best current theories for their respective explications of "something" and "nothing", what they can mean in the context of a theory on its own, and how one can try to understand the relations among them as represented in different theories.

2 Something and Nothing

Before beginning the arguments of the paper proper, I will briefly discuss what I mean by "something" in the scientifically pre-theoretic sense. I neither promise nor threaten you with a detailed analysis and account. A crude sketch, drawn with the broadest of brushes, whose import can be somewhat illuminated by examples, will have to suffice. For the purposes of this paper, I take "something" to mean "something physical", as opposed to "abstract". I do not know how to define either 'physical' or 'abstract' in satisfying and non-circular ways, so I'll take them as primitives. In any event, the physical includes (at least) what is treated by empirically grounded physics. I exclude what is purportedly treated by speculative, potential physics that has not yet made contact with experiment, such as string theory. I take it to be unproblematic that this idea of the physical encompasses the objects we deal with in ordinary life, not only carefully prepared and controlled systems in the context of experimentation, nor only systems (such as distant galaxies) that we cannot prepare or control but that are nonetheless subject to rigorous scientific observation. The abstract includes, *inter alia*, numbers (and mathematical entities more generally), concepts and universals (depending on one's views on this), counterfactual situations ("possible worlds"), and so on. One mark of the abstract is that it cannot, in principle, causally bear on indubitable instances of the physical, no matter how ecumenical one is in elucidating the idea of "causally bearing on".[5]

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[5] There is also the problem of "physical laws"—the Einstein field equation, the principle of energy conservation, the Second Law of thermodynamics, ... Are they "something"? I am going to punt on that question. I do not feel

In mathematics, at least, I take it that there is a strong candidate for the definition and representation of nothing: the empty set, in some suitable axiomatization of set theory. The empty set is itself something, but it contains no elements, which is to say, its contents are nothing. Something, then, is everything else beyond the empty set treated in the axiomatic system, endowed with an appropriate semantics. One can then perhaps answer the fundamental question by pointing to the fact that the given axiomatization requires the empty set for consistency—something is needed for the very representation of nothing. More precisely, following this route, one would not so much answer the fundamental question as reject it: there is both something and nothing in this context, necessarily so (in a thin, logical sense), and this is what I mean by both.

My brief sketch of what I want to count as something, however, in the sense relevant to my purposes here, still leaves much ambiguity. One can, I think, reasonably question whether the proposed thermodynamical behavior of black holes, for example, counts as "physical" on my understanding, since it is treated by a framework—quantum field theory on curved spacetime (or semi-classical gravity more generally)—that has not made, and perhaps never will make, contact with experiment or even merely careful observation. I still want to treat such theoretically characterized phenomena as physical, on the basis that they are treated by a combination of theories—general relativity and quantum field theory—each of which is empirically well grounded, even though their combination has not been guided by the constraint of empirical data, but rather by pure theorizing constrained only by physical intuition. We thus have some reason, based on indirect contact with experiment, to believe in Hawking radiation (say). In so far as programs in quantum gravity such as string theory have not made even indirect contact with experiment, I consider the entities they purport to treat as abstract.

In the end, I trust that what I am gesturing at is adequately clear for my purposes. There may be difficult cases that can be adjudicated only by detailed examination of their particulars. How one settles such cases, however, will not bear on my arguments.

3 Existence in Physics Is Said in Many Ways

> [I]t has become the custom in physics ... of being liberal in bestowing "existence." ¶ Are [spacetime points] real? What are they really like? These questions are dealt with (more accurately, avoided) by means of ... custom. Physics does not, at least in my opinion, deal with what is "real" or with what something is "really like." The reason, I suppose, is some combination of (1) One does not know how to effectively attack such questions. (2) One does not know what sort of thing would represent an answer. (3) These questions are too hard.
>
> Robert Geroch
> *General Relativity from A to B*

The first fact that strikes the canny investigator when contemplating our physical theories is the richness of variegation both in the types of structure the theories employ and in the roles

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as though I have a good enough grip on the idea of a "law" to say anything sensible about it right now.

those structures play in our representation of physical systems. Even those structural entities in our theories that seem directly to represent physical things—something!—turn out, on closer examination, to suggest quite different meanings for the sense in which the purportedly represented things exist.

Consider the question, do spacetime points and electrons exist? On a naive reading of the mathematics of standard presentations of the theory of general relativity, points of the spacetime manifold appear to have concrete existence, if anything in the theory does—they are the entities with respect to which metric structure is defined, the bearer of field values, and so on. Likewise for electrons in (say) standard presentations of quantum electrodynamics. In so far as one thinks that both theories are latching on to the physical world in deep and substantive ways—and I believe we ought to think they do—it seems one is committed to saying that both spacetime points and electrons exist in a straightforward sense as physical entities, or at least something very much like them, if not exactly as the theories portray them. An implicit assumption in arriving at this conclusion is that the sense of existence at issue is uncontroversial, or, at any rate, is the same in both cases. Quine, after all, has taught us that we need no more in such investigations, and should in fact be content with no more, than the thinnest logical notion of existence: to be is to be the possible value of a bound variable. Fix one's formal system, fix an appropriate semantics for it, and then "to exist" just means "to be part of the domain over which one's quantified variables range".

Closer consideration of the issue, however, leads one to doubt the naive judgement, or at least that part of it conveyed by the idea that the sense of existence at issue is both straightforward and the same in both cases. There are three definite, clear, related senses in which spacetime points are not physical entities in the way that electrons are:

1. no other manifestly physical system couples to spacetime points as the electromagnetic field couples to electrons (spacetime points don't "interact" with other physical systems);
2. spacetime points have no distinguished class of physical quantities associated with them, as electrons have mass, charge, spin, position, momentum, and so on;
3. and spacetime points obey no set of equations of motion or field equations.

In quantum electrodynamics, each electron bears a set of fixed kinematic quantities, the same for all electrons, including mass, charge, absolute value of spin, and magnetic moment (and, depending on one's sophistication, lepton number, weak isospin charge, *et al.*). Electrons as represented by the theory have as well a shared, fixed set of dynamic quantities: position, momentum, angular momentum, spin orientation, energy, *et al.* Finally, their dynamical behavior is governed, everywhere and always (so far as we know), by a fixed equation of motion, the Dirac equation. One cannot attribute shear viscosity (say) to an electron—its equations of motion are not appropriate for the representation of the electron as bearing such a physical quantity.

In general relativity, to the contrary, one can "attribute" *any* physical quantity to a spacetime point, be it shear viscosity or charge or what-have-you. The spacetime point itself does not bear the physical quantity in any physically significant way, at least not in the way that electrons bear mass. A spacetime point can be occupied by a viscous fluid or by an electron promiscuously, so we can paste any old physical quantity onto it. Correlatively, there are no equations of motion for a spacetime point: spacetime points evince no "behavior". This is why electrons have a distinguished set of physical couplings (*e.g.*, via charge) with a distinguished set of other physical systems (*inter alia*, Maxwell fields), whereas spacetime points do not. That, to my mind, is one of the very marks of a physical system in something like the standard sense of the term (if there is one): that it have a definite number and type of possible couplings it can enter into with other physical systems based on the kinematic quantities one can sensibly attribute to it and the equations of motion those couplings obey. So far as "existence" goes, the difference between spacetime points and electrons could not be more complete.

Still, at least electrons exist in a univocal way, right? We can, surely, give canonical significance to the question "do electrons exist?" independent of theory or investigative context. I do not believe so. Think of the different contexts in which the concept of an electron may come into play, and the natural ways in those contexts one may want to attribute existence (or not) to electrons. A small sample:

- as a component in a quantum, non-relativistic model of the Hydrogen atom;
- as an element in the relativistic explanation of the Lamb shift;
- as a measuring device in the observation of quark structure from deep inelastic scattering of electrons off protons, as treated by the Standard Model;
- as a possible "constituent" of Hawking radiation in an analysis of its spectrum.

We attribute existence to the electron in each context for different reasons, and that mode of existence is correlatively different:

Hydrogen atom its associated quantities enter into the initial-value formulation of the system's equations of motion for free evolution, as part of the system itself;

Lamb shift as the bearer of definite values for the kinematic Casimir invariants of spin and mass, as well as the conserved quantity electric charge, it couples with vacuum fluctuations of the quantum Maxwell field and so plays the role of background structure with respect to the observed photons;

quark scattering it is the locus of charge, spin and lepton number (*inter alia*) associated with the mass-energy resonance representing it, used to identify it by further measuring devices after scattering;

Hawking radiation there is no good definition of an electron in quantum field theory on generic curved spacetimes, only non-localized excited modes of the Dirac field.

The lesson generalizes. There are many reasons and ways to think something described, postulated or otherwise relied on by a theory may exist or "be physical":

- it possesses mass-energy (*e.g.*, the Maxwell field);
- it is required for the initial-value formulation of manifestly physical fields (*e.g.*, the Maxwell field, the metric, the affine connection);
- it dynamically couples to manifestly physical entities (*e.g.*, the Maxwell field, electric charge, gravitational radiation);

- it dynamically couples to manifestly physical quantities that more than one type of physical system can bear (*e.g.*, the Einstein tensor);
- it acts as a measure of an observable aspect of the behavior of manifestly physical entities (*e.g.*, the Riemann curvature);
- it enters, in an ineliminable way, the field equation or equation of motion of a manifestly physical structure (*e.g.*, the metric, the Einstein tensor, entropy);
- it constrains the behavior of a manifestly physical entity (*e.g.*, entropy, metric symmetries, global light-cone structure);
- it plays an ineliminable (albeit physically obscure) role in the mathematical structure required to formulate the theory (*e.g.*, spacetime points).

This list is not meant to be exhaustive. Even so, it is already the case that no quantity, entity, or structure I know, in any physical theory, related to any physical system, plays all those roles. Because of this variety, I prefer to speak of why it is that we think the various entities postulated or treated by our best physical theories are physical, and in what that physicality consists, rather than to ask whether they exist or not *simpliciter*. Physics seems to be trying to tell us that we need a more sophisticated and finely grained analysis of what it may mean for something to exist. To paraphrase Aristotle, 'existence', if said at all in physics, is said in many ways.

You can beat your fists on the table and vigorously demand, "No, I just mean *exist*! I don't need *criteria* for what I mean by that!"—and I will tip my hat and bid you "good day", because we have nothing more to talk about. A concept or idea that cannot be discussed, argued about, analyzed, whose relations to other concepts cannot be teased apart and probed, whose possibly different uses in different contexts one cannot attempt to explicate—and thus for which some criteria or principles must up be for grabs—has no place in serious intellectual work.

Still, my abrupt dismissal of the naive metaphysician perhaps calls for a few more justificatory remarks, particularly on the logic of 'to exist'. One may want to object that I am conflating two questions:

1. whether there are different ways for things to exist (and different reasons for believing something exists);
2. as opposed to whether the intended meaning of 'exists' is still determinate and fixed uniquely.

Strictly speaking, a positive answer to the first question does not entail a negative answer to the second question. One could still follow Quine, and say that the meaning of 'exists' is a "thin" logical one, as given, *e.g.*, by the logical and semantic rules for the existential quantifier, one and the same for all the different "modes" of existence indicated by my list of criteria for the attribution of physicality.

One who wants to push back against my line of thought in this way, however, faces the serious problem that, strictly speaking, there is no term in the formalism of any theory of the electron we have (the theory of classical Maxwell fields and charged particles, quantum electrodynamics, and so on) that denotes electrons (neither the concept nor individuals falling under it). There are only terms that denote physical quantities we think of as being borne by the electron, such as mass, charge, spin, parity, lepton number, and so on. In the Dirac equation, one does have a variable representing the Dirac field, to be sure, but that is not a representation of the electron; the electron, rather, is a manifestation of an excited mode of that field. The creation operator, for instance, acting on the Dirac field, produces a mode with determinate energy and momentum observables; the product of its action is not a variable that directly "represents an electron".

One natural way to interpret this state of affairs is that, in such theories, "electron" is a concept constructed out of the basic concepts of the theory (*viz.*, the physical quantities). *One does not quantify over electrons in the formalism of any theory.* One has to extend the formalism, constructing a new one with its own logical connectives, quantifiers, variables, logical and semantic rules, and so on. I do not know, however, how to compare the meanings of existential quantifiers in two different formal systems—in the constructed system, one quantifies over what had been predicates in the original system, so it is not obvious that the quantifiers "mean the same thing" in the two systems. Thus, I do not know how to decide whether 'exists' means the same thing in the two systems.

In any event, if *everything* exists in the thin, Quinean sense, and thus all in the same way, then to say something exists is to have said nothing at all. It has no physical content. This all becomes even more poignant when one reflects on the fact that, on the Quinean picture, one will end up attributing existence to structures such as the fixing of gauge, since that involves quantification, or the center of momentum of a system of particles. It is not a viable option, however, to believe that the Coulomb gauge and the Lorenz gauge in Maxwell theory both exist, or the center of mass of the Solar System, in any way similar to the way we think the Maxwell field and the Sun exist.

These remarks point to another relevant fact about the way that physical theories represent entities, and in particular about the logical roles played by purportedly designating terms that do appear in a theory's formalism: generally speaking, in field theories (as opposed to theories of classical mechanics), quantities appearing in the field equations can have manifestly different ontological import. In Maxwell's equations, the terms denoting electric charge and current represent quantities borne by a physical system; the terms denoting the electric and magnetic fields represent a physical system itself, the Maxwell field, not quantities that it bears. In other words, the field terms play the role of "substrate" or "substance" or "subject", and all other terms play the role of "property", "attribute", or "predicate". One can make this idea precise. If I know only the value of the electric charge of a system, I cannot tell you what kind of system it is, much less the values of its other quantities. If I know the values of the electric and magnetic fields, not only do I (trivially) know what kind of system it is, I also can calculate the values of all other quantities borne by it (energy, momentum, angular momentum, polarization, *etc.*). The value of none of those other quantities, however, uniquely determines the state of the Maxwell field, much less that the system at issue *is* a Maxwell field.

It is a deep and, so far as I know, completely unexplored question why field theories have this character, while theories of classical mechanics—particle mechanics, fluid mechanics, the mechanics of elastic media—do not. In all theories of classical mechanics, no quantity plays the role of "substance" in the way the Maxwell field does in Maxwell theory.[6]

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[6] There is another deep and interesting question lurking in the background here: the difference between a representation of the world in which there is no Maxwell field (say) and one in which there is a Maxwell field but it vanishes everywhere (*i.e.*, its value is everywhere zero). I take it that science can address only the latter sort of claim. The former fall under the rubric of what Carnap (1956) called "external questions". It would take us too far

To return to the main line of my argument, it is time to connect the discussion of the different senses of existence—or physicality—at play in physics with the question I am intending to address. Once one recognizes these different senses, routes to addressing the question particularized to each one begin to suggest themselves more or less naturally. What does a reason why something like the metric in general relativity exists look like? Any satisfying answer to that question will, at least in part, I suggest, invoke at least two facts: it is required for the initial-value formulation of manifestly physical fields; and correlatively it plays an ineliminable role in the formulation of the equations of motion and field equations of other manifestly physical systems. Indeed, one may take those two facts to provide an answer to the fundamental question itself, narrowed down from "something" to "the metric". Why does the metric exist? Because other physical systems do whose dynamical evolutions depend on it.

4 What Our Best Theories Have to Say

In our current fundamental physical theories, general relativity and the Standard Model of quantum field theory, the best candidate for a representation of "nothing" is the vacuum. The fundamental question in this context therefore becomes: why is the world not the vacuum?[7] In the end, as I shall argue, the vacuum, in both general relativity and quantum field theory, is not nothing in any traditional sense. The upshot is that our best contemporary theories cannot explicate, much less answer, anything like the fundamental question as one naturally wants to try to construe it.[8]

What our best theories can rather do is articulate the closest conceptions of nothing (as traditionally conceived) each makes available. One can then attempt to ask the question, why is there not nothing in the sense available in each of our theories? One may balk at this as a cheat. I see it rather as a succesful instance of one of the most urgent tasks philosophers can undertake: the revision of old concepts and ideas, and the questions formulated in their terms, so as to accord with our best current knowledge. Sometimes, as in this case, the traditional concept is rejected, to be replaced by a subtler and deeper one, or set of them. I count this as a victory for the understanding. (I discuss this role of philosophy in §5, in my concluding remarks.)

Although we honor its name with the definite article, as we shall see the idea of the vacuum in each theory is complex and multifarious, with different aspects each of which finds the question of its existence most readily addressed by application of some but not others of the different criteria for physicality I sketched in §3. To the bald question, Why is there a world *simpliciter* at all?, I

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afield to discuss this further, however.

[7] Note that this is not the same as asking whether or not we can *determine* by empirical means whether or not the world is in an appropriate vacuum state. See, *e.g.*, Albert (1988) for an interesting discussion of that question.

[8] Lawrence Krauss, a cosmologist, published a book (Krauss 2012) in which he argues that there is something (the physical world with its full complement of material things as we see them) rather than nothing—the vacuum as represented by quantum field theory—because the relevant vacuum state is unstable. This argument completely misses the point that the vacuum state of a quantum field is not nothing in the sense that philosophers and theologians care about, but is rather itself a fully fledged something. Albert (2012), in his review of the book, roundly criticizes Krauss for related—and unrelated but delightfully and illuminatingly abusive—reasons, in his inimitable way. I am in complete accord with Albert's criticisms. I cannot strongly enough urge the reader to read this brief review, even if he or she has not read Krauss. I also recommend Weatherall (2016), which includes insightful discussion of these issues—in the context of both general relativity and quantum field theory—in a way I am deeply sympathetic to, and whose conclusions share a great deal of commonality with my own.

do not think physics can say anything useful at all.

Due to time constraints—to get this paper to the other participants of the workshop in a timely manner—the remainder of this section consists only of the barest of outlines. I hope that the discussion of the previous section will readily suggest how the details, as I will present them in my talk, will go.

general relativity

1. g_{ab} is special: it is the only field representable in the framework of general relativity that is not allowed to take the value 0 ("$\nabla_a = 0$" makes no mathematical sense, as ∇_a is an affine object; one can set Christoffel symbols to 0, but that has no physical significance, since they are coordinate-dependent entities)
2. the best candidate for "nothing" is a vacuum spacetime, *i.e.*, one in which the stress-energy tensor vanishes
3. the difference between matter (as ordinarily conceived) and vacuum is just the difference between Ricci and Weyl curvature
4. there are uncountably many vacuum spacetimes in general relativity (as there are uncountably many possible values for a Riemann tensor consisting solely of Weyl curvature), so "nothing" is not a single thing (as, *e.g.*, van Inwagen 1996 would have it)
5. the metric has physicality in several ways, as discussed in §3, but none in the way that, *e.g.*, the Maxwell field does
6. curvature as a generic phenomenon has energetic quantities associated with it, else we could not extract energy by exploiting geodesic deviation, but it is not localizable in any well defined sense, as shown by the fact that it has no associated stress-energy tensor
7. gravitational radiation in particular indubitably carries energetic quantities, else we could not detect it with LIGO, but, again, it has no stress-energy tensor
8. singularities (incomplete, inexendible curves) have physicality in several senses, but the inextendibility of the curve itself—the manifestation of singular behavior—is not localizable
9. the event horizon of a black hole, as standardly defined, is not localizable, and is not even a locally distinguished surface in spacetime in any way
10. global structures in general, such as topological features, causal structure, and so on, are not localizable and in many cases, strictly speaking, not even determinable by any finite set of observations

quantum field theory

1. the best candidate for "nothing" is the vacuum state of a quantum field
2. there are different plausible, even compelling ways of characterizing the idea of a vacuum state—*e.g.*, a state of lowest possible energy, a state with zero particle number, and so on—none of which agree with each other in all contexts, under all conditions
3. no matter how one characterizes it, a vacuum state in quantum field theory is a richly textured place populated by a lively crowd of highly correlated fluctuations

4. the representation of those fluctuations require a great deal of background structure (a spacetime metric, an algebra of observables, and so on), each of which has physicality in different ways
5. those correlated fluctuations themselves manifest physicality in many different ways

semi-classical gravity

1. Hawking radiation—surely something—arises from the transformation of one nothing (the vacuum state of a quantum field) into another (changes in the vacuum structure of the event horizon of a black hole)
2. black hole entropy also is associated with nothing, being an attribute of the (vacuum) event horizon

One fascinating problem that this discussion naturally leads to is the relation between the concepts and representations of "nothing" in different theories. What counts as nothing in quantum field theory does not do so in general relativity, as shown by the formulation of the semi-classical Einstein field equation: the vacuum state of a quantum field in a generic curved spacetime has a non-zero expectation value for its associated stress-energy tensor operator. When general relativity looks at the vacuum state of a quantum field, it sees something. Quantum field theory does not admit a representation of nothing in the sense that general relativity suggests.

5 Envoi

One may complain that I have cheated in my discussion, by changing the question. I see the situation rather as one in which we have learned something deep about the world: we have discovered that, in the end, it is likely that we will never have a definitive answer to the fundamental question, even when reconceived so as to accord with the knowledge and understanding we have gained from the progress of science and philosophy. That is not the nature of such questions.

One of the greatest physicists (and philosophers!) of all time, James Clerk Maxwell, spelled out quite clearly what I see as the role and value of such questions in the enterprise of expanding our knowledge and understanding of the world (Maxwell 1875):

> [W]e must bear in mind that the scientific or science-producing value of the efforts made to answer these old standing questions is not to be measured by the prospect they afford us of ultimately obtaining a solution, but by their effect in stimulating men to a thorough investigation of nature. To propose a scientific question presupposes scientific knowledge, and the questions which exercise men's minds in the present state of science may very likely be such that a little more knowledge would shew us that no answer is possible. The scientific value of the question, How do bodies act on one another at a distance? is to be found in the stimulus it has given to investigations into the properties of the intervening medium.

Likewise, the scientific value of the question, Why is there something rather than nothing?, is to be found in the stimulus it has given to investigations into the nature of concrete physical systems such as the vacuum, and also into the nature of how it is that our scientific representations of physical systems reach out and latch onto the physical world in a substantive way. It has pushed us to transform our concept of "nothing" in ways that are profoundly fruitful.

It is perhaps not a popular view that philosophy can make real progress, but it is one I hold and strongly advocate in favor of. What may count as progress, of course, depends on what one thinks philosophy is, and what it's supposed to do. One common measure of progress in an intellectual field is collective convergence to the truth. I cannot accept this, as I do not think we ever achieve truth in philosophy. For me, philosophy is not a form of knowledge (ἐπιστήμη), and so it does not aim at or converge on truth. Rather, at its best it yields deeper understanding characterized by fruitfulness of conception and application (σοφία and νοῦς).

There are two important kinds of progress I think we can, and do, make in philosophy: positive and negative. On the positive side, one very important form of progress occurs when we realize that what we had taken as a necessary idea or relation among ideas in thought is not necessary after all, and so, in particular, need not reflect anything that holds of necessity in the world. In giving up old "necessities" of thought, we open our mind to new conceptual possibilities. We free ourselves to look in new directions, to ask new questions and new forms of questions, and so to give new forms of answers. A good example: Newton's rejection of the necessity of the then reigning "mechanical philosophy" in his derivation of universal gravitation. This was progress both in method, in so far as Newton discovered and employed a new method of reasoning in natural philosophy (rejecting the hypothetico-deductive method that went hand in hand with the mechanical philosophy), and in content or substance, in so far as he rejected the contemporary belief that progress in natural philosophy could come only from conceiving all interactions among physical systems as being by immediately contiguous contact. (See Stein 1994, p. 643, on Newton's "respectful skepticism about the demands of 'the philosophy of the present day.'") If the work in this paper makes any philosophical progress, I think it is in part of this kind.

Another good example of this is the development of modern formal logic at the end of the 19th century at the hands of Frege and Peirce. The weaknesses and limitations of Aristotelian syllogistic had long been recognized before that, but it was only at that time that positive progress was made in developing a new framework, by giving up the alleged necessities (for possible forms of argument, etc.) that the Aristotelian system imposed. Think of the new philosophical possibilities that opened up with the advent of formal logic, the new kinds of argument one could make, even the new kinds of positions one could articulate. Russell's revolutionary treatment of denoting, including his analysis of its epistemological implications, is an excellent example of both.

Progress, therefore, is not measured only by the contents of conceptual space, but also in the tools—the forms of explication, reasoning, argumentation, analysis, and synthesis—that we use in applying those contents to formulate and address problems.

There is another important kind of positive progress possible in philosophy, intimately related to the first: the recognition and revelation of what we had been, unawares, assuming all along. A beautiful example of this is Helmholtz's analysis of the facts that ground the kinds of use we make of geometry in applying it to problems in physical space. Once these kinds of assumptions are clarified and explicated, they can support progress in a variety of ways—allowing one to prove new results, obtaining a deeper understanding of the conceptual structural of a subject, fostering a skeptical eye towards the prevailing philosophy of the day, and thereby providing arguments against alleged necessities.

On the negative side, progress may occur when we realize that some form of thought, some idea or relations among them, that we previously held to be of fundamental importance, perhaps even necessary, is in the event inconsistent, incoherent, or just unfruitful for the purposes at hand. We thus close off avenues leading only to dead-ends, alleys that quickly become dark and dangerous and direct our steps only to miscreants and ne'er-do-wells. A good example of this: the Aristotelian and scholastic idea of "capacities" or "potentialities" or "causal forms", which, it was realized by the time of Galileo, explained nothing. Again, this was progress both in method and in content. The development of modern formal logic can also be viewed in this light, as a negative development, for the same reasons given above. If my rejection of any traditional view of "nothing" as relevant to our understanding of the way that physics gives us understanding of the world works at all, it also marks progress of this sort.

In sum, a widening and deepening of the space of conceptual possibilities on the one hand, and a pruning and winnowing from it on the other—in short, any fruitful modification of its content and structure—must count as cognitive progress, in any field.

My views can be summed up by comparing the Sophist and the Philosopher:

The Sophist

- "I can think of no other way it can be; therefore, it must be that way." A sophistical argument.
- A sophist: one who says "it *must* be so" and thinks he means something by it.

The Philosopher

- "It may be this way. Let me play with it, explore it, to see where it may lead. That will be another possibility." A philosophical argument.
- A philosopher: one who says "this is another way it may be so" and knows she means something by it.

I want to conclude with another quotation, this from someone I consider one of the deepest philosophers of the Twentieth Century, Howard Stein, from the end of his unpublished manuscript "How Does Physics Bear Upon Metaphysics; and Why Did Plato Hold that Philosophy Cannot Be Written Down?":

> Aristotle tells us (*Posterior Analytics* I 9) that *it is hard to know whether one knows*, and (*Metaphysics* I 2, 982b12, 983a12-21) that *philosophy begins in wonder, but ends in the contrary state*. Plato never wrote the hinted-at sequel to the *Theaetetus*, *Sophist*, and *Statesman*, to have been called the *Philosopher*. I have long cherished the fantasy, anachronistic though it be, that in that work Socrates, questioning Aristotle, would have led him to admit that it is impossible to know whether one knows, and that if wisdom is the contrary state to wonder, then philosophy never ends.

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