Metaphysical Problems of Physics
Lecture 8: Possibility

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Contents

1 General Remarks and Questions

1. must one advert to non-actual (*i.e.*, *possible*) stuff in order to make sense of modal claims? if so, is that not a *petitio principii*? (one wants to ask how to make sense of modal claims; one concludes that the question itself makes sense only if possible things are in some sense real; in other words, given our linguistic and cognitive practices, it is not possible that there not be real possible things. . .)

2. everyone wants to classify different kinds of possibility: what is the basis for the urge? are there or can there be (in some sense of possibility) principled criteria for fixing differentiæ for a classification?

3. are there cogent senses of possibility *sub specie æternitatis*? or must one always fix something like an investigative context ("pragmatics, not semantics") in order to produce or find a cogent (not to mention fruitful) one?

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4. how can one control the content of modal claims?[1] must one, again, fix an investigative context to do so?

5. what roles does possibility, in any of its possible guises, play in physics?

2 Williamson's "Spaces of Possibility"

2.1 Different Kinds of Possibility

Williamson (2018) begins the essay by iterating distinctions one may make in defining kinds of possibilities:

1. epistemic versus objective:

   epistemic "concerns relevant speakers' states of knowledge": 'concerns' is vague

   objective he gives no clear or precise characterization. rather saying that

   > The distinctions between what is accidental and what is inevitable, or between what is contingent and what is necessary, concern objective modality.

   I don't want to know what "concerns" it, I want to know what it goddamn is! What he says "concerns" it, moreover, is at least as murky as "objective", if not more so—"accidental", "inevitable", "contingent", "necessary". One might have hoped an account of objective possibility would be used to explicate *those* vague notions, not vice-versa. In any event, he goes on to iterate subclasses:

   practical "highly restricted by circumstances" (very difficult to see how this does not "concern relevant speakers' states of knowledge", unless he rules out, *e.g.*, the use of artifacts and technology from events or things falling under this category—but he explicitly mentions the use of technology in stating the possibility of "touching the moon"; since he's 65 years old, it's not clear t me he could survive the rigors of a trip to the moon, so is this really possible for him anyway? or would it count to touch a moon rock brought back to Earth? one begins to see the difficulty in controlling the content of modal claims when proposed or evaluated in isolation from a real context)

   fixed past glossed only by example, "to give a sense in which it is impossible for you never to have been born" (DO NOT DO THIS IN YOUR PHILOSOPHY PAPERS—define your goddamn terms)

   variable past ditto, "a sense in which it is possible for you never to have been born"

1. Quine (1948, p. 23)

   > Take, for instance, the possible fat man in that doorway; and, again, the possible bald man in that doorway. Are they the same possible man, or two possible men? How do we decide? How many possible men are there in that doorway?

fixed laws of physics ditto, "a sense in which the actual laws could not have failed"—but it is not clear to me what counts as a "failure" of a physical law (see discussion below, §3, of "compatibility with laws"); note implicit assumption that "laws of physics" are something that in no way "concerns our state of knowledge"

variable laws ditto

nomic he finally gives something like a definition (p. 192):

> In a given situation, something is *nomically possible* if and only if it is compatible with the laws of nature in that situation.

Note the qualifier "in a given situation"—is it not applicable or relevant to the earlier types of objective possibility? We now strike a substantive problem, perhaps the first so far in the essay: what does it mean for something to be "compatible" with the laws of nature? He seems to assume this is not only a univocal concept, but a perspicuous one, requiring no explanation. I will discuss this further in §3 below.

metaphysical "most general" form, implied by every other form; it is not clear whether he endorses the postulation of such a form, stating only that "arguably" there is such a one; it is also not clear whether, if there is such a form, it is characterized in any way above and beyond being implied by all other forms—but if that is all there is to it, it is difficult to see what cognitive work it can accomplish, and if it's not all there is, then I want to hear what more there is

doxastic or subjective I think he wants to claim that there is a sense of possibility of this kind, in analogy to the probability of this kind he gestures at, but I am not sure, because he does not come right out and say it; if so, then it stands in relation to an agent's beliefs, in contrast with epistemic modality, which stands so to agent's knowledge

What is the basis for these distinctions? What are the criteria are introducing a distinction? I can find no trace of a clue for even an implicit plan. It is as though he has a few ideas that struck him, and more, struck him as clever, and so he spins them out—but, if clever at all, it is a cleverness out of any relation to fruitfulness, for there is no basis for hope that any of this correctly describes modalities as they are used in physics, much less that this analysis could be of use in understanding the character of scientific knowledge and the ways that modalities inform its structure, in light of the fact that he made contact with no real physics in the exposition.

What, in the end, is the use of this iteration?

2.2 Dynamical Systems and Possible Worlds

1. Williamson uses the idea of "phase space" as it appears in the theory of dynamical systems to argue that (p. 197) "much of natural science is an exploration of objective modal space."

2. He is, sadly but not surprisingly, woefully lax when it comes to specifying what he means. Is he talking of the phase space of a kind of system at the highest level of abstraction in a theory, *e.g.*, the phase space of the Navier-Stokes equations or Maxwell's equations with

no initial or boundary conditions imposed, no values fixed for kinematic constants such as shear viscosity and electric permitivity, and so on ("fluid" and "Maxwell field" in complete generality)? For a particular species of system treated by a theory (liquid water as treated by Navier-Stokes theory, or free electromagnetic radiation *in vacuo*, each fixed by assigning determinate values to all the kinematical constants appearing in the equations)? Or this individual system right here (the water contained in this bottle, as determined by fixing initial and boundary conditions)? Each will require its own treatment with regard to the forms of possibility it may support and participate in. One is not free to assume that one can treat only one of them and then blithely "extend the analysis in the obvious way" to the other cases. There is no *a priori* naturally distinguished "obvious way". My remarks below will show what some of the complications are.

3. let's assume that he means the last, a phase space of a definite individual, as some of his remarks suggest (though he does often use interpolations such as "dynamical systems theory is applied to a given (type of) physical system"); it is otherwise difficult if not impossible to make sense of the analogy of states of phase space with possible worlds in a semantics *à la* Kripke—I don't know how to understand the idea of a Kripkean possible world representing the abstract state of a "type" of system, with no determinate values for any of its quantities

4. let's also put aside many his fatuously false claims about dynamical systems, which seem to be advanced in the spirit of showing he has some mastery of the subject, but which, pitiably, show only the contrary (*e.g.*, p. 199, "If there are only finitely many states, every state is involved in such an eternal recurrence" and "In the special case where the partition contains only one orbit, the system sooner or later traverses every state.")

5. p. 200: [2]

2. Compare Ruetsche (2011, p. 7):

> To interpret a physical theory is not only to equip it with content but also to explicate the notion of physical possibility allied with it. . . . ¶ On the standard account, then, to interpret a theory is to characterize the worlds possible according to it. These possible worlds are (i) models (in something like the logician's sense), and (ii) characterized as physical.

The notion of physical possibility here is deeply tied up with the explanatory capacities of a theory, since "characterized as physical" (to distinguish the physical theory from, *e.g.*, a theory of pure mathematics) depends on the notion of physical possibility the theory delimits, which according to Ruetsche must ground or be deeply involved in what its explanatory powers are. *Cf.* also Ruetsche (2011, ch. 6, §1, pp. 118–119, emphases hers):

> [T]he methodological ideal of pristine interpretation . . . requires the interpreter of a physical theory to appeal only to its laws and his own insight into matters logically antecedent to particular applications of theory—including matters of mathematics, metaphysics, and the nature of science—when saying what worlds are possible according to the theory. Pristine interpretation forswears appeal to extranomic or *a posteriori* considerations, considera tions such as initial or boundary conditions, dynamical details, or exigencies pressing upon physicists attempting to frame new theories, when equipping a theory with content. The worlds possible according to a pristinely interpreted theory can be identified in advance of, and without recourse to, those adulterating details. These details are of course relevant to the mundane business of *applying* the theory to particular problems. But on the pristine picture, this business lacks foundational interest.

Ruetsche's heart is in the right place, but she goes astray in granting that those matters are "*a posteriori*" in any interesting sense—one cannot even *begin* to characterize the theory's modal structure (what its notion of "possibility" is) before one knows how to characterize its domain of applicability, as discussed in §3 below.

> How can we articulate the modal dimension of dynamical systems explicitly? The key is to appreciate the analogy between possible states in phase space and possible worlds in models of modal logic as developed by Saul Kripke – who was aware of the analogy when doing his pioneering work. The set of worlds in a Kripke model corresponds to the set of states in a dynamical system, or, more generally, in a phase space. Possible worlds, like possible states, are conceived as maximally specific, mutually exclusive, and jointly exhaustive. Moreover, just as we can ask what is true or false in a possible world, so we can ask what is true or false in a possible state of the dynamical system.... ¶ [A] sentence can be interpreted over a dynamical system by being assigned a proposition, modelled as a subset of the set of states in the dynamical system: the proposition is true at the states it contains and false at the other states, and the sentence receives exactly that truth-condition. This framework allows us to interpret modal operators over the system, just as in the simplest models of modal logic...

6. It is difficult for me to square the libertine attitude of Kripkean possible-world semantics with the stern strictures science requires to endow a formal phase space with empirical content, to render its components and constituents physical significance. Kripke (1980, p. 44, italics his) sums up the attitude concisely: "'Possible worlds' are *stipulated*, not *discovered* by powerful telescopes." *Argumentum ex italico.* (See also *ibid.*, p. 49: "Generally things aren't 'found out' about a counterfactual situation, [*sic*] they are stipulated.") But that's wrong, at least for an adequacy semantics for physical theories. We *do* discover them, using the telescopes our theories and other empirical knowledge provide us. *Fictional* worlds are stipulated, not scientifically possible ones.

7. One particular way this freedom in Kripkean semantics is incompatible with the requirements of a semantics for physical theories: there is no room in Kripkean semantics for non-trivial semantic content to reside in relations among worlds, but such global relations on phase space in fact do have non-trivial physical significance (as Williamson himself seems aware), and that of such a kind as to be necessary for comprehending the empirical content of the phase space itself and the theory to which it belongs. Williamson seems at least partly aware of the problem, for he does admit propositional quantifiers, but that will not suffice. The envisaged formal language, endowed with Kripkean semantics and extended to include such propositional quantifiers will, *e.g.*, yet be unable to represent, much less to define, the topology of the phase space, because not all topological concepts can be reduced to propositions about the values of quantities in collections of states (any global property, *e.g.*, such as the space's Euler characteristic). I don't see how to rectify the problem.

And Williamson, Fellow of the Royal Society of Edinburgh, Fellow of the British Academy, Fellow of the Norwegian Academy of Science and Letters, Foreign Honorary Fellow of the American Academy of Arts & Sciences, holds the Wykeham Professorship in Logic at Oxford. "*This* is the excellent foppery of the world..." – *King Lear*.

The saddest part of this whole train-wreck? I agree with the gist of his conclusion.

3 'Possibility' in Physics Is Said in Many Ways

1. according to a plausible and common story, a theory tells us what the possibilities are for the kind of physical system it represents in its full class of models (*e.g.*, Tarskian models, solutions to equations of motion, *etc.*, depending on one's views on the semantics of theory)

2. this seems to be the view of Williamson (2018)

3. this is physical possibility in the broadest possible sense

4. it is, however, also physical possibility in an attenuated sense, as the class of models by itself does not determine the semantics of the theory—we need also to know the domain of applicability, which no theory on its own can demarcate

5. we may then want to pare down the class of models we will take seriously in our physical reasoning, for any of several reasons (some don't satisfy or are in tension with a physical principle we like, some are manifestly inconsistent with other of our best current theories, *etc.*), but note that to do this we need to have a full semantics in hand, not just the class of models

6. another issue: in every theory we know of, there is always part of an individual model (solution, state, ...) that "does not represent"—and this has nothing to do with that tired old topic of "surplus structure"; it has rather to do with the fact that the grasp of a state of a system in every theory we know of exceeds the reach of the theory's domain of applicability—a state of a fluid in Navier-Stokes theory, *e.g.*, specifies is shear-stress at scales of 10^{-100} `cm` (it's a continuum theory)

7. I will now give a proposal for identifying and explicating different types of modality in a fixed physical framework, as an example of how I think one ought to proceed, *viz.*, by attending to the way the epistemic content of the framework is applied in the scientific enterprise.

   a. Consider general relativity as a framework, *viz.*, an epistemic structure within which one formulate definite theories of particular types of physical systems (*e.g.*, Maxwell fields on curved spacetimes). That fixes the highest, broadest level of modal structure, the most general class of possibilities (*e.g.*, that stress-energy distribution is related to curvature by Einstein field equation, that no spacetime has the topology $\mathbb{S}^4$, *etc.*). Call this *framework possibility.* (Example: is it possible in the framework of Newtonian mechanics for a particle to have a spatially discontinuous trajectory? Sure, if you allow distributional forces. The lesson: there is much one must fix and decide before one has a determinate notion of even this broadest, most abstract form of modality.) One can then further restrict the class of possibilities in two ways, corresponding to the practice of theoretical and experimental physicists (in, *e.g.*, their attempts to define the idea of a "physically reasonable spacetime").

      i. Fix (formulate) a theory of a definite kind of matter field, *e.g.*, perfect fluids. Relative to this theory, only spacetime models with perfect fluids are possibilities. Call this *nomological possibility.*

ii. Impose general conditions (or constraints) or require general properties, *e.g.*, the dominant energy condition or global hyperbolicity. This restricts the class of possibilities to those spacetime models in which T_{ab} satisfies the dominant energy condition or in which spacetime has a Cauchy slice. The spacetimes in this class are not related in any lawlike way (on any standard construal of "law"); they are related only in so far as they satisfy the same (fixed) physical condition or constraint, or ave the same property—let's generically call such things *principles*. Call this *principle possibility*.

iii. Clearly, in general, any given nomological possibility class will be neither a superset nor a superset of (nor identical with) any principle possibility class, though in general the two will have a non-trivial intersection (*e.g.*, the class of all perfect-fluid spacetimes satisfying the dominant energy condition in spacetimes that are globally hyperbolic). Such an intersection determines a fourth kind of possibility class, *physical possibility*.

iv. Finally, there is *experimental possibility*: taking account of full complexity of modeling real systems (*e.g.*, schematized representations of instruments, *etc.*), comparing results of different calculations ("predictions" or "kinematic characterizations"), and so on—this is where the theory acquires empirical content, and one both needs knowledge of the domain of applicability to characterize this form of possibility, and in turn one must use this form to characterize and delimit the domain of applicability

b. Of course, one can define all five of these in the abstract, without relying on general relativity, and one can use any framework to exemplify them, *e.g.*, Newtonian mechanics, Lagrangian mechanics, Hamiltonian mechanics, statistical mechanics, quantum theory, *etc.*

c. Note also that there will not be in general unique natural, canonical definitions of these types; it does not seem possible, *e.g.*, in our current epistemic state, to define "physically reasonable spacetime" once and for all, for all possible investigative contexts; sometimes, in different contexts, one wants mutually inconsistent conditions, and sometimes one wants conditions for different reasons, *viz.*, "reasonability" means something different in different contexts, as does "physical"[3]

d. there also seem to be important senses of "physically reasonable" that are orthogonal to the kind of definitions of types of possibility I give above, and yet clearly have something important to do with modality in the theory: the use of spacetimes in GR, *e.g.*, that are not necessarily possible in any sense stronger than framework possibility, but which nonetheless seem able to illuminate or clarify, help us to understand, something about what is physically possible; think of the use of anti-de Sitter spacetime in the AdS/CFT correspondence—there is no sense in which anti-de Sitter can represent anything physically possible about the real world, and yet physicists think it can teach us something about the real world[4]

3. Earman (1995, §3.4, p. 80) gives a nice discussion of this phenomenon in the context of cosmic censorship.
4. Juliusz Doboszewski gave a nice talk ("On 'unphysical' spacetimes in QG") on these issues at the Black Hole Initiative philosophy colloquium on 22. March 2021: `https://www.youtube.com/watch?v=joQeAXdaEAM`.

4 Possibility in False Theories

1. Williamson wants to talk of possibility as being fixed by "the natural laws", but when it comes time to argue that modality plays an essential role in physics, he falls back on the language and concepts of particular *theories*. This is not surprising. It appears difficult to say anything sensible, with anything like epistemic warrant, about "natural laws" without the mediation of our best current theories. This leads to the following problem: we have deep and powerful reasons for believing that every theory we currently have is false. How, then, to talk meaingfully about possibility in a framework in which every statement is, literally speaking, false?

2. classical mechanics, *e.g.*, is false, so we cannot say, "the possible physical systems according to classical mechanics are those that could exist"

3. a strictly "internal" or "intrinsic" notion of possibility for such a theory does not, I think, make sense, or at least does not make sense outside the realm of formal semantics, which is to say, does not make sense in any way relevant to our understanding of how classical mechanics as a physical theory is a theory about the world, and not just a purely formal system

4. one possibility: "a physical systems is possible according to classical mechanics if there is a system that could exist and is appropriately and adequately described by the relevant classical mechanical model"—but that is exactly the sort of epistemic, pragmatic, doxastic possibility that Williamson frowns upon, at least so far as the metaphysical mettle of physics is concerned.

5 Invitation to a Short Essay

I invite you to write me a short discussion (no more than 2 pages, *i.e.*, no more than 1000 words) on any issue discussed in any of this week's three readings. You can raise further questions, propose answers or interpretations, or whatever seems of most interest to you. If you get it to me by the start of next lecture (29. Jun), then I will return it to you with my comments the following week.

References

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