Counterpossible Reasoning in Physics

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Overview

• Does physics require us to think about the (physically or
metaphysically) impossible?

• Standard answer: yes, to evaluate contingently false physical
theories.
  • I shall argue against this standard answer.

• New answer: yes, to capture objective dependence structure in
physics.
  • I shall argue that mainstream conceptions of causal structure and of
grounding structure incur commitment to non-trivial counterpossibles.
Plan

• Counterpossibles and the modal status of laws of nature.

• Do we need non-trivial counterpossibles to make sense of:
  • our practices of inquiry into different physical theories? (no)
  • the causal structure posited by physical theories? (yes – counternomics)
  • the grounding structure posited by physical theories? (yes – countermetaphysicals!)

• Conclusion: counterpossible reasoning is everyone’s problem.
Necessary laws of physics?
Modal Necessitarianism

- Modal necessitarianism (MN) identifies physical modality and metaphysical modality.
  - The space of objective metaphysical possibilities is just the state space of the true fundamental physical theory.

- The possible worlds relevant to counterfactual evaluation are just the histories permitted by the fundamental dynamical laws, as applied to some range of possible boundary conditions.
Why modal necessitarianism?

• Argument from rational relevance of laws (Wilson 2013)
  • MN explains why we care about laws of nature.

• Argument from counterfactual support (Wilson 2013)
  • MN explains why laws are held fixed in counterfactual deliberations.

• Argument from modal epistemology (Wilson 2013)
  • MN folds modal epistemology into ordinary scientific epistemology.

• Argument from quantum modal realism (Wilson 2020)
  • MN falls out of an attractive theory of the nature of metaphysical modality.
Counterpossibles in Physical Theorizing
Counterfactual theory-evaluation

• Suppose some string-theory model of quantum gravity is in fact correct.

• Then MN makes these *counternomics* into counterpossibles:
  A. If spacetime were Newtonian, it would have a Euclidean geometry. [T]
  B. If GR were complete and correct, gravity would be quantized. [F]
  C. If loop quantum gravity were correct, there would be no spin foams. [F]

• Reasoned evaluation of the theories in question seems to require ascribing counternomics non-trivial truth-values.
The Argument from Physical Theorizing

1. Evaluating Newtonian mechanics/general relativity/loop quantum gravity involves assessing the truth or falsity of counterfactuals such as A/B/C.

2. We can and do evaluate Newtonian mechanics/general relativity/loop quantum gravity in our physical theorizing.

3. A/B/C are counterfactuals with physically impossible antecedents.

4. We assess the truth or falsity of counterfactuals with physically impossible antecedents in our physical theorizing. (From 1, 2, 3.)

4 looks like **bad news for modal necessitarians**: it combines with their view to entail that counterfactuals with metaphysically impossible antecedents have an important role to play in physical theorizing.
Necessitarian responses

- **Inflationary approach:**
  Appeal to physically (hence metaphysically) impossible worlds to give truth-conditions to counternomics.

- **Deflationary approach:**
  Give an explanation of the apparent epistemic role of counternomics in physical theorizing compatible with their having trivial truth conditions.

- I want to explore the deflationary approach, which retains this attractive core principle:
  - **Counterfactual Aboutness:** Counterfactuals are about how things stand with respect to genuine alternative possibilities.
The Two-Dimensionalist Response

• Evaluate counternomics as embedded in indicative conditionals (Handfield 2004).
  1. If contingentism is correct, then if spacetime were Newtonian, it would have a Euclidean geometry. [T]
  2. If contingentism is correct, then if GR were complete and correct, gravity would be quantized. [F]

• But this strategy complicates the semantics, creates potential embedding problems, and makes the evaluation of counternomics parasitic on a false metaphysical theory.
The Metalinguistic Response

- Embraces trivial counternomics, and deny that physical theorizing needs them after all.
- Perhaps counternomic evaluation can be replaced by direct theorizing about models:
  1. If spacetime were Newtonian, it would have a Euclidean geometry.
  2. Models of Newtonian spacetime assign it a Euclidean geometry.
- This is unattractive: it does too much damage to logical form.
  - (and what if we do not know whether some claim is a counternomic?)
The Error Theory Response

• Error theorists can say we do reason in terms of counternomics, but erroneously.

• However, the relevant metalinguistic fact about models explains why we succeed in our theoretical goals regardless.

• I think this is a more attractive approach, but sub-optimal for the same reasons that error theories in general are unattractive.

• General charity principle: if we can understand ourselves as non-confused, we should!
The Fictionalist Response (1)

• On this response, we make and evaluate counternomic counterfactuals within the context of a pretence.
  • This is fictionalism about counternomics in the make-believe version of Walton (1990), not in the fictional-operator version of Rosen (1990).

• When we evaluate some counternomic, we pretend that the antecedent is physically possible, and then evaluate the counterfactual within that pretence.
  • For example, within the pretence that Newtonian mechanics is physically possible, competent users of the theory will be willing to assert (A).
The Fictionalist Response (2)

• The fictionalist approach complements a natural approach to *reductio* proofs within mathematics.
  • When doing reductio proofs, we pretend that something not known true is true, in order to derive a contradiction.
  • When doing counterpossible reasoning, we pretend that something not known possible is possible, in order to derive nomic consequences.

• In each case the pretence may or may not be true/possible; but we don’t need to know whether it is in order to engage in it.

• I want to leave open here whether the conditionals one assesses from within the pretence are indicative or subjunctive.
Summary

• Rejecting Counterfactual Aboutness opens the door for all views to account for all needed counterpossibles in terms of impossible worlds.

• If we wish to retain counterfactual aboutness, this doesn't work.

• Various deflationary accounts of the epistemic role of counterpossibles in physical theorizing are available.

• These accounts remain compatible with Counterfactual Aboutness.
Counterpossibles in Causal Structure
Impossible Causal Interventions

• Counternomic counterfactuals are entailed by causal structure.
  • Interventionists about causation analyse causal claims in terms of the counterfactual consequences of interventions.
  • Such interventions can be physically impossible (Woodward 2003).
  • If the intervention counterfactuals trivialize, then we lack the differences in truth-value to support non-trivial causal structure.

• The problem also afflicts realist and reductionist views of causation which are intended to entail the relevant interventionist counterfactuals.
Conservation-Violating Interventions

• A first problematic kind of impossible intervention is a conservation-violating intervention.
  • If the Sun were removed from the solar system by an intervention, the Earth would cease to move in an ellipse.
  • So the presence of the Sun is the cause of the Earth’s elliptical motion.
  • Making sense of this requires an intervention to remove the Sun.
• The Sun cannot simply be deleted from reality: this would violate conservation of energy and angular momentum.
Structural Interventions:

• Another problematic class of impossible interventions involve changing the background structure of the physical world.
  • If an intervention were to adjust the number of spatial dimensions to four, then the orbits of the planets would be unstable.
  • So, the three-dimensionality of space is the cause of the stable orbits of the planets.
  • Making sense of this requires an intervention to alter the number of spatial dimensions.
• Intervening on the dimensionality of space is physically impossible.
Summary: A Problem for MN

• It looks like the objectivity of causal claims is in tension with Counterfactual Aboutness, given MN.
  • A two-dimensionalist approach makes causal claims true only relative to the supposition that contingentism is correct,
  • A metalinguistic approach captures only causal dependencies between models, not causal dependencies in reality.
  • An error-theory approach leads to an error theory of the causal claims.
  • A fictionalist approach leads to fictionalism about the causal claims.

• The challenge from causal structure is a serious problem for MN.
Counterpossibles in Grounding Structure
Grounding and Impossible Interventions

• Grounding claims entail non-trivial counterpossibles (Wilson 2018)

• The structural similarity between grounding and causation suggests that the asymmetry of grounding is reflected in an asymmetry of consequences of interventions.
  • If we intervene to change the grounding fact, the grounded fact changes.
  • If we intervene to change the grounded fact, the grounding fact does not change.
Constitutive Interventions

• Consider the claim that the pressure of a gas is grounded in the average linear momentum of the gas molecules.
  • If an (impossible) intervention were to ground an increased average momentum, the pressure would also be higher.
  • But if an (impossible) intervention were to ground a higher pressure, the average momentum of the molecules would be unchanged.
  • Making sense of this requires interventions that violate grounding principles linking molecular motion with pressure.

• The counterfactuals that we need are countermetaphysicals.
Summary: A Problem for Everyone

• It now looks like the objectivity of grounding claims is in tension with Counterfactual Aboutness, given either MN or contingentism.
  • A two-dimensionalist approach makes grounding claims true only relative to the supposition that contingentism about metaphysics is correct.
  • A metalinguistic approach captures only grounding dependencies between models, not grounding dependencies in reality.
  • An error-theory approach leads to an error theory of the grounding claims.
  • A fictionalist approach leads to fictionalism about the grounding claims.
• The challenge from grounding structure is a problem for everyone.
Conclusion
Conclusions

• Modal necessitarianism has various viable options for responding to the challenge from physical theorizing.

• These responses do not work for the challenge from causal structure, which is a serious problem for MN.

• An analogous challenge from grounding structure faces everyone, necessitarian or contingentist.

• Two potential ways out of the challenge from grounding structure:
  • An account of counterpossibles in terms of impossible worlds, or;
  • Eliminativist / reductionist / conventionalist / instrumentalist / nihilist denial of objective grounding structure in the physical world.
Thanks for listening!

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References