Reconsidering Emergence:

Functionalism, Vagueness, and the Explanatory Gaps in Wallace's Everettian Quantum Mechanics

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Overview and Aims

- This paper critically assesses how Wallace's version of Everettian mechanics explains macroscopic phenomena
- Part I: Exposition
  - Superpositions as real, effectively classical, non-interacting 'worlds'
  - Macroscopic objects as vague, functionally emerging entities
  - Connection with structural realism
  - Fundamental theories as frameworks
  - Spacetime state realism (with Timpson)
- Part II: Critical Evaluation
  - Premature rejection of compositional explanations
  - Framework view distorts classical mechanics unnecessarily
  - Failure of explaining why specific structures emerge at particular levels
  - Implausibility of functional emergence at all scales
    - Practice vs. theory; Functionalism vs. spacetime

Everettian Quantum Mechanics

- Quantum Mechanics and the Measurement Problem
  - QM is challenging from a realist perspective
  - Problematic macroscopic superpositions
  - Problematic Von Neumann's Collapse Postulate
    - It's mysterious what counts as a "measurement"
    - It leads to inconsistencies in nested measurements (Everett's Critique)
  - Everett's solution: Keep pure Schrödinger dynamics (no collapse).
    - Every term in the superposition represents a relative perspective of some observer →Collapse is just a subjective appearance
      - » The theory is:
        - Deterministic formally, Probabilistic subjectively (for observers).
      - » Empirical adequacy: Everett showed that measurement records follow standard quantum statistics.

Everettian Quantum Mechanics

- Many-Worlds Interpretation (DeWitt and Graham, 1973)
  - Reinterpreted Everett's view with a many-worlds metaphysics:
    - Superposition terms = actual branching into multiple observers (one per term)
    - Introduced the notion of 'worlds'. Multiple ways to define branching and worlds → many variations of the interpretation.
- Wallace's version of Everettian Mechanics (2012)
    - Everettian mechanics = quantum formalism without collapse
    - The quantum state is all that exists fundamentally (however, see later)
    - It evolves linearly and deterministically
    - Everything else (macroscopic objects, mesoscopic and microscopic structures, even 'worlds') emerges functionally from the quantum state
      - Worlds are not created by branching—they are emergent patterns in the quantum state

Superpositions, Multiplicity, Worlds and Real Patterns

- Superpositions represent multiplicity, not indefiniteness
  - Analogy:
    - Like a superposition of a wave going left and one going right. We say two waves exist, not one ambiguous wave
    - Likewise, a superposition implies multiple entities, not a fuzzy single one
- The measurement problem is addressed in two steps:
    - Each superposition term is real but we observe only one outcome
    - The 'dead-alive cat' superposition means:
      - There are two cats in two quasi-classical, effectively independent and mutually inaccessible worlds
        - » Decoherence:
          - Superpositions spread (e.g., from atoms to vials to cats) but interacting with the environment, they lose coherence
          - Loss of coherence prevents interference, making branches effectively non-interacting

Superpositions, Multiplicity, Worlds and Real Patterns

- Each term in the wavefunction can be labeled a ‘world’:
  - Not literal splitting of matter or spacetime
  - Worlds emerge from the macroscopic dynamics of the quantum state
- These worlds are patterns, not fundamental entities:
  - Following Dennett (1991), patterns are real if useful for explanation
- Other entities at other levels are also patterns
  - Atoms, cats, people, poison vials are real, but not fundamental
  - They emerge structurally from the quantum state
  - They are real at different descriptive levels:
    - Atomic level → ‘atom pattern’; Macroscopic level → ‘cat pattern’, etc.
    - Fundamentally: Only the quantum state exists
    - Non-fundamentally: All else (patterns/worlds/entities) emerges from it

Functionalism and Vagueness

- Wallace (following Dennett): patterns are functionally defined
  - A pattern is what it does, not what it's made of:
    - A tiger is defined by tiger-like behavior, not by a precise composition. There's no fixed number of particles that makes something a tiger
    - The same goes for worlds: Worlds are structurally emergent. No exact composition defines a world. No sharp boundaries between one world and another, or between a tiger and a non-tiger.
- Vagueness may seem ontologically problematic:
  - In classical mechanics, systems are precisely defined (e.g., number and properties of particles)
  - In contrast, patterns (like tigers or worlds) are vague
  - However, vagueness is acceptable and even necessary:
    - A tiger remains a tiger if it loses fur
    - A world is a world if it continues to behave quasi-classically, regardless of its exact matter content

Functionalism and Vagueness

- Functional vs. Compositional Explanation
- Wallace’s key idea: explanation happens at the functional level, not the compositional one
    - We explain tiger behavior in terms of desires, dispositions, actions. Not by counting atoms, molecules, or proteins
  - Follow at all levels what happens in high-level sciences (like zoology), where one uses vague categories:
    - We talk about tiger-like behavior, not particle configurations
- Thus:
  - Tigers and worlds are real patterns
  - Their vagueness is not a flaw, but a feature: it's what makes them usable and explanatory at their respective levels of description

Emergence and High-Level Ontologies

- In general, all higher-level regularities (atoms, molecules, organisms, etc.) are:
    - Structurally emergent, non-fundamental, real patterns
- Each high-level science explanation relies on its own effective ontology:
    - Chemistry: atoms and molecules; Biology: cells and DNA; Zoology: organisms and behavior; Astronomy: stars and galaxies
  - It is not explanatorily useful to reduce them to more fundamental levels:
    - Chemistry explains molecular reactions without referring to quarks; Biology explains life processes without tracking subatomic particles; Zoology explains tigers in terms of their behavior, not their molecular makeup
  - Indeed, invoking deeper levels can hinder explanation:
    - Effective ontologies behave "as if" they were primitive:
      - Atoms in chemistry are treated as indivisible; Molecules in biology are treated as stable units; Cats in zoology are treated as coherent wholes

Emergence and High-Level Ontologies

- Wallace's Key Insight (2012) :“The entities of zoology cannot be discarded in favour of the austere ontology of molecular physics alone… those entities are structures instantiated within molecular physics… almost all science is the study of such structures.”
  - Higher-level scientific explanations depend on the autonomous stability of emergent patterns
  - These patterns are:
    - Stable: they persist under coarse-grained description
    - Opaque: their internal structure is irrelevant
    - Autonomous: their behavior is self-contained at that level
  - Scientific progress is possible without a final theory because of the autonomy and robustness of effective ontologies

Structural Realism and the Aim of Science

- Everettian QM *a la* Wallace fits well with structural realism:
  - Real patterns are structures which exist at multiple levels of description (atoms, tigers, worlds)
- Rainforest Realism (Ladyman & Ross 2007)
  - At the fundamental level, there is only structure
  - All so-called "objects" (particles, molecules, chairs, etc.), macroscopic and microscopic:
    - Are not composed of more basic entities; are not fundamentally real but are effective, structural descriptions; exist only as useful fictions that capture regularities at certain levels
- It is still realism: even if there are no fundamental objects, it is still realist about structure Also, it holds that:
  - Scientific theories talk about the world; entities emerge at various levels of description
- Wallace's Position is
  - Less radical than rainforest realism: he accepts a fundamental entity: the quantum state
  - But agrees that the aim of science is discovering the structure of reality, and that non-fundamental entities (cats, atoms, etc.) are useful structures that emerge from the fundamental level

Quantum Mechanics as a Framework

- Typically realists think of theories as specifying:
  - An ontology: what exists (e.g., particles, fields),
  - And dynamics: how it behaves (via laws)
    - Example: Classical mechanics posits point-like particles obeying Newton's laws
- Instead, for Wallace QM is a Framework:
  - It provides a mathematical structure, which must be "filled in" by additional physical content to become a full theory
  - Components of the Quantum Framework
    - A Hilbert space: whose rays represent quantum states
    - A set of self-adjoint operators: corresponding to physical observables
    - A Hamiltonian operator: generates dynamics via the Schrödinger equation
    - The Born rule: assigns probabilities or expectation values to measurement outcomes
  - The formalism can be instantiated in many ways:
    - Ex: in the position basis using wfs over configuration space

Quantum Mechanics as a Framework

- Comparison with Other Types of Theories
  - Einstein's Distinction (1919)
    - Constructive theories:
      - Have a microscopic fundamental ontology
      - Explain phenomena via compositional and dynamical analysis
        - » Example: Classical mechanics
    - Principle theories:
      - Explain via general principles, without appeal to underlying micro-entities
        - » Example: Thermodynamics

Ontology and Spacetime State Realism

- Can we reduce the fundamental even further? Specifically, can spacetime itself be an emergent feature?
- The View That Spacetime Might Emerge (Albert, Ney, Carroll…)
- Wallace's Rejection of Emergent Spacetime
  - We cannot infer metaphysics from formalism alone: "The formalism does not transparently display the appropriate metaphysical description of the system"
  - He evaluates and rejects reasons for demoting spacetime as unconvincing
  - Spacetime's role in:
    - Relativity theory (special and general)
    - The very formulation of classical and quantum mechanics
      - Particle mechanics is defined in terms of the spacetime symmetry group
      - In algebraic quantum field theory, the theory is specified by mapping spacetime regions to algebras of observables—spacetime is integral to the setup
  - Conclusion: For now, spacetime should be retained at the fundamental level (though Wallace acknowledges this might change with future theoretical developments)

Ontology and Spacetime State Realism

- Problem: If the quantum state lives in configuration space or Hilbert space, how does it describe spatiotemporal reality?
  - Spacetime State Realism (Wallace & Timpson 2009)
    - Proposal: It is not the quantum state itself that has ontological priority; rather, what matters are the properties the quantum state assigns to spatiotemporal regions
    - The ontologically significant bearers are spacetime regions, each of which is associated with a density operator.
    - This view generalizes classical ontology:
      - In electromagnetism, fields assign values to spacetime points, in classical mechanics, particles exist in space and move in time
      - Similarly, in quantum theory, subsystems of spacetime regions instantiate properties via density operators
      - Outcome: The fundamental ontology is a kind of spatiotemporal field, defined via these operators
  - Wallace and Timpson remain epistemically modest:
    - "There is no guide to ontology beyond the mathematical structure of the theory." But: Good representations are those that make manifest the theory's structural commitments

Rejecting Compositionality?

- In classical mechanics macroscopic phenomena are explained through compositionality (by appealing to microscopic parts)
  - Ex - Rigid bodies, fluids, and gases
    - Water = H_2O molecules. Each H_2O molecule = 2 Hydrogen atoms + 1 Oxygen atom
    - Atoms = electrons orbiting nuclei (protons and neutrons)
    - Liquidity at room temp = consequence of the polar bonds formed by H_2O molecules (loose but cohesive).
  - This explanatory model is intuitive, visualizable, and empirically successful
- Wallace's proposal: explaining via emergence instead
- Worry:
  - A radical departure from the traditional, compositional understanding of science
  - Does abandoning compositional explanation undermine the success of classical mechanics?
  - Shouldn't we be cautious before discarding a proven schema?

Rejecting Compositionality?

- Wallace's Reply: rejection of the explanatory power of compositionality:
  - No denying that things are made of other things:
    - Tigers → cells → DNA → amino acids → molecules → atoms → particles, etc.
  - But: these 'components' only emerge structurally:
    - Their inner composition is irrelevant to explanation
    - What matters is the functional role they play in the system
- This is a rejection of a powerful form of reductionism ("everyday reductionism“, Gillett): compositional relations to explain higher-level phenomena and derive laws
- Wallace critiques the "tower of theories" view (each level reducing to the one below) and advocates for a "patchwork" model instead (different descriptions apply at different levels, without a unifying compositional reduction)

Rejecting Compositionality?

- Wallace's Critique of Compositional Explanation
  - Example: "A proton is composed of three quarks" is:
    - At best, a popular-science heuristic; at worst, a child's story.
  - Quarks = field excitations, not "building blocks" in any intuitive sense
  - No clear, general logic of composition exists that transcends messy case-by-case analyses
  - Often, such accounts confuse ontological categories (e.g., conflating objects with properties)

Rejecting Compositionality?

- Counter-Argument: the argument against compositionality appears weak
  - Quantum mechanics lacks visualizable models, so current metaphors are instrumental; but instrumentalism is not realism
    - A realist wants a clear ontological picture, not just a predictive tool
    - If Everettian mechanics demands rejection of compositionality due to lack of clear pictures:
      - That's a weakness of Everettian mechanics, not of compositional explanation
    - Alternative theories, like pilot-wave theory in the primitive ontology framework, do provide:
      - A non-metaphorical, microscopic picture and identifiable building blocks of reality → they retain compositional explanation

Rejecting Compositionality?

- Challenge Case: Superconductive currents (Laughlin 2005)
  - Allegedly a case of downward causation, challenging compositionality: electrons behave differently when alone vs. in pairs
  - Response: compositional explanation is possible if one explains why electrons behave differently in different contexts:
    - The interactions between electrons and the crystal lattice is a collective behavior, not genuine downward causation
    - No failure of compositionality (unless one adopts an excessively rigid standard)
    - → Compositional explanation remains viable—even in complex quantum systems

A Revisionary Account of Classical Physics?

- Classical Mechanics typically understood as a Constructive Theory
  - Microscopic point-like particles in 3D compose macroscopic objects
  - Compositional and dynamical explanation accounts for macroscopic behavior
- Wallace: all theories are frameworks
  - QM is a framework that offers the simplest mathematical model to fit empirical data and its success depends on predictive adequacy within a framework
  - Classical Mechanics is also a framework: the notion that classical mechanics is a constructive, particle-based theory is misguided:
    - E.g., Hamiltonian or Lagrangian mechanics = abstract structures for formulating dynamical laws
    - Classical "particle mechanics" = just one part of the broader framework
    - Fails to capture phenomena like electromagnetism, rigid bodies, or fluid dynamics
    - Thus, both classical and quantum mechanics should be seen as families of models or frameworks, not as single concrete theories.
  - No radical shift from classical to quantum theory

A Revisionary Account of Classical Physics?

- Objections to Wallace's Reinterpretation.
  - 1-Compositional explanation is still viable
    - Thus, there is no need to abandon the constructive paradigm if alternative quantum theories still provide it
  - 2-In conflict with historical views of classical mechanics:
    - Schrödinger, de Broglie, Einstein, Lorentz did not treat classical mechanics as an abstract framework
      - Schrödinger sought a wave mechanics that was constructive and universal
      - De Broglie revised Newtonian, not Hamiltonian, mechanics
      - Einstein explicitly argued that physics should aim for constructive theories
      - Lorentz also favored constructive accounts (Frisch 2005).
    - Thus, Wallace's reinterpretation goes against both historical realism and philosophical intent of major figures.

A Revisionary Account of Classical Physics?

- Objections to Wallace's Reinterpretation.
  - 3-Contemporary science widely embraces compositional explanation (Gillett 2025)
    - So the burden of proof lies with Wallace:
      - He must show that the framework view of classical mechanics is superior to the constructive one
      - Or justify that a 'paradigm shift' has occurred from classical to quantum theory in terms of what counts as explanation
  - 4-The framework view is unsatisfactory
    - For Wallace's view is prescriptive:
      - all theories should be frameworks
    - If it is descriptive:
      - all best current theories are frameworks
    - … but…

A Revisionary Account of Classical Physics?

- … When frameworks are instantiated to explain real-world phenomena, they become principle theories which define effective ontologies at different scales (i.e., real patterns)
- However, they offer no account of why those ontologies work
- Einstein's view: principle theories are acceptable but provisional
  - In absence of a constructive theory, they are tolerable, but they do not fully explain ***why*** the principles or effective patterns hold
- Wallace's response ("real patterns emerge from lower-level patterns") looks circular:
  - We use principles because they work; they work because we use them
- Why be satisfied with this, if deeper, constructive answers are available?

A Revisionary Account of Classical Physics?

- Conclusion: Wallace's framework view challenges the traditional explanatory standards in physics but:
  - Conflicts with historical understaning
  - Neglects ongoing support for compositional explanation
  - Relies on an unsatisfying epistemology that risks circularity and anti-realism
  - If constructive quantum theories are available, framework-based explanations seem philosophically premature

Are Structures Enough?

- Traditional scientific realism:
  - Seeks to describe both the nature of objects and their interactions
  - Assumes that theories should offer a picture of the world, including object ontology
- Structural realism, in contrast:
  - Science reveals only the structural relations between objects, not their intrinsic nature
  - Epistemic structural realism (ESR): We can only know structures, but objects' natures may exist
  - Ontic structural realism (OSR): Structure is all there is
    - This view entails a radical revision of how physics is typically understood → many criticisms

Are Structures Enough?

- Wallace adopts a less radical stance than full OSR:
  - Structures emerge when a framework (classical or quantum) is instantiated
  - Avoids the problem of uninstantiated structure by grounding higher-level patterns in actual physical states
- Nonetheless, it retains key explanatory limitations:
  - No explanation of <u>*why*</u> specific effective ontologies (e.g., liquidity, temperature) emerge:
    - Why certain patterns (e.g., water, mammals, economies) emerge at a given level?
      - Wallace cannot say water emerges because because it's composed of H_2O, since he rejects compositional explanation
  - This is in contrast with compositional accounts (e.g., molecular explanation of water's liquidity):
    - Can track how macroscopic properties emerge from microstructure; offer inter-level explanatory support

Are Structures Enough?

- Wallace justifies special science explanations (e.g., zoology, economics) by:
  – Asserting that explanatory power lies within the level-specific structure (effective ontology)
  – Translation into microphysical terms destroys the explanatory content
- However, this view also does not explain why these emergent structures are effective
- Compositional approaches offer a better answer:
  – higher-level structures effectively emerge because of the properties of lower-level components

Are Structures Enough?

- Conclusion
- Wallace's structuralism avoids full-blown ontic radicalism, but still fails to explain:
  - Why effective ontologies emerge at all
  - How macro-properties relate causally or compositionally to microstructures
- Compositional explanations retain a clear advantage in explanatory depth and inter-level coherence
- The structuralist turn, even in Wallace's moderate version, appears philosophically and scientifically incomplete

Functional Definitions All the Way Down?

- Wallace's Constitutive Functionalism (Knox and Wallace 2025):
  - Ontologies are real patterns, functionally defined within the relevant level of description
  - No appeal is made to underlying lower-level compositions
- Functionally defined effective ontologies are vague, and Wallace connects their explanatory power to their vagueness
- Compositional eplanation instead seems connected to precision: there is a given number of particles that makes this object up
- Because of these, Wallace thinks his functionally defined effective ontologies are essential to guarantee the explanatory power of high-level sciences

Functional Definitions All the Way Down?

- While macroscopic ontologies (e.g., tigers, gases, solids) are typically vague:
  - Their identity does not depend on precise composition; functional definitions naturally align with this vagueness
- Microscopic ontologies (e.g., molecules, atoms) are instead precise:
  - Composition matters greatly: $H_2O \neq H_3O$; Identity is typically defined by specific constituents
    - Wallace does not seem to be able to account for why that is
- Nonetheless, even microscopic entities can be defined functionally:
  - Electron: defined by its behavior in fields (e.g., turning right in an EM field)
- Thus, functional definitions can be precise and non-vague: vagueness is not essential to functionalism:
  - Functionalism and compositionality are not mutually exclusive

Functional Definitions All the Way Down?

- Compositional-Functionalism as a Superior Alternative
  - Called “Causal role functionalism” (Knox & Wallace 2025):
    - Effective ontologies are functionally defined in terms of the ontology of a lower-level theory
    - Explains why vagueness arises at macroscopic scales and why compositionality matters at small scales
    - Explanation:
      - When a system is made of few components, each component matters → compositionality is crucial
      - As systems grow, individual components’ impact diminishes → vagueness becomes acceptable
      - Macroscopic systems = those where adding/removing one particle makes negligible difference

Functional Definitions All the Way Down?

- Compositionality explains more:
  - Why certain laws apply at one level but not at another
  - Why microscopic definitions are precise and macroscopic ones are vague
  - Why high-level laws can have exceptions, while fundamental laws (e.g., electromagnetism) do not.
    - Example: Thermodynamics laws are vague/probabilistic. Statistical mechanics explains why these laws are not exceptionless, grounding them in particle behavior
- Wallace's approach:
  - Does not explain the origin of exceptions or the success of compositionally grounded sciences
  - Ignores how compositional structures generate macroscopic regularities and predict exceptions

Functional Definitions All the Way Down?

- Summary of Key Criticisms of Wallace's View
  - Constitutive functionalism does not explain:
    - Why composition matters at microscopic levels
    - Why vagueness becomes tolerable only at larger scales
    - Why compositionally defined ontologies (e.g., molecules) are so explanatorily successful
    - Why laws at different levels differ in generality, precision, and exceptionlessness
  - Compositional accounts:
    - Can incorporate functionalism
    - Retain explanatory power by tracking how micro-components give rise to macro-behaviors
    - Offer an account of lawful exceptionality and scale-dependent explanatory strategies

Follow the Practice in Physics?

- Wallace motivates Everettian mechanics by claiming it is the formalism most physicists use
  - The principle of theory selection: We should trust what most practicing physicists do or believe
  - However:
    - Majority belief is not a reliable indicator of truth
    - Physicists are often instrumentalists about quantum mechanics
    - History shows that majorities can be wrong, especially in complex theoretical matters

Follow the Practice in Physics?

- Internal Tension in Trusting Scientists Selectively
  - If we follow Wallace's principle consistently, we should adopt reductionism, too:
    - Gillett (2025) shows most scientists are everyday reductionists—they explain phenomena compositionally
    - Thus, accepting the majority's approach would imply rejecting Wallace's constitutive functionalism
      - Inconsistency: Wallace endorses scientific consensus when it supports Everettian mechanics, but disregards it when it comes to explanatory compositionality
      - The selective appeal to consensus is philosophically problematic

Follow the Practice in Physics?

- Wallace’s spacetime exceptionalism
  - Functionalism applies to everything except spacetime
  - Reason: ST is essential to the structure of our best theories
- Critique: unpersuasive commitment
  - Wallace insists on spacetime realism because it's built into our best theories
  - But compositionality is also central to these theories, yet Wallace rejects it
  - Compositionality and spacetime are connected:
    - If macro objects are composed of micro entities, and macro objects are in spacetime, then micro entities must be in spacetime too
    - Rejecting compositionality undermines the necessity of spacetime, unless one reintroduces it via customary formalism

Follow the Practice in Physics?

- Relativity is not a framework
  - Wallace argues that relativity depends on spacetime, hence we can't dispense with it
  - Yet relativity is not a framework like quantum mechanics—it’s a theory of spacetime, not a meta-framework
  - Thus, it's unclear what Wallace means when he speaks of "generalizing" quantum theory with respect to relativity

Follow the Practice in Physics?

- Summary of the Criticisms
- Selective epistemic trust:
  - Wallace inconsistently appeals to scientific practice:
    - follows it for quantum mechanics, but not for compositionality
  - Spacetime exceptionalism is not well-motivated:
    - If Wallace rejects compositionality despite its presence in physical theory, why should spacetime be treated differently?
    - Compositional explanations arguably entail spatiotemporality—so rejecting the former undercuts the latter
  - Wallace's appeal to framework structure is unclear:
    - Relativity is not clearly generalizable in Wallace's framework-first approach
    - The commitment to spacetime may stem more from convention than philosophical necessity

Summary and Conclusions

- 1. Overview of Wallace's Everettian Mechanics
  - Wallace explains macroscopic phenomena through effective ontologies that functionally emerge at a given scale
  - He rejects compositional explanation:
    - higher-level phenomena are not composed of lower-level entities
    - His view aligns with:
      - Framework-based theory structure: theories are tools for explanation, not literal descriptions
      - Structural realism: science aims to capture the structure, not the substance, of the world

Summary and Conclusions

- 2. Main Criticisms of Wallace's View
- a. Loss of Explanatory Power
  - Rejecting compositional and constructive explanations limits the ability to:
    - Explain why specific structures emerge at particular scales
    - Provide deeper causal or mechanistic accounts of macroscopic phenomena
- b. Failure to Account for Scale-Dependent Compositionality
  - Wallace's framework mystifies the observation that:
    - Compositionality is crucial at microscopic scales (e.g. H_2O vs. H_3O)
    - It becomes less relevant at macroscopic scales (e.g. tigers, gases)
    - A compositional perspective explains this scale-dependence naturally; Wallace's view does not

Summary and Conclusions

- c. Inconsistency in Appealing to Scientific Practice
  - Wallace endorses Everettian mechanics by appealing to what physicists do
  - But most scientists also use compositional explanations, especially in the special sciences
  - Therefore, his principle undermines his own account if applied consistently
- d. Tension in Wallace's Treatment of Spacetime
  - Wallace resists functionalist treatment of spacetime, seeing it as fundamental
  - Yet his reasons for treating spacetime as special seem to rely on compositional reasoning
  - This creates a tension, since he otherwise rejects compositionality

Summary and Conclusions

- In a nutshell:
- Wallace's rejection of compositional and constructive explanation weakens the explanatory scope of his account
- His framework struggles to explain:
  - Scale-dependent ontology
  - The success of compositional explanations in the sciences
  - The special status he accords to spacetime
  - A compositional approach offers more explanatory depth, and aligns better with scientific practice

Thank you for your attention!