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CURRENT CONTROVERSIES IN METAPHYSICS OF SCIENCE: TOPICS, FOUNDATIONS, AND SCOPE

Controversias actuales en metafísica de la ciencia: temas, fundamentos y alcance

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In recent decades, the metaphysics of science has established itself as a distinct and dynamic field. This development has not only revitalized metaphysics as a serious area of inquiry but has also built a crucial bridge between scientific practice and enduring metaphysical questions. By anchoring metaphysical investigation in our best scientific theories, the field seeks to uncover and explore the fundamental nature of reality. This approach moves beyond a priori speculation, engaging directly with the empirical concepts and theoretical structures that shape our understanding of the physical world.

The dynamism of the field stems from a range of fundamental controversies. Some debates concern its methodological status: Is the metaphysics of science a form of naturalized or "scientific" metaphysics, or is it methodologically continuous with traditional metaphysics? Other discussions revisit perennial metaphysical questions through a scientific lens—for example, the nature of space-time, the existence of natural kinds, the status of dispositional properties, and the relationship between emergence and reduction. While the metaphysics of science is already well

established in the global philosophical community, it has recently gained notable momentum among philosophers and scientists in Latin America.

This special issue aims to foster and strengthen this growing international dialogue by engaging with some of the most relevant and pressing debates in the field. The contributions gathered here, authored by scholars across the globe, reflect both the breadth and sophistication of the ongoing debates in metaphysics of science. They offer fresh perspectives on central topics such as causation, the nature of reality, spatial location, and the epistemological structure of scientific models. Together, they exemplify how the metaphysics of science continues to advance, drawing from both traditional metaphysical concerns and the novel challenges raised by contemporary science.

In "Constitution and Causation in Mechanisms," Max Kistler examines the intricate problem of how constitutive relevance is discovered and represented in the modeling of multi-level mechanisms. Kistler critically examines prominent proposals, including Craver's theory of mutual manipulability and the concept of "causal betweenness." He argues that these accounts are inadequate for capturing the complexity of biological mechanisms, which often involve causal chains and parallel activities. Kistler proposes a two-step solution: first, constructing partial, purely causal models for each level through level-specific experiments, and second, merging these into a comprehensive model that represents both causal links and non-causal constitution relations, guided by spatio-temporal constraints.

Fernanda Caroliny Cardoso and Silvio Seno Chibeni, in their article "Naturalised Realism in the Metaphysics of Science: Hume's 'Mitigated Scepticism' on Causality and Reality," challenge the traditional interpretation of David Hume as a radical sceptic hostile to metaphysics. They argue that Hume's philosophy is better understood as a pioneering form of "naturalized realism." According to their analysis, Hume contends that our beliefs in causality and an external world are not justified by rational proof but arise from the natural, instinctual operations of the human mind. This perspective reframes epistemology as an empirical "science of man," suggesting that Hume's project, rather than eliminating metaphysics, accommodates it within a fallibilistic and naturalistic framework akin to science itself.

Jorge Manero's "On a Bohmian Structural Approach without Space Fundamentality" examines the ontology of Bohmian mechanics and the long-standing dispute between three-dimensional and high-dimensional worldviews. The article reviews three-dimensional options—nomological wave function and the multi-field account—alongside

the high-dimensional "world-particle + field" picture and argues that standard theoretical/metaphysical virtues (parsimony, explanatory power, common sense, and ontological continuity) cannot break the resulting underdetermination. Manero then advances an ontic-structural realist reading: both three-dimensional and high-dimensional descriptions are alternative representations of a single fundamental structure identified via dynamical symmetries (symplectic Lie groups), thereby denying space's fundamentality. Overall, the paper positions structural realism as a principled route to dissolve object-oriented stalemates in Bohmian metaphysics.

In "Locación y funcionalidad" Carlo Rossi offers a critical survey of the metaphysics of exact location, focusing on Functionality, the thesis that no object has more than one exact location. Rossi reconstructs leading arguments for Functionality, especially definition-driven and naturalness-based strategies, and argues that they fail to secure its truth or neutrality. He shows that adopting Functionality carries substantive commitments for theories of persistence, multilocation, and mereology, undermining claims that the principle is a harmless axiom. The paper recommends caution about elevating Functionality to first principles and sketches space for alternative frameworks that allow multilocation without illicit ontological burdens, thereby reframing current debates about location, composition, and the structure of material objects.

Matías Pasqualini's "Quantum Entanglement as an Internal Relation" argues that entanglement is best understood as an internal rather than an external, non-supervenient relation. Drawing on Fine's logic of essence and work on ontological dependence, Pasqualini develops a non-reductionist account that captures the modal constraints built into entangled systems. After surveying physics and metaphysics of entanglement and marking its irreflexivity, symmetry, non-transitivity, and multigrade character, the article critiques Humean-supervenience treatments and shows why external-relation strategies are ill-suited. It then demonstrates how an internal-relation reading embeds fruitfully within three frameworks: ontic structural realism, priority monism, and coherentism, clarifying what each requires and how entanglement supports them.

In "Modalist Empiricism and Physical Laws," Otávio Bueno and Cristián Soto develop a novel empiricist approach to nomic modality that challenges both Humean and non-Humean accounts of laws of nature. They argue that physical modality best accounts for the modal status of laws, understood as empirical regularities that inform us about physical possibilities and necessities in their domains. Their modalist empiricism

rejects the traditional distinction between nomic and accidental generalizations, proposing instead that laws exhibit varying scopes of modal information—from local to global, from stochastic to deterministic systems. The authors contend that nomic modality is simply physical modality, requiring no metaphysical grounding in universals or dispositions, and that physical laws are minimally defined as empirical hypotheses expressing generalizations about physical domains and their modal properties.

In "Best Systems in Lawless Worlds," Ulrich Meyer presents a fundamental challenge to David Lewis's Best System Account (BSA) of laws of nature. Meyer argues that BSA faces a critical problem: it finds laws of nature even in lawless worlds—possible worlds where there are no genuine counterfactual dependencies between property instantiations and everything happens by accident. He demonstrates that neither the language requirement (restricting laws to perfectly natural properties) nor strength thresholds can adequately address this problem. Meyer shows that BSA must accommodate equations of motion as laws in multi-particle worlds, but this opens the door to "Frankenstein regularities" in lawless worlds—gerrymandered conjunctions of conditionals that lack systematic unity yet satisfy BSA's criteria for lawhood. This suggests that BSA, while capturing an important logical role of laws in systematizing information, provides at best an incomplete account of genuine lawhood.

Nina Emery's "Two Types of Naturalism and the Metaphysics of Science" examines the relationship between metaphysics and science through the lens of two distinct forms of naturalism: content naturalism (avoiding theories that conflict with our best scientific theories) and methodological naturalism (using scientific methodology in metaphysical theorizing). Emery argues for a crucial *content-methodology link*—that one cannot coherently accept content naturalism without also accepting methodological naturalism, since respecting scientific content requires respecting the methodology that produces it. This connection has far-reaching implications: if methodological naturalism is substantive, then scientific considerations become relevant to all metaphysical debates, not just those traditionally considered part of the metaphysics of science. Emery concludes that this dissolves the supposed distinction between naturalistic and *a priori* metaphysics, making all metaphysical inquiry beholden to scientific considerations.

Vanessa Seifert's article, "Why Water May Not Be a Natural Kind After All", challenges the widely held view that chemical substances are natural kinds by introducing a novel argument centered on the role of chemical stability. Unlike traditional critiques that question substances' essential properties or their reduction to physical bases, the author argues

that the very property required to identify a substance—its stability—is not natural but instead determined by chemists under specific conditions. As a result, substances like water fail to meet two key requirements of natural kinds: being individuated by natural properties and being categorically distinct. Focusing on IUPAC's definition of substances as matter of constant composition, the article examines how this practice-based determination of stability undermines the metaphysical significance of chemical classifications, posing a problem particularly for natural realist interpretations, while also exploring possible alternative conceptions of kinds.

In his article, "Modal Naturalism, Laws of Nature, and the Asymmetries between Possibility and Necessity", Vassilis Livanios examines modal naturalism (MN), a position within the metaphysics of science that aims to ground knowledge of objective modal facts in the reliability of scientific practice, while distancing itself from traditional, intuition-based a priori metaphysics. After outlining the broader methodological tensions between the metaphysics of science and a prioristic approaches, the author focuses on two recent debates highlighted by Amanda Bryant and Alastair Wilson in their 2024 book, *Modal Naturalism: Science and the Modal Facts*: the impact of competing views on the modal status of fundamental laws—nomic necessitarianism versus nomic contingentism—on MN, and the epistemic asymmetries between possibility and necessity. The paper argues that MN cannot remain neutral on the first debate without becoming extensionally inadequate, ultimately defending a contingentist version of MN, and shows that the asymmetries provide no grounds for favoring necessitarianism. In doing so, the article challenges the assumption that contingentism undermines MN by reintroducing modal intuitions and instead positions contingentism as compatible with MN's scientific orientation.

Raoni Arroyo and Jonas Becker Arenhart's article, "Two Quantum-Mechanical Arguments against the Metaphysical Equivalence between Substratum and Bundle Theories of Individuality," revisits the debate on the metaphysical status of quantum entities, specifically whether they should be regarded as individuals or non-individuals, a question that quantum mechanics itself leaves underdetermined. Traditionally, bundle theories of individuality have been dismissed due to the failure of the Principle of Identity of Indiscernibles under permutation symmetry, while substratum theories (bare particulars) have been thought to remain compatible with quantum mechanics. However, the paper brings into focus Jiri Benovsky's claim that bundle theory and substratum theory are metaphysically equivalent, a thesis that has so far been overlooked in the quantum context. The authors argue that both camps have underestimated the challenges

quantum mechanics poses: not only does bundle theory face difficulties, but substratum theories may also fail under certain interpretations of quantum theory, such as those invoking metaphysical indeterminacy or wave function realism. By showing how Benovsky's equivalence thesis falters in light of these considerations, the paper deepens the discussion of metaphysical underdetermination in quantum mechanics and highlights broader metametaphysical lessons about the interaction between science and metaphysics.

In "Ontic Structural Realism and the Case of the Missing Kantian Residue," Ragnar van der Merwe addresses a central challenge to Ontic Structural Realism (OSR), the thesis that reality consists solely of structure. Critics have argued that OSR's ontology is incomplete: structure alone cannot account for why it exhibits non-arbitrary properties. Focusing on James Ladyman's version (OSRL), van der Merwe develops a response grounded in Kant's philosophy. Drawing on Rae Langton's thesis of Kantian humility, he introduces the notion of Kantian responsibility, which posits a noumenal "something=x" beyond structure. This mysterious something=x is said to exist and to be responsible for the structure's stability and form. Responsibility is conceived as a modal relation, potentially aligned with causation, grounding, or determination. In a deflationary spirit, van der Merwe does not attempt to describe the nature of something=x, but only to argue that it accounts for structure. This minimalist proposal preserves OSR's commitment to structure while addressing critics' concerns.

In their article, "La ley y el orden: explorando las conexiones entre las ontologías de las leyes de la naturaleza y el espacio-tiempo," Manuel Herrera, Ignacio Madroñal, and Andrés Okita explore the connections between two major metaphysical debates that have traditionally been treated in isolation: the nature of laws of nature and the nature of space-time. Starting from the everyday and scientific assumptions that objects exist, occupy space, persist through time, and undergo changes often explained causally, the authors argue that a coherent naturalistic metaphysics must simultaneously address both debates. They aim to establish affinities between positions on laws of nature—such as regularism and nomological necessitarianism—and positions on space-time—such as relationalism, substantivalism, and supersubstantivalism. The paper defends a minimal thesis that metaphysical theories should integrate both discussions and a stronger thesis suggesting that positions with similar metaphysical commitments across debates are naturally aligned. By examining the views of Leibniz and Lewis as case studies, the article seeks to demonstrate these affinities and motivate further research into the systematic interplay between theories of laws and theories of space-time.

Ezequiel Irigoyen and Alejandro Rota, in their article "El 'realismo heurístico' y su rol en la segunda revolución cuántica," examine the historical and philosophical interplay between scientific realism and instrumentalism in the context of orthodox quantum mechanics (Copenhagen interpretation) and argue that realist attitudes have been crucial for major scientific breakthroughs. While logical positivism and the Copenhagen school promoted an instrumentalist view that dismissed metaphysical accounts of unobservable entities as meaningless or impossible, the paper highlights how realist commitments motivated key advances. Focusing on the discovery of non-local correlations—a revolutionary phenomenon in 20th-century physics—the authors show that figures such as Einstein, Bohm, and Bell were driven by a realist pursuit of an ontological framework that could reconcile quantum mechanics with relativity. The paper reconstructs the stages leading to the theoretical and experimental acceptance of non-locality, demonstrating that such progress would not have been possible under a purely instrumentalist stance, and concludes by reflecting on the kind of scientific metaphysics that fostered this discovery.

Bruno Borge and Dalila Serebrinsky's "Deep and Deeper Disagreements in Metaphysics of Science" examines deep disagreements in the metaphysics of science, with a particular focus on debates in scientific ontology. Drawing on the epistemology of disagreement, the article argues that these disputes satisfy all the core criteria of deep disagreements—being genuine, systematic, reason-sensitive, and persistent—while also exhibiting degrees of depth. The central case study is the clash between empiricist and metaphysical stances, which represents the deepest level of disagreement due to their conflicting epistemic principles: empiricists reject explanations invoking unobservables, while metaphysicians prioritize explanatory power and accept robust ontological commitments. Within each stance, however, disputes over modality reveal intermediate levels of depth, whereas more localized debates are comparatively shallow. This three-level mapping clarifies why some debates prove more intractable than others do. By recognizing gradability, the article enriches both metaphysics of science and the epistemology of disagreement, offering a nuanced framework for understanding philosophical disputes.

In their article, "Dispositions and Grounding in a Causal Dispositional Framework," Vanesa Triviño and María Cerezo examine whether grounding relations arise within causal dispositionalism (CD), a framework in which causation is understood in terms of dispositions and their manifestations. Grounding is typically characterized as a metaphysical relation of non-causal dependence that explains why one fact obtains in virtue of another. While grounding and dispositional theories have each

been extensively studied, their intersection remains largely unexplored. They address this by focusing on a specific dependence relation within CD: the relation between a cause and the disposition(s) whose manifestation(s) initiate a causal process (GD-C). Although existing debates already consider grounding relations between causal powers and categorical bases (GD-A) and between natural properties and the dispositions they bestow (GD-B), Triviño and Cerezo argue that GD-C is an additional, overlooked grounding relation. They thereby assess whether GD-C meets the standard criteria for grounding—irreflexivity, asymmetry, and transitivity—and show that it is neither an identity nor a causal relation. They conclude by suggesting that recognizing GD-C helps clarify the interaction and production gaps within dispositional theories of causation.

Taken together, the articles in this issue illustrate the vitality and conceptual diversity of contemporary metaphysics of science, and they show how ongoing debates continue to reshape the ontological and methodological foundations of the field.