The Grammar of Relations

Carlo Rovelli's Relational Physics and the Closure Framework: Facts Without Foundations and Time Without Flow

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> *Quantum mechanics is a theory about the physical description of physical systems relative to other systems, and this is a complete description of the world.*
> Carlo Rovelli, Relational Quantum Mechanics, 1996

> *Every finite closure generates remainder. The remainder is not noise. It is the proof that the grammar is finite.*
> CF Dietz, Consciousness, Closure, and the Cosmos, 2026

Abstract

Carlo Rovelli is the most cosmologically ambitious physicist currently working at the intersection of quantum gravity, thermodynamics, and philosophy of physics. His relational quantum mechanics holds that physical quantities have no absolute values: they exist only relative to other systems. His thermal time hypothesis holds that time is not a fundamental feature of the universe but emerges from the thermodynamic relationships between systems that cannot observe all the microscopic details of each other. His ontology of events holds that the world is made not of things but of interactions: temporary relational events that produce facts for the systems involved without producing absolute facts for a view from nowhere. This paper argues that Rovelli's relational physics and the closure framework developed in Consciousness, Closure, and the Cosmos are tracking the same structural truth about the physical world from different directions. Rovelli's relational facts are facts constituted within closure regimes. His thermal time is the temporal experience that finite closure regimes have when they encounter the remainder they cannot model. His event ontology is the ontology of a world made of interactions between closure regimes rather than things that persist independently of any closure. The convergence runs from quantum mechanics through thermodynamics to philosophy of time, and in each domain it is precise rather than approximate. The paper also engages Rovelli's one significant divergence from the CC-C framework: his conviction that consciousness has nothing to do with fundamental physics, which the closure framework contests not by making consciousness fundamental to physics but by showing that the closure structure that generates relational facts at the quantum level is the same structure that generates conscious experience at the cognitive level.

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1. The Electron That Has No Speed

An electron does not have a speed. Not in the sense that we do not know its speed, or that it is moving too fast to measure, or that it is in multiple places at once in some mystical superposition. In the precise sense that speed, as a definite physical quantity with a definite value, does not belong to the electron as a property it possesses independently of any interaction. The electron has a speed relative to whatever system has interacted with it in a way that produces a fact about its speed. Relative to a system that has not interacted with it in the relevant way, the electron has no speed at all. Not an unknown speed. No speed.

This is not a limitation of our measuring instruments. It is not an artifact of quantum uncertainty in the sense that a more refined measurement would resolve the ambiguity. It is, according to Carlo Rovelli, the actual structure of physical reality. Properties are not possessed by things absolutely. They are produced in interactions between systems. Before the interaction, the property does not exist. After the interaction, it exists relative to the system the interaction occurred with. There is no further fact, no global view from nowhere, that says what the property is absolutely.

Rovelli arrived at this position by taking quantum mechanics seriously in a way that most physicists avoid. The equations of quantum mechanics describe the evolution of quantum states. When two quantum systems interact, the state of each is updated relative to the other. That update produces a fact: a definite value for the relevant physical quantity, but definite only relative to the system involved in the interaction. From the perspective of a third system that did not participate in the interaction, neither of the first two systems has a definite state: they are still in superposition from that perspective. There is no contradiction here, only the recognition that facts are relational. They are produced in interactions. They belong to the interaction, not to either system independently.

Rovelli calls this relational quantum mechanics. He has spent three decades developing it, defending it against objections, and extending its implications into thermodynamics, the philosophy of time, and the metaphysics of matter. This paper argues that what he found in quantum mechanics is what the closure framework independently derived from philosophy of mind: facts are constituted within relations, not discovered independently. The grammar constitutes the fact. The interaction constitutes the property. The closure regime constitutes what is real within its scope. Rovelli found the relational structure of fact-constitution in physics. The closure framework found it in epistemology and phenomenology. The convergence is the argument.

2. Rovelli's Four Claims

Rovelli's contributions to physics and philosophy of physics cluster around four interconnected claims, developed across his technical work on relational quantum mechanics and loop quantum gravity and his popular books Seven Brief Lessons on Physics, The Order of Time, and Helgoland.

2.1 Relational Facts: Properties Exist Only Relative to Systems

Rovelli's central claim is that quantum mechanics forces us to abandon the notion of observer-independent states. The state of a physical system, the values of its physical quantities, is not an absolute feature of the system. It is a description of the system relative to another system that has interacted with it. Two different systems that have interacted with the same quantum system may have different, mutually incompatible descriptions of it, and both descriptions are correct relative to their respective interaction histories. There is no third description that is correct absolutely.

This is the quantum analogue of what Einstein established for simultaneity. Before Einstein, physicists assumed that two events either are simultaneous or are not, absolutely, regardless of any observer. Einstein showed that simultaneity is relative to a reference frame: the same two events are simultaneous relative to one frame and non-simultaneous relative to another, and both are correct. Rovelli's move is the same for quantum states. Before Rovelli, physicists assumed that a quantum system either has or does not have a definite value for a given quantity, absolutely. Rovelli shows that having a definite value is relative to a system: the same quantum system has a definite position relative to one system and an indefinite position relative to another, and both are correct.

The consequence is an ontology in which facts are relational through and through. Nothing has absolute properties. Everything that is real is real relative to something else. There is no level of description at which absolute, observer-independent facts can be found. The dream of a complete physical description from a view from nowhere is not merely unachieved. It is incoherent.

2.2 Event Ontology: The World Is Made of Interactions, Not Things

If properties are relational, what is the world made of? Rovelli's answer is events: interactions between systems that produce relational facts. The world is not made of things that persist through time with intrinsic properties. It is made of events, temporary interactions that produce facts relative to the systems involved and then dissolve. Between interactions, systems do not have definite properties. They are in a state of relational indeterminacy that is resolved only when the next interaction occurs.

This event ontology dissolves several of the traditional puzzles of quantum mechanics. The measurement problem, which asks how a quantum state collapses to a definite value when observed, ceases to be a problem once we recognize that the collapse is just the production of a relational fact in the interaction between the quantum system and the measuring system. There is no mysterious collapse of an absolute state. There is the production of a fact relative to the measuring system, which may or may not be the same as the fact produced relative to a different measuring system.

The event ontology also connects quantum mechanics to the rest of physics in a way that the thing-based ontology does not. If the world is made of events rather than things, then the relationship between quantum mechanics and thermodynamics, between the microscopic and the macroscopic, between the reversible equations of fundamental physics and the irreversible arrow of time, all become questions about the structure of event-sequences and the information that systems have about each other rather than questions about the properties of things.

2.3 Thermal Time: Time Emerges from What We Cannot See

Rovelli's thermal time hypothesis addresses one of the deepest puzzles in theoretical physics: the equations of fundamental physics are time-symmetric. They work equally well run forward or backward. There is no preferred direction in the basic laws. And yet we experience time as having a direction: the past is fixed, the future is open, entropy increases, things age and do not un-age. Where does this asymmetry come from if the fundamental laws have none?

Rovelli's answer is that the arrow of time comes from our epistemic position relative to the world, not from the world's fundamental structure. We do not observe the full microscopic state of any macroscopic system. We observe coarse-grained summaries of it: the temperature of a gas rather than the position and momentum of each molecule, the color of an object rather than the state of each atom. Because we observe coarse-grained summaries, there is an enormous number of microscopic states that produce the same macroscopic observation. Entropy is a measure of this number. A low-entropy state is one where few microscopic arrangements produce the observed macroscopic state. A high-entropy state is one where many do. Because there are vastly more high-entropy states than low-entropy ones, any system that starts in a low-entropy state will almost certainly evolve toward higher entropy. That is the arrow of time: not a feature of the fundamental laws but an artifact of our coarse-grained perspective on a world whose microscopic details we cannot fully see.

Time, in this account, emerges from our ignorance. The thermal time hypothesis formalizes this: given any state that a system is in from the coarse-grained perspective of another system, there is a natural time flow defined by the thermal state of the first system as seen from the second. This thermal time is what we experience as the flow of time. It is real as an experience and as a thermodynamic fact. It is not real as a fundamental feature of the universe, which at its most basic level is timeless.

2.4 The World Without a View from Nowhere

Rovelli's fourth and most philosophically radical claim is that there is no view from nowhere. Not just that we cannot achieve such a view, but that the concept of a complete, absolute, perspective-independent description of the world is incoherent. Every description is a description relative to something. Every fact is a fact for some system. Every observation is an observation by some observer, where any physical system can play the role of observer. The universe does not have an absolute state. It has a network of partial, perspectival, relational descriptions, each correct relative to the system from which it is made, none correct absolutely.

This is not relativism in the philosophical sense of saying that all descriptions are equally valid or that there are no facts. Relational facts are fully real. The electron's speed relative to this measuring apparatus at this moment is as real as anything can be. But it is real relative to, not real absolutely. The grammar of the universe is relational from the bottom up. Every fact is constituted in an interaction. Nothing has a value except relative to something else.

3. What Rovelli Needs

Rovelli's relational physics is among the most philosophically sophisticated positions in contemporary theoretical physics. It takes quantum mechanics seriously as a description of nature rather than as a calculation tool. It connects quantum mechanics to thermodynamics through the thermal time hypothesis. It offers a coherent ontology of events and relations rather than things and properties. And it does all this without invoking consciousness, non-physical causes, or any departure from the scientific method.

There is a question, however, that Rovelli's framework raises with particular urgency without fully answering. If every fact is relational, constituted in an interaction relative to the system that interacts, then what determines which relational facts are constituted? What makes the electron's speed relative to this apparatus at this time this particular value rather than some other? Rovelli's answer is the quantum state, the Hilbert space formalism, the Born rule. These are correct as far as they go. But they describe the probabilities of relational facts without explaining what it is about the structure of the interacting systems that determines which relational facts are possible at all.

The closure framework provides this explanation. A closure regime constitutes facts within its scope: the identity criteria of the closure determine which relational facts are possible between the closure and what it interacts with. The quantum state is a description of the closure's current relational potential, the set of interactions it can enter into and the facts those interactions can produce. The closure framework grounds the relational ontology by explaining what it is about organized systems that enables them to enter into relations that produce facts: it is their closure, their constitutive distinctions, their identity criteria. Rovelli describes the relational structure of fact-production. The closure framework explains why any organized system has a relational structure at all.

Additionally, Rovelli's account of thermal time describes how time emerges from coarse-grained observation without explaining what coarse-graining is at the structural level. The closure framework explains this precisely. A closure regime cannot model all the microscopic details of what it interacts with: this is the formal definition of remainder. The coarse-grained observation that Rovelli describes as the source of thermal time is the observation of a closure regime that generates remainder at its boundary. Thermal time is the time experience of a finite closure encountering remainder. Rovelli found the phenomenon. The closure framework names the structural mechanism.

4. Two Concepts That Ground Relational Physics

The closure framework is introduced here at the minimum level needed to ground Rovelli's account. Two concepts. Readers who want the full architecture are directed to Consciousness, Closure, and the Cosmos.

4.1 Closure Regime: What Makes Relational Facts Possible

A closure regime is a system that stabilizes some content by drawing distinctions, establishing identity criteria, and maintaining lawful relationships among its elements. It constitutes facts within its scope and generates remainder at its boundary: the content it cannot

model, the interactions it cannot fully absorb, the aspects of the world its distinctions cannot capture.

Rovelli's observing system, the system relative to which a quantum state is defined, is a closure regime in this precise sense. It has identity criteria that determine which interactions produce facts relative to it. It has lawful relationships among its elements that determine how those facts are integrated into its current state. And it generates remainder: the microscopic details of what it interacts with that its coarse-grained perspective cannot see. A quantum interaction produces a relational fact relative to the system because the system is a closure regime: it has the constitutive structure that makes fact-production in interaction possible. A system without closure, without identity criteria, without constitutive distinctions, could not enter into an interaction that produces a fact relative to it, because there would be no it for the fact to be relative to.

Remainder is the key connection to Rovelli's thermal time. The coarse-grained perspective that generates thermal time is precisely the perspective of a closure regime that cannot model all the microscopic details of what it interacts with. The remainder generated at the closure boundary is exactly the microscopic detail that is invisible to the coarse-grained observer. Thermal time is the temporal structure that emerges from the relationship between a closure regime and its remainder. The time that flows for any physical system is the time generated by the gap between what the system can constitute and what it opens onto.

4.2 Nested Closure: Why the World Has Levels

Rovelli's event ontology describes a world of interactions between systems, where each interaction produces a relational fact without producing an absolute fact. The closure framework describes a world of nested closure regimes, each interacting with others at their respective boundaries, each producing facts within its scope without producing absolute facts for a view from nowhere. These are the same description of the same world.

The nesting matters for Rovelli's program in a specific way. Rovelli acknowledges that the relational facts produced at the quantum level must somehow be compatible with the approximately classical facts we experience at the macroscopic level. The same electron that has no absolute speed must be part of a macroscopic system that, for all practical purposes, does have a definite speed. This compatibility is guaranteed by the nested structure of closure regimes. Higher-level closures constitute facts from the outputs of lower-level interactions, integrating the relational facts produced at the quantum level into the coarser but more stable facts that constitute the macroscopic world. The macroscopic world does not have absolute facts: it has facts constituted at a higher level of closure, facts that are stable across a wider range of interactions, facts that are for all practical purposes classical without being absolutely so.

A note on scope, directed at readers who know Rovelli's work and who may be skeptical of any framework that extends physical claims into philosophy of mind or cosmology. The CC-C framework makes cosmological and phenomenological claims that go beyond what Rovelli's physics requires or endorses. The argument of this paper does not ask Rovelli to accept those extensions. Closure as constitutive of relational facts and nested closure as the structure of multi-level physical organization are independently defensible on grounds that are entirely compatible with Rovelli's physicalism. A reader who accepts the argument made here is not thereby committed to anything beyond the relational physics Rovelli has already established.

5. Four Claims, One Structure

The vocabulary correspondence between Rovelli's physics and the closure framework is direct and philosophically precise. What Rovelli calls a relational fact, a physical quantity with a definite value relative to a system, the closure framework calls a fact constituted within a closure regime. What Rovelli calls the state of a system relative to another system, the framework calls the closure's current constitutive configuration. What Rovelli calls coarse-grained observation, the perspective of a system that cannot see all the microscopic details of what it interacts with, the framework calls the encounter of a closure regime with its remainder. What Rovelli calls thermal time, the temporal structure that emerges from coarse-grained thermodynamic relationships, the framework calls the time experience of a finite closure encountering remainder. And what Rovelli calls the view from nowhere, the impossible absolute perspective that no physical system can occupy, the framework calls the infinite closure that generates no remainder: possible only as a limit concept, never as a physical reality.

5.1 Relational Facts Are Constituted Facts

Rovelli's central claim, that physical quantities exist only relative to systems that interact with them, is the closure framework's central claim that facts are constituted within closure regimes rather than discovered independently. Both claims deny that there are absolute, perspective-independent facts about the world. Both claims affirm that relational, perspective-dependent facts are fully real. Both claims trace this structure to the basic features of organized physical systems rather than to any limitation of human cognition or any philosophical idealism.

The difference between the frameworks at this point is one of derivation rather than content. Rovelli derives the relational structure of facts from quantum mechanics: the equations force us to abandon observer-independent states, and once we do, relational facts follow. The closure framework derives the same structure from first principles about organized systems: any system with identity criteria constitutes facts relative to those criteria, and the facts it constitutes are real relative to those criteria without being real absolutely. Both derivations arrive at the same destination. The quantum derivation is empirically grounded and mathematically rigorous. The structural derivation is more general and shows why any organized physical system must exhibit relational fact-constitution.

5.2 Event Ontology Is the Ontology of Closure Interactions

Rovelli's event ontology, the world as made of interactions rather than things, maps precisely onto the closure framework's account of how closure regimes relate to each other. Closure regimes interact at their boundaries: these interactions produce facts relative to each closure regime involved, facts that are integrated into the closure's current state, without producing absolute facts for any perspective outside the interaction. An interaction between two closure regimes is exactly an event in Rovelli's sense: a temporary relational occurrence that produces facts for the systems involved without producing absolute facts for a view from nowhere.

This mapping clarifies the relationship between Rovelli's event ontology and the persistence of organized systems across time. Rovelli's world of pure events, with no persisting things, might seem to make the persistence of any organized system mysterious: if the world is

made of events, what makes a cell or an organism or a planet the same thing across time? The closure framework answers this: a closure regime is exactly a system whose identity criteria persist across interactions. The cell is the same cell because its organizational closure, its constitutive distinctions and lawful relationships, persists even as every molecular component is replaced and every quantum interaction produces new relational facts. Persistence is not the persistence of things but the persistence of organizational closure: the maintenance of identity criteria across an ongoing sequence of relational events.

5.3 Thermal Time Is Remainder-Time

Rovelli's thermal time hypothesis holds that the experienced flow of time emerges from the coarse-grained thermodynamic relationships between systems that cannot observe each other's full microscopic state. The arrow of time, the distinction between past and future, the sense that time flows from one moment to the next: all of these emerge from the entropy differential between a system and what it interacts with, from the vast number of microscopic states that produce the same macroscopic observation.

The closure framework identifies the mechanism that Rovelli's thermodynamics describes: it is the relationship between a closure regime and its remainder. A closure regime cannot model all the microscopic details of what it opens onto. That inability is the formal definition of remainder: the content the closure's identity criteria cannot capture. The entropy differential that generates thermal time is the thermodynamic expression of remainder: the number of microscopic states invisible to the coarse-grained observer is exactly the number of ways the world can be at the level that falls outside the closure's modeling capacity. Thermal time is the temporal structure that emerges when a finite closure encounters its remainder. The time that flows for any physical system is generated by the gap between what the system can constitute and what exceeds its constitutive capacity.

This connection has a striking consequence. The closure framework treats M, the inexhaustible ground that every closure opens onto, as genuinely real and structurally irreducible. Rovelli's thermal time emerges from our perspective on M: from our inability to observe all the microscopic detail that M contains at any level of description. The time we experience is the time of finite closures encountering an inexhaustible world. It is not an illusion. It is the real temporal structure of the encounter between finite organization and what exceeds it. Rovelli is right that time is not fundamental in the sense of being a background structure independent of any physical system. The closure framework adds: time is the real experience of finite closure encountering remainder.

5.4 No View from Nowhere Is the Structural Truth of Finite Closure

Rovelli's philosophical claim that there is no view from nowhere, that every description is a description relative to some system, is the structural truth that follows necessarily from the closure framework. Any finite closure generates remainder. The remainder is what falls outside the closure's constitutive capacity. A view from nowhere would require a closure with no remainder: a closure that constitutes all facts about the world without leaving anything outside its scope. That is an infinite closure. There are no infinite closures in the physical world.

This is not a philosophical preference or an epistemological limitation. It is a structural necessity. Any system that draws distinctions leaves something undistinguished. Any system that has identity criteria leaves something outside those criteria. Any system that constitutes facts has remainder at its boundary. The view from nowhere is the closure that generates no remainder, and its non-existence is not a contingent fact about the universe but a consequence of what any finite organized system must be. Rovelli found this in quantum mechanics. The closure framework derives it from the structure of organization itself.

6. The One Productive Divergence

Rovelli is explicit and emphatic that consciousness has nothing to do with fundamental physics. When asked about the relationship between his relational quantum mechanics and consciousness, he dismisses the connection: consciousness is a complex phenomenon we will slowly disentangle, like life was before molecular biology, and it has no direct connection to the foundations of quantum theory. His relational observer is any physical system, not a conscious one. His thermal time is a physical phenomenon, not a phenomenological one.

The closure framework contests this dismissal, but not in the way that most quantum consciousness theorists contest it. The closure framework does not claim that quantum mechanics requires consciousness or that consciousness collapses wave functions or that there is a special quantum role for phenomenal experience. It claims something more structural and less dependent on the specific mechanics of quantum theory.

The claim is this: the closure structure that generates relational facts at the quantum level is the same structure that generates conscious experience at the cognitive level. The electron's speed relative to the measuring apparatus is constituted in their interaction because the apparatus is a closure regime with identity criteria that make speed-relative-to-it a possible fact. The conscious experience of redness relative to a seeing organism is constituted in their interaction because the organism is a closure regime with identity criteria that make color-experience-relative-to-it a possible fact. The mechanism is the same. The level is different. Consciousness is not added to the relational structure: it is what the relational structure is, at the level of closure regimes sophisticated enough to have felt interiors.

This divergence is productive rather than merely terminological. Rovelli is right that quantum mechanics does not require consciousness for its formalism to work. The closure framework agrees: consciousness is not required for fact-constitution at any level. But the closure framework adds that conscious experience is the felt interior of fact-constitution at the cognitive level: the way the relational structure of the world presents itself to a closure regime that is organized enough to experience rather than merely register its encounters with what it opens onto. Rovelli's relational quantum mechanics describes the structure from outside. The closure framework describes the same structure from inside, at the level where inside and outside first become distinguishable.

7. What the Encounter Produces

The encounter between Rovelli's relational physics and the closure framework has consequences for both.

For Rovelli's framework, the closure account provides the structural grounding for the relational ontology. Relational facts are possible because organized systems are closure regimes with identity criteria. The view from nowhere is impossible because finite closure always generates remainder. Thermal time emerges from remainder: from the gap between what a closure can constitute and what it opens onto. These structural derivations show why Rovelli's physics must work the way it does, not merely that it does work. The relational structure of quantum mechanics is not an accident of the specific equations physicists happened to discover. It is the necessary consequence of what any organized physical system must be.

For the closure framework, Rovelli's physics provides the physical confirmation that the relational structure of fact-constitution extends all the way down to the quantum level. The closure framework claims that facts are constituted within closure regimes at every level of organization. Rovelli's relational quantum mechanics confirms this at the most fundamental physical level currently accessible to experiment and theory. The framework's account of nested closure regimes producing facts at every level, from the molecular to the cognitive, is grounded in the quantum relational structure that Rovelli has established as the foundational feature of physical reality.

For physics and philosophy jointly, the convergence between Rovelli and the closure framework is the most physically grounded confirmation in the series that the relational constitution of facts is a structural feature of the world from the bottom up. The physicist and the philosopher found the same structure from different directions. The physicist found it in the equations of quantum mechanics and the thermodynamics of systems far from equilibrium. The philosopher found it in the structure of organized experience in an inexhaustible world. When the equations and the phenomenology point to the same structure, the structure is almost certainly real.

8. The Grammar of Relations

An electron does not have a speed. It has a speed relative to something. The fact of its speed is produced in an interaction and exists relative to the system that participated in the interaction. There is no further fact, no absolute ground beneath the relational facts, no view from nowhere at which the electron's speed is simply what it is. The relational fact is all there is. And the relational fact is real.

Carlo Rovelli found this in quantum mechanics and followed where it led. Through event ontology, through thermal time, through the dissolution of the view from nowhere, through the recognition that the world is made not of things with intrinsic properties but of interactions that produce relational facts. He built one of the most coherent and challenging philosophical positions in contemporary physics: a world of pure relations, where every fact is relative, every description is perspectival, and the aspiration to an absolute description is not merely unachieved but incoherent.

The closure framework arrived at the same place from philosophy of mind. Any finite closure generates remainder. Any system with identity criteria constitutes facts relative to those criteria without constituting absolute facts. Any organized physical system occupies a perspective on what it opens onto, and that perspective is what it is because the system is a finite closure: it can constitute some things and not others, it can see some things and not others, it generates remainder at its boundary precisely because it is finite. There is no view from nowhere because there is no infinite closure. Every fact is constituted. Every time is thermal. Every observer is a closure encountering what it cannot fully model.

Rovelli's quantum mechanics and the closure framework are not competing descriptions of the world. They are descriptions of the same structural truth at different levels: the physicist's account of how relational facts are produced in quantum interactions, and the philosopher's account of what any organized system must be for relational fact-production to be possible at all. The grammar of relations is what the world speaks at every level, from the electron with no absolute speed to the conscious being with no absolute perspective. Rovelli heard it in the equations. The closure framework found it in the structure of organized experience. Both are right, and what they are right about is the same thing.

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Author's Note

This paper is the sixth in a series engaging thinkers whose work converges with the closure framework developed in Consciousness, Closure, and the Cosmos. Carlo Rovelli is Emeritus Professor at the Centre de Physique Théorique in Marseille and Distinguished Visiting Research Chair at the Perimeter Institute. His work spans loop quantum gravity, relational quantum mechanics, the thermal time hypothesis, and the philosophy of physics. His popular books have reached millions of readers worldwide and brought foundational questions in physics to a broad public audience. The author regards the convergence between Rovelli's relational physics and the closure framework's account of constituted facts as the most cosmologically ambitious convergence in the series: it establishes that the relational structure of fact-constitution that the closure framework describes as a structural necessity of any organized system is confirmed by our best physical theory of the quantum world. The divergence on consciousness is genuine and productive, and the author welcomes engagement from Rovelli directly and from physicists and philosophers of physics who find the connection between relational quantum mechanics and structural accounts of organized systems either illuminating or contestable.