Many-Body Non-Locality as the Ontological Default of Physical Reality

Exceptional Localizations and the Emergence of Physical Law

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Abstract

We propose a reorganization of physical theory based not on solvability or methodological convenience, but on ontological default. Contrary to the traditional hierarchy—where one-body and two-body systems are treated as fundamental and many-body systems as complex extensions—we argue that many-body systems constitute the non-local default structure of physical reality.

In this framework, many-body systems are intrinsically non-local, characterized by irreducible correlations, asynchronous updates, and residual relational structures that cannot be eliminated by spatial localization. Two-body systems emerge as exceptional local configurations, in which symmetry, conservation laws, and analytical solvability temporarily hold. One-body descriptions represent typical local limits associated with observation and embodiment.

Re-examining the historical development of physics under this reordering, we show that several contemporary conceptual difficulties—including the many-body problem, quantum non-locality, dark matter, dark energy, and the arrow of time—can be coherently reinterpreted as consequences of treating exceptional localizations as universal bases.

This many-body–first reconfiguration provides a unified conceptual ground in which non-locality is not an anomaly but the default condition, locality is a derived constraint, and physical laws emerge as contingent stabilizations within a fundamentally relational and non-synchronous structure of reality.

1 Introduction

Modern physics has historically organized its foundational descriptions around systems that are analytically tractable. One-body systems offer idealized locality and direct observability, while two-body systems provide symmetry, conservation laws, and closed-form solutions. Many-body systems, by contrast, have typically been treated as complex extensions of these simpler cases.

In this work, we argue that this hierarchy is inverted at the ontological level. Many-body systems constitute the default structure of physical reality, while one-body and two-body descriptions arise only under exceptional conditions of localization and stabilization. Treating exceptional local cases as universal has obscured the interpretation of several foundational phenomena in contemporary physics.

2 Dark Matter as a Many-Body Non-Local Residual

Dark matter is commonly interpreted as missing mass or as evidence for modified gravitational dynamics. Within a many-body non-local framework, we reinterpret dark matter as a residual effect arising when intrinsically non-local many-body correlations are projected onto locally synchronized two-body descriptions.

This residual does not correspond to a new particle species, but to relational structures that cannot be absorbed by local approximations. Galactic rotation curves and large-scale structure thus reflect many-body non-local residues rather than undiscovered matter components.

3 Dark Energy as Non-Local Lag Pressure

Cosmic acceleration is conventionally attributed to dark energy or a cosmological constant. In the present framework, we interpret this phenomenon as a manifestation of non-local lag pressure: a structural effect produced when non-synchronous many-body updating is constrained into globally synchronized spacetime descriptions.

This lag pressure is not a force but an emergent relational tension arising from enforced synchronization, naturally leading to large-scale acceleration effects.

4 The Arrow of Time as a Projection of Non-Synchronous Many-Body Updating

The arrow of time is often grounded in entropy growth or cosmological initial conditions. Here, we propose that temporal asymmetry arises from projecting inherently non-synchronous many-body updating processes into single-clock local descriptions.

Temporal directionality thus reflects a representational ordering imposed by localization, rather than a fundamental asymmetry of underlying dynamics.

5 General Discussion: Many-Body Ontology and Physical Law

From a many-body ontological standpoint, physical laws are not universal governing principles but emergent regularities that stabilize under specific localization conditions. Symmetry, conservation, and locality arise when many-body interactions align into exceptional configurations.

This perspective does not reject existing physical laws, but repositions them as contingent relational structures rather than fundamental axioms.

6 Conclusion

We have argued that many-body non-locality constitutes the ontological default of physical reality. One-body and two-body descriptions, while indispensable for observation and calculation, represent exceptional localizations rather than universal foundations.

Reinterpreting dark matter, dark energy, and the arrow of time within this framework dissolves several conceptual tensions without introducing ad hoc entities or forces. More broadly, this reconfiguration invites a shift in foundational inquiry: from asking what is missing in our theories to examining which localization assumptions are being imposed.

Future work will focus on formalizing this ontological shift within explicit mathematical frameworks and exploring its observational consequences. The present work provides a conceptual starting point for such developments.

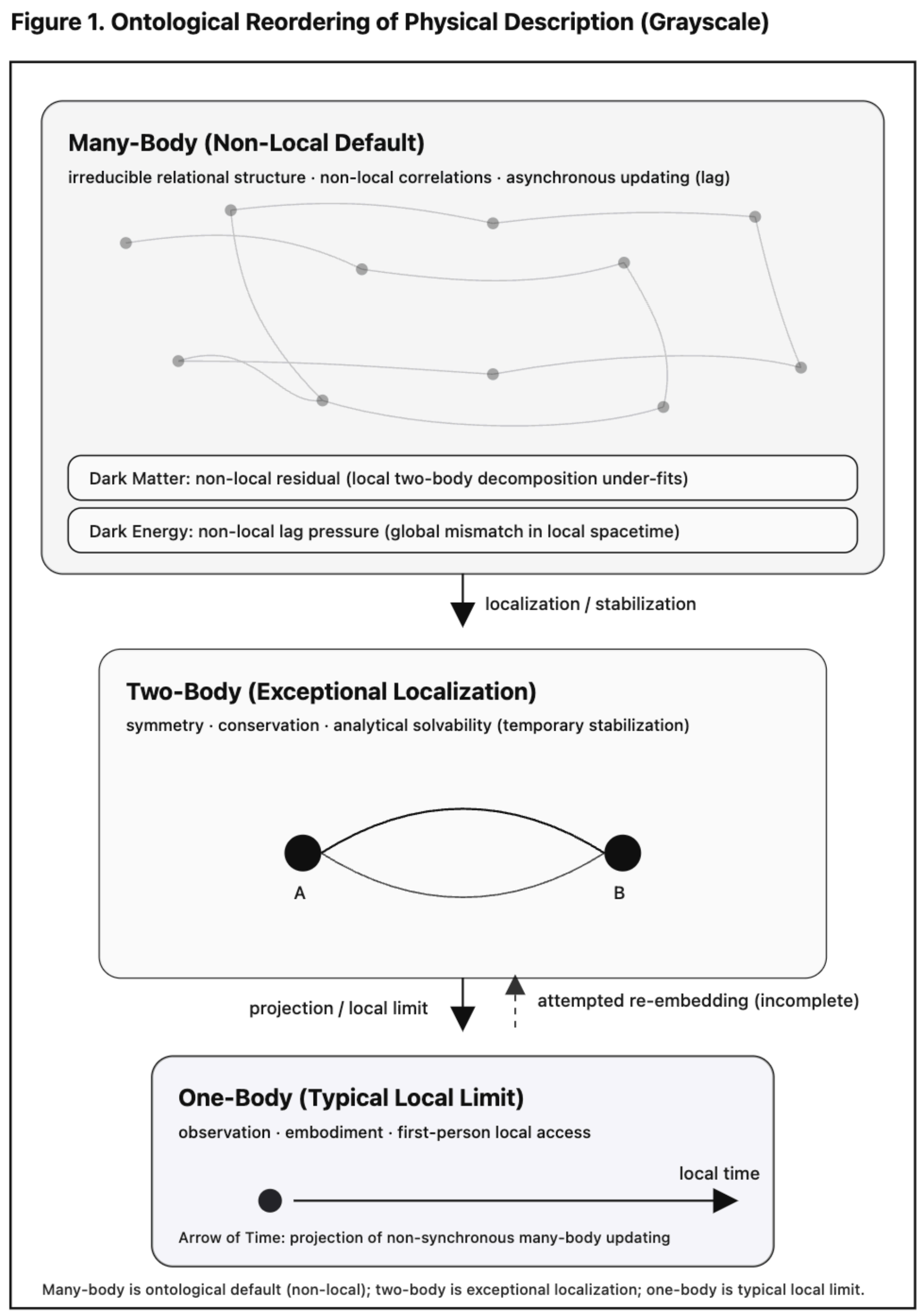

Figure 1: Ontological reordering of physical description. Many-body systems form the non-local default of physical reality. Two-body systems emerge as exceptional local stabilizations enabling symmetry and solvability. One-body descriptions represent typical local observational limits. Dark matter, dark energy, and the arrow of time appear as projection effects under localized and synchronized descriptions.