A Note on Interaction, Cognition, and Epistemic Limits in Physical Theories

Scientific knowledge is obtained through observation, measurement, and inference, all of which are mediated by human cognition and by physical instruments designed, calibrated, and interpreted by humans. As a result, scientific theories do not access reality directly, but instead describe regularities that are accessible through specific modes of interaction. This mediation is not a weakness of science; it is a structural condition under which scientific knowledge is possible.

All physical measurements require interaction between the system under study and a measuring apparatus. Information enters scientific description only insofar as such interactions occur and produce observable effects. Consequently, the domain of scientific inquiry is necessarily restricted to aspects of reality that couple—directly or indirectly—to matter, fields, or spacetime structures that our instruments and cognition can register. Where no interaction exists, no information can be transmitted, and no empirical distinction can be made.

From an epistemic standpoint, any hypothetical aspect of reality that does not interact with observable systems is indistinguishable from non-existence. This statement does not assert that such aspects do or do not exist; rather, it defines a boundary on what can be meaningfully known or modeled within an empirical scientific framework. Science cannot adjudicate questions that lie entirely outside the space of interaction and information exchange.

To illustrate this boundary, consider a purely hypothetical example: suppose there existed a form of energy or field that does not couple to known particles, forces, or spacetime degrees of freedom in any detectable way. Such an entity would produce no observable effect on matter, no measurable signal in detectors, and no influence on experimental outcomes. Even if it were postulated to “exist,” it would carry no information accessible to observation. Epistemically, such an entity would be indistinguishable from non-existence. This example is not a proposal of new physics, but a demonstration of how interaction defines the limits of knowledge.

This observation has implications for how scientific theories are interpreted. Empirical success—predictive accuracy, internal consistency, and technological utility—does not entail ontological completeness. A theory may correctly describe all observable phenomena within its domain while remaining a representation shaped by cognitive constraints, experimental access, and chosen abstractions. Historical cases, such as classical mechanics or thermodynamics, show that highly successful theories can later be understood as effective descriptions rather than final accounts of reality’s structure.

Quantum mechanics, despite its extraordinary empirical success, does not escape this general condition. Its formalism provides a precise and reliable framework for predicting outcomes of measurements, yet its interpretation remains underdetermined by experiment alone. This suggests that the question of whether a theory reflects reality “as it is” may be less well-posed than the question of whether it provides a consistent and effective interface between interaction and prediction.

This note does not propose new physical principles, hidden entities, or revisions to established theories. Nor does it imply that interacting aspects of reality are unknowable or that scientific progress is fundamentally limited. Its purpose is only to mark an epistemic boundary: scientific theories describe reality insofar as reality is accessible through interaction, measurement, and cognition. Beyond that boundary, statements about existence or structure lose empirical content.

Recognizing this limit is not a retreat from science, but a safeguard against category errors. It clarifies what scientific knowledge can legitimately claim while preserving the distinction between effective description and ontological assertion. This note is therefore intended as a conceptual marker rather than a thesis, and as a reminder of the conditions under which scientific understanding is possible.