Peer Review

Review of: "Some Mathematical Issues Regarding a New Approach Towards Quantum Foundations"

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Prof. Helland proposes a **minimalist mathematical framework** for quantum theory based on **theoretical variables**—some accessible, some inaccessible—attached to observers or groups of observers. This leads naturally to an **epistemic interpretation** of quantum mechanics, where quantum theory describes knowledge about reality rather than reality itself.

The two versions of Inge S. Helland's paper differ primarily in their **mathematical assumptions**, **technical refinements**, and **clarity of exposition**.

The earlier version assumed a **multivariate representation** $U\cdot$ with specific properties to derive the Hilbert space formalism. The newer version shows that such a representation can be **constructed explicitly**, making the assumption **unnecessary**. This leads to a **weaker and more general theorem**. Furthermore, this version emphasizes that the theory is **epistemic**, with variables tied to the **mind of the observer** or a **communicating group**.

In addition, the earlier version touched briefly on applications to decision theory and the Bell experiment, while the newer version formalizes cognitive limitations via **Corollaries**:

- Observers cannot simultaneously entertain certain unrelated maximal variables.
- This limitation explains **CHSH inequality violations** and informs **quantum decision theory**.

Despite various improvements, **Helland's epistemic interpretation**—like other quantum mechanics (QM) interpretations—still has unresolved issues regarding **logical structure**, **self-consistency**, and **simplicity**.

Here's a structured critique.

Criterion	*Description*
Logical Structure	Internal coherence and deductive rigor of the interpretation.
Self-Consistency	Absence of contradictions within the framework and with known physics.
Simplicity	Parsimony in assumptions and mathematical formalism.

Evaluation of criteria

Strengths and Deficiencies

Minimalist Derivation	Derives Hilbert space formalism from symmetry and complementarity, avoiding ontological commitments.
Epistemic Clarity	Frames QM as a theory of knowledge, not reality—aligning with Bayesian and QBist traditions.
Intersubjective Objectivity	Introduces observer groups to generalize QBism, offering a novel epistemic structure.

Strengths

Issue	*Description*
Measurement Problem	Helland's framework does not offer a physical mechanism for wavefunction collapse or definite outcomes. It reframes the problem epistemically but does not resolve it ontologically.
Fine-Tuning	Like other epistemic models, it inherits the issue of unexplained parameter choices (e.g., Born rule derivation, symmetry group selection) that appear "tuned" to yield quantum behaviour.
Logical Inconsistencies	Weak measurement schemes and postselection can lead to contradictions in certain setups (e.g., Vaidman's three-box paradox), challenging the internal consistency of epistemic interpretations.
No Ontological Resolution	Avoids realism, but this evasion leaves open questions about what quantum systems "are" when not observed.
Limited Scope	While elegant for finite-dimensional systems and decision theory, it's unclear how Helland's approach scales to quantum field theory or gravity.

Deficiencies

Interpretation	*Measurement Problem*	*Fine-Tuning*	*Logical Issues*
Copenhagen	Conceals collapse; lacks mechanism	Implicit in wavefunction postulates	Ambiguous ontology
Many-Worlds	Avoids collapse; introduces branching	Requires precise decoherence	Ontological extravagance
de Broglie–Bohm	Deterministic trajectories	Nonlocality is fine-tuned	Conflicts with relativity
QBism	Subjective collapse; avoids ontology	Agent-based probabilities	Limited intersubjectivity
Helland	Epistemic reframing; no collapse mechanism	Symmetry assumptions may be fine-tuned	Weak measurement paradoxes

Comparative Perspective

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No interpretation fully resolves all foundational issues. Helland's approach reframes rather than solves the measurement problem and inherits fine-tuning and scalability concerns.

Philosophical Implications

Helland's interpretation contributes to a growing movement that views quantum mechanics as a **theory of knowledge**, not of reality. It aligns with cognitive science and decision theory, suggesting that quantum structure reflects **limits of human cognition and intersubjective consensus**.

However, reframing foundational problems epistemically does not eliminate their physical relevance. The absence of a collapse mechanism or ontological account of quantum systems remains a critical gap.

Conclusion

Helland's epistemic interpretation offers a **logically elegant and minimalist** framework that deepens our understanding of quantum formalism. It generalizes QBism and introduces novel cognitive constraints. **Yet, like all interpretations, it faces unresolved deficiencies**:

- Measurement remains epistemically reframed but physically unexplained.
- Fine-tuning and symmetry choices lack deeper justification.
- Ontological questions are deferred rather than answered.

We recommend Prof. Helland examine if his framework extends to field-theoretic regimes, whether its assumptions have deeper foundations, and how it addresses paradoxes from contextuality and weak measurements.

Declarations

Potential competing interests: No potential competing interests to declare.