

Epistemic values and realism in quantum mechanics

The case of contemporary solutions to the EPR
controversy

X international ontology congress
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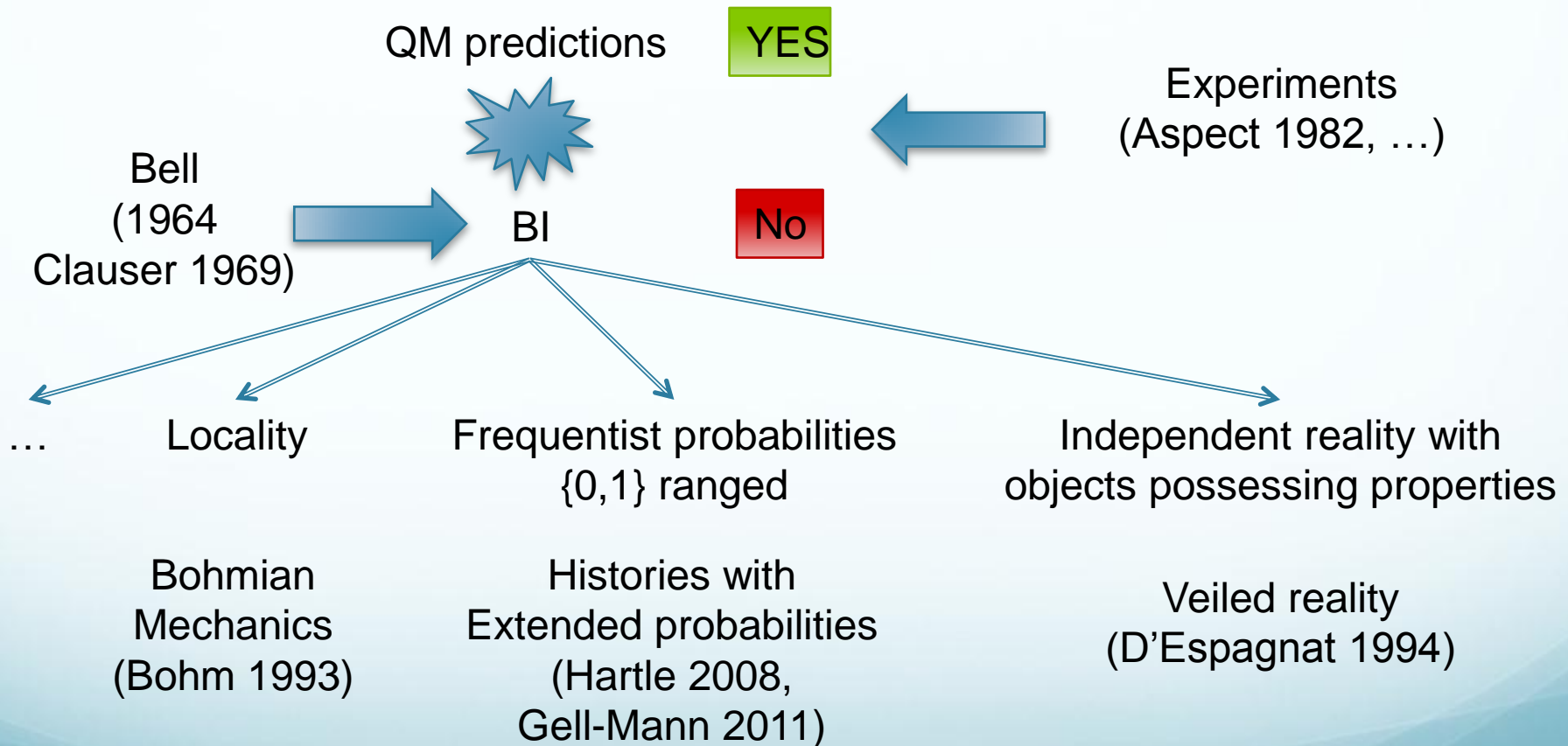


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★ EPR, Bohr and the Bell's inequalities:



★ Bohmian Mechanics:

Wave function $\psi(q, t) : (\mathbb{R}^{3N}, \mathbb{R}) \rightarrow \mathbb{C}$

Additional variables $Q(t) : N \text{ functions } \mathbb{R} \rightarrow \mathbb{R}^3$

Schrödinger equation

$$i\hbar \frac{\partial \psi}{\partial t} = H\psi$$

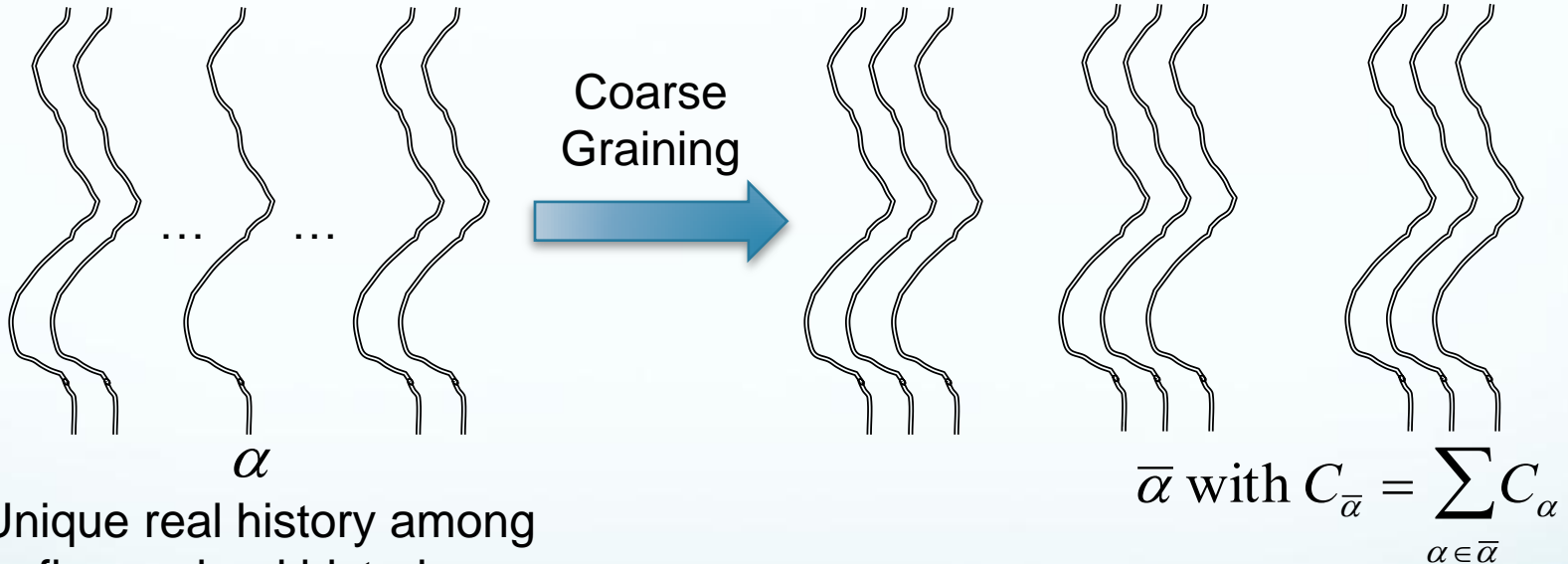
Velocity field

$$\frac{dQ}{dt} \equiv v_1^\psi \mathbf{K} v_N^\psi \text{ with } v_k^\psi = \frac{\hbar}{m_k} \text{Im} \frac{\nabla_k \psi}{\psi}$$

★ Histories with EP:

$$\text{History } (t_1, \dots, t_N): \quad \alpha = (\alpha_1, \mathbf{K}, \alpha_n), \quad C_\alpha = P_{\alpha_n}^n(t_n) \mathbf{K} P_{\alpha_1}^1(t_1)$$

Family = exhaustive set of histories:



Coarse-grained Histories

In general:

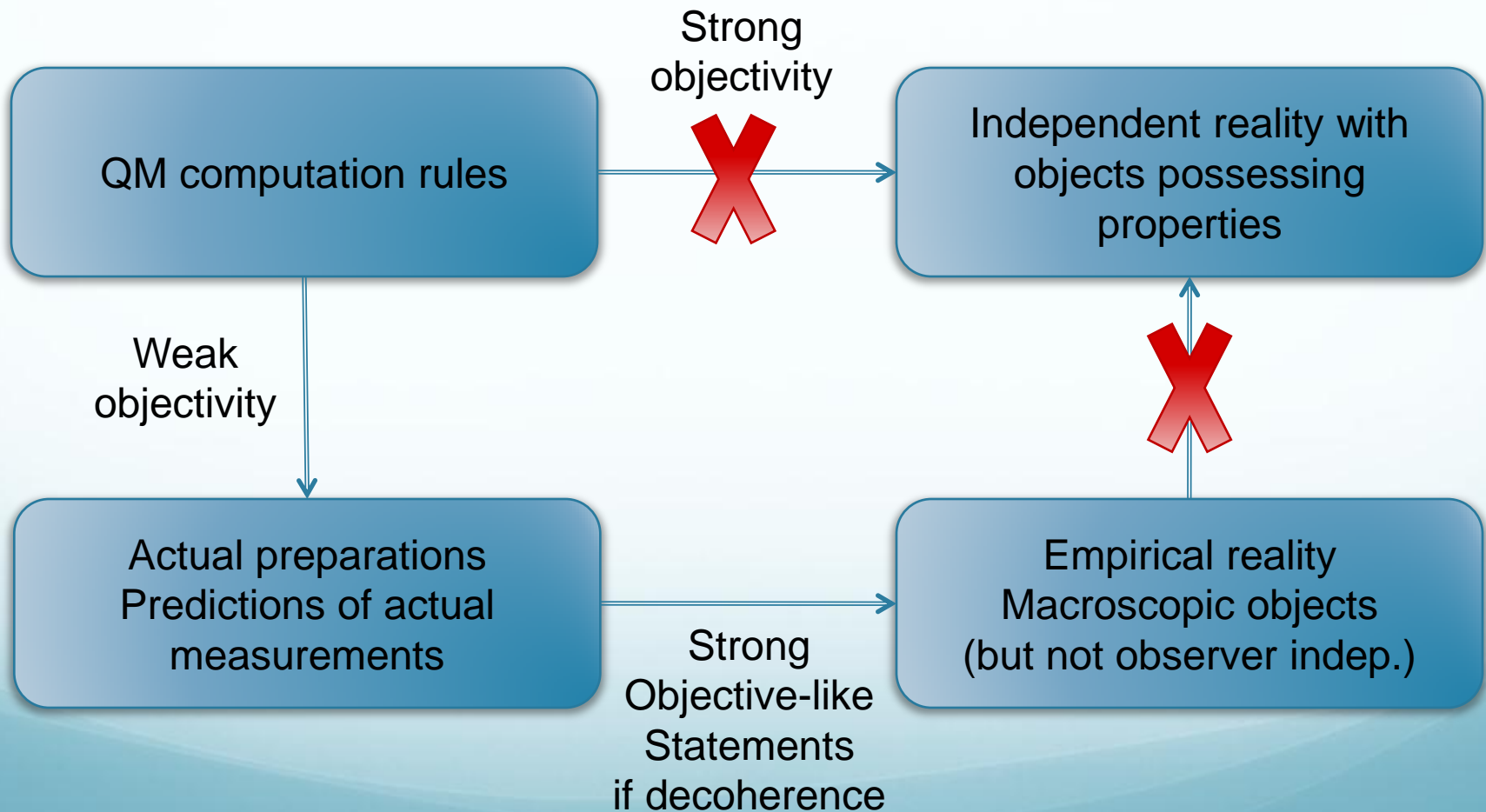
$$P_\alpha = \text{Re}(\langle \psi | C_\alpha | \psi \rangle) \notin \{0,1\}$$

Quantum interferences

$$P_{\bar{\alpha}} \in \{0,1\}$$

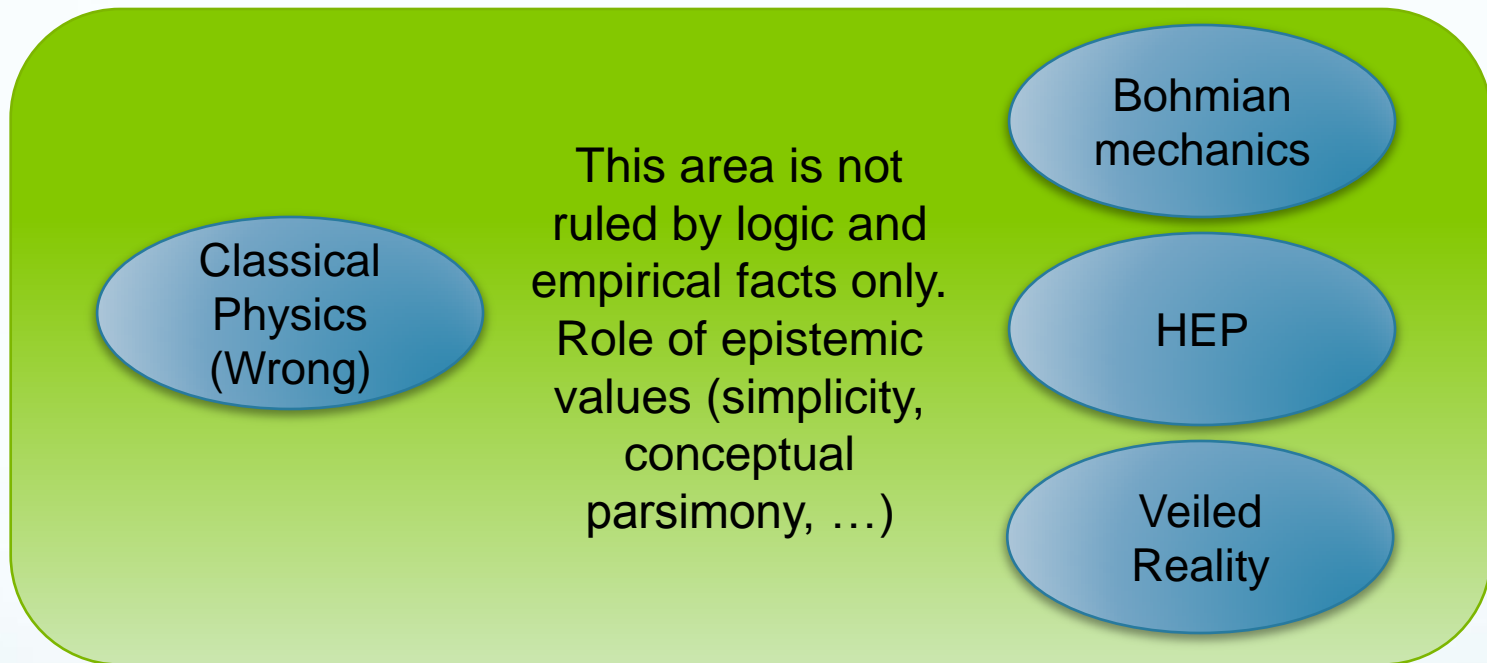
Decoherent Histories

★ The veiled reality:



Epistemic Values (1/2)

★ Kuhnian conception on paradigm change:



Set of epistemic values for classical physics:

- Ontological reference
- Consistency between theories
- Logical consistency
- Conceptual parsimony, ...
- Empirical adequacy

Premises of BI

Conflict in quantum system context with



Epistemic Values (2/2)

★ Reorganization in the selected approaches:

Bohmian mechanics:

- ★ Reality composed by particles possessing properties → Ontological reference.
- ★ $v_k^{\psi} \propto f(\nabla \psi)$, non locality → Not consistent with relativity

Histories with extended probabilities:

- ★ Real fine-grained history not knowable in principle (part of an out ranged set) + access only to coarse-grained information conceived as instructions for bets (Bayesian conception) → No ontological reference (only indirect talk)
- ★ Coarse graining washes out the non-local effects → consistent with relativity

Veiled reality:

- ★ Direct talk about empirical reality or only weak objectivity
 - No ontological reference (reality defined with respect to observer characteristics)
 - Consistency with relativity

Realism (1/2)

★ Philosophical issues with ontological reference (link with Putnam):

Externalist perspective:

- God's eye point of view
- Correspondentist conception of truth

Pb: unexplainable reference relationship

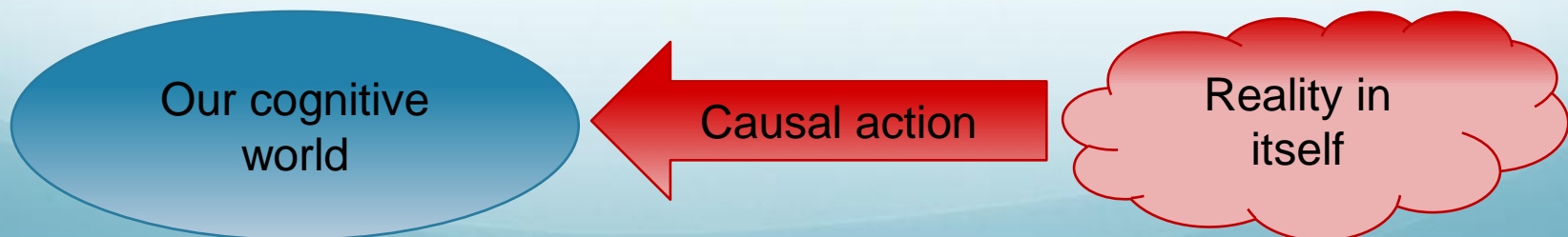
Internalist perspective:

- No God's eye point of view
- Truth as verification under "sufficiently good epistemic conditions"

Problem



Part of the problem can be related to the "Causal Theory of perception":



★ Causal Theory of perception (CTP):

Quantum World

?

Our macroscopic world

Through decoherence

Bohmian mechanics:

3N dimension WF

→ usual 3D behavior (free of non-local effects)

Histories with EP:

Out-ranged probabilities → well
 {0,1} ranged probabilities

Veiled reality:

Improper mixtures (Q statistics)

→ proper mixtures (classical statistics)

+ Validity of a strong objective-like talk about the empirical reality



Realism (2/2)

Externalist perspective

Q world = Reality



Quasiclassical description
(negl. $\neq 0$)

Approximately classical
description

Macroscopic world as a
very good illusion (fapp)

CTP implied

Approximate connection with our day-to-day experience

Internalist perspective

QM = talk about actual
measurements (ref to the obs)



Rigorous classical description
(negligible become =0)

But only about the empirical
reality (ref. to obs. charac.)

Robust empirical reality

Possibility to escape CTP
Rigorous connection



Conclusion

	Bohmian mechanics	Histories with Extended probabilities	Veiled reality
Ontological reference	YES	NO (only indirect)	NO (empirical reality)
Consistency with relativity	NO	YES	YES
Connection with day-to-day life (also consistency with other scientific theory – common starting point)	Approximate	Approximate	Rigorous

Externalist vs. internalist perspective	Externalist	Externalist	Internalist
Causal Theory of perception	Implied	Implied	Rejection possible

Eskerrik asko zure arretagatik

Gracias por su atención

Thank you for you attention

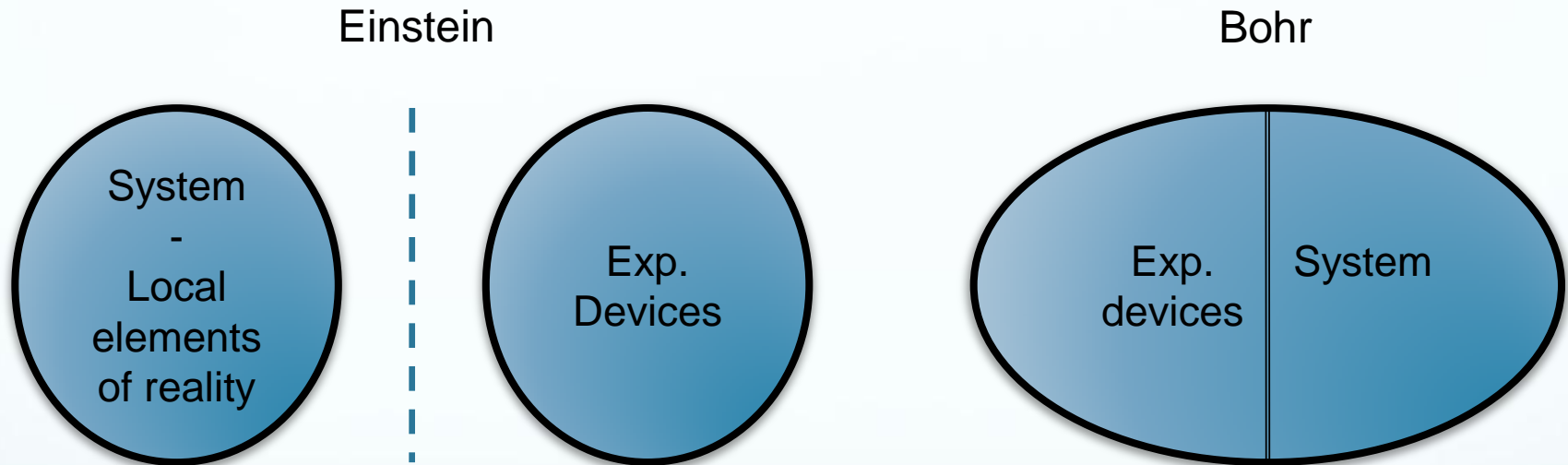


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★ The EPR controversy:



EPR theorem:

QM predictions
+
Einstein view on reality



QM is incomplete



Realism (2/3)

★ Externalist vs. internalist perspective:

Bohmian mechanics:

- ★ Additional variables describe particles and their properties existing independently

→ Externalist perspective

Histories with extended probabilities:

- ★ Claim about a unique unknowable (in principle) real fine grained history

→ Externalist perspective

Veiled reality:

- ★ QM provides only weak objective statements or strong objective-like statements restricted to an empirical reality defined in connection with observer characteristics

→ Internalist perspective



★ GRW Approach ?

- ★ Spontaneous collapse.
- ★ Ontological reference?
 - ★ Mass densities \rightarrow non local
 - ★ Flash ontology (Bell), particles exist only when WF collapses.

Lorentz invariant and not incompatible with ontological reference, but not a reality made with objects possessing properties at each instant.