UFPR
UNIVERSIDADE FEDERAL DO PARANÁ

An ontological approach to (non)locality

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Group: Foundations of Quantum Mechanics

Outline

1. Motivation

2. Classical, quantum and Bohmian mechanics in a nutshell
   - Quantum mechanics
   - Bohmian mechanics

3. An ontological approach to locality
   - Newton's (non)locality
   - Bell's (non)locality

4. Conclusion
   - The pivotal role of ontology to locality

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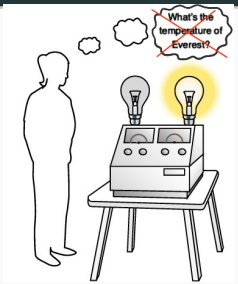
- Locality guarantees Separability: a theory in disagreement with Locality wouldn't permit independent statements concerning subsystems and, therefore, wouldn't be empirically falsifiable.



Insofar as her lab is not in the Everest, she doesn't need to consider its temperature in the experiments.

Locality makes Alice's life (and empirical science) much easier.

Classical, quantum and Bohmian mechanics in a nutshell

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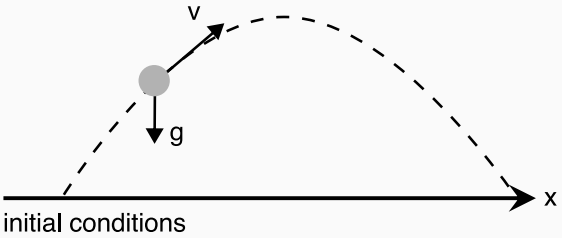

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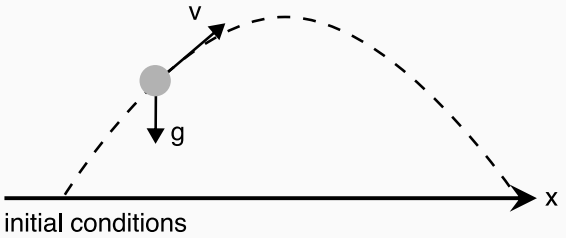

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Two centuries forward in time...

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  - Solution: quantum wave-particle duality.

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- Device:
  - Light source (S);
  - Opaque screen (P) with slits ($F_{1(2)}$);
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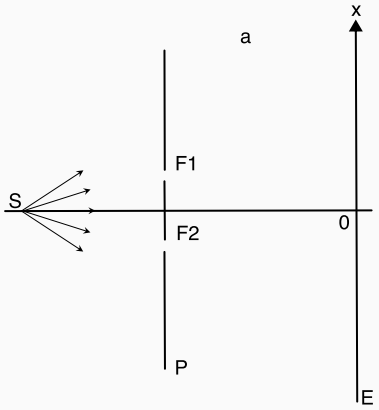

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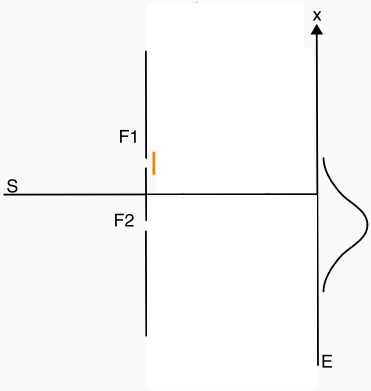

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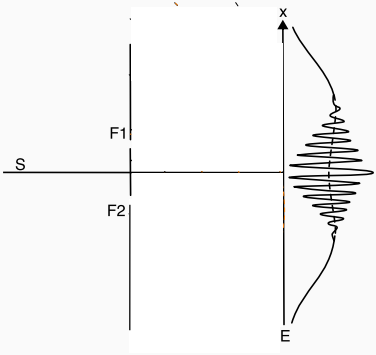

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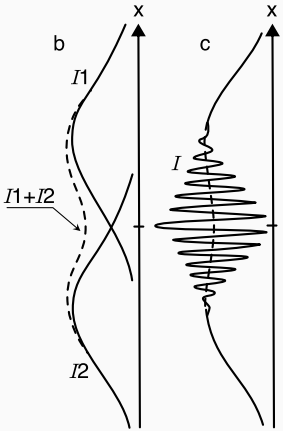

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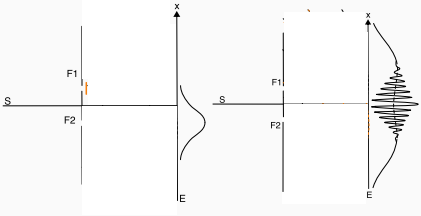

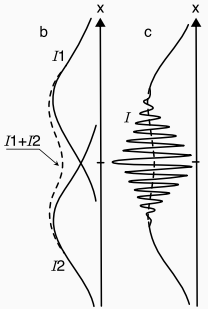

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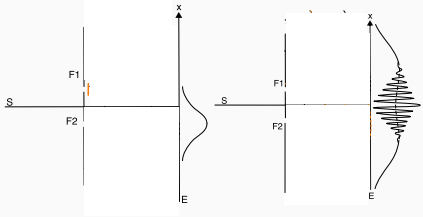

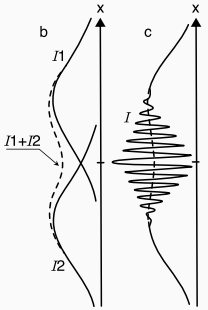

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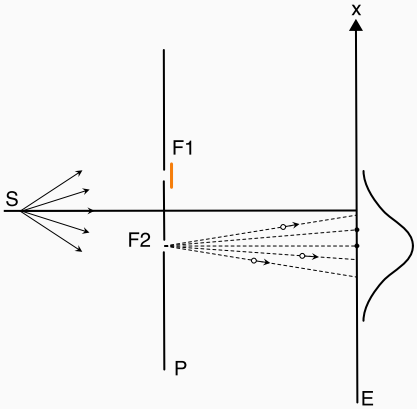

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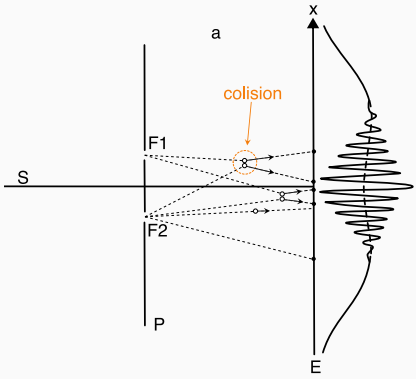

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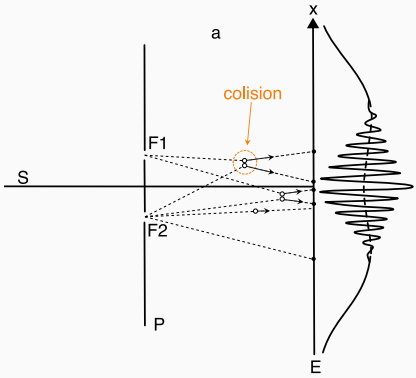

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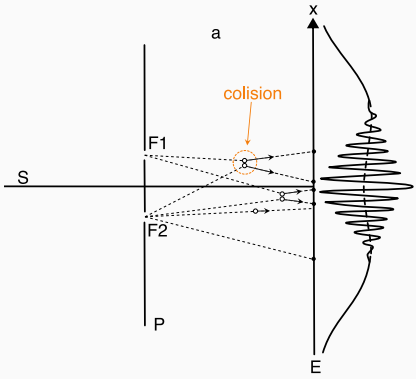

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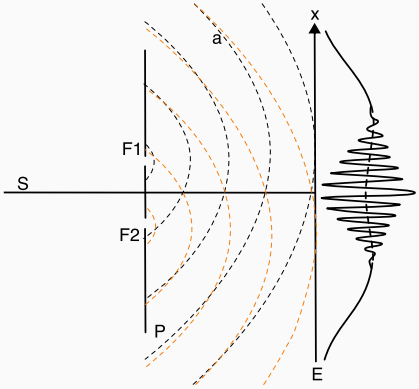

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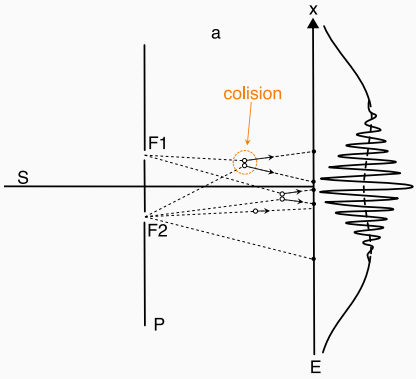

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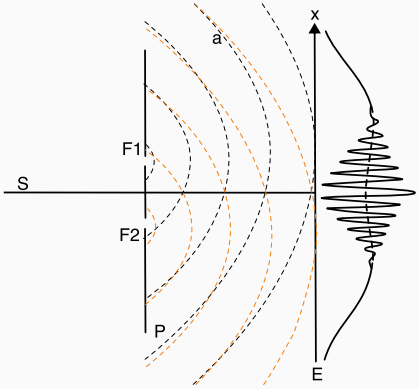

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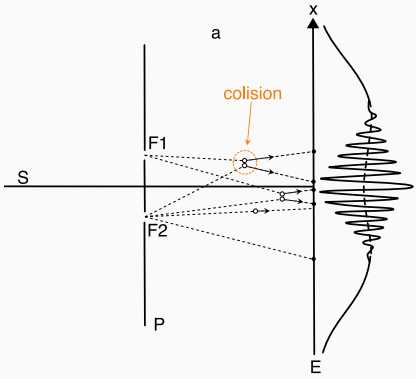

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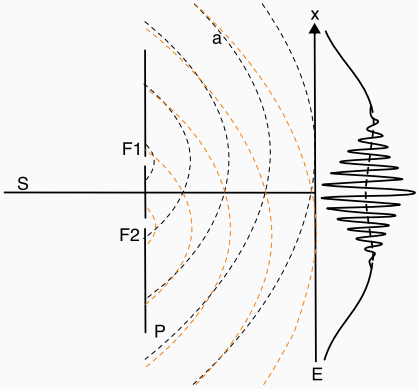
  - The interference pattern is the result of two overlapping circular waves.



What do these models predict when the source of light is so *weak*? (photons emitted one by one)

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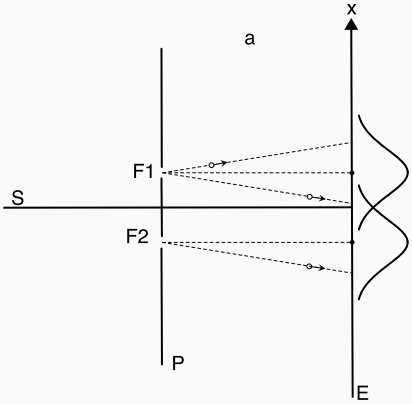
- Since just a single photon crosses the slits each time, there's nothing for the photon to interact with;
- *The interference pattern will disappear.*



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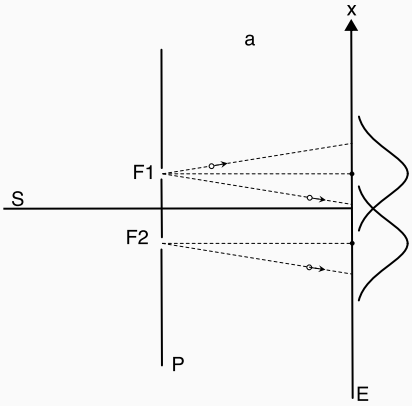

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- Diminishing the intensity of the source will simply cause the pattern to diminish in intensity, never vanishing.
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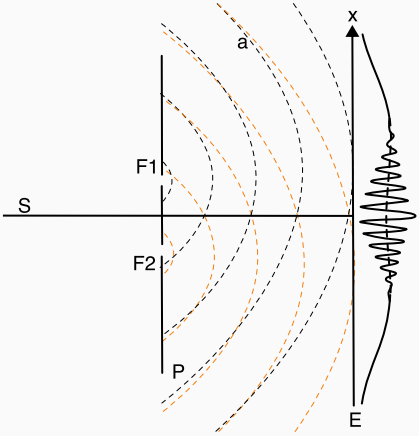

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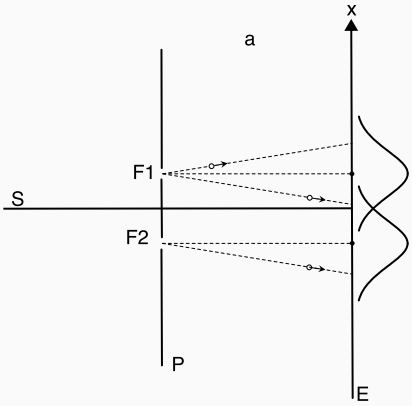

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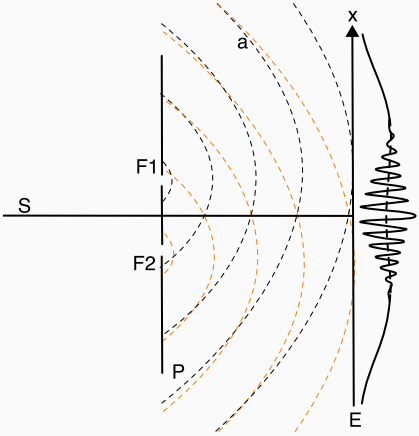

But, what actually happens when S emits photons practically one by one?

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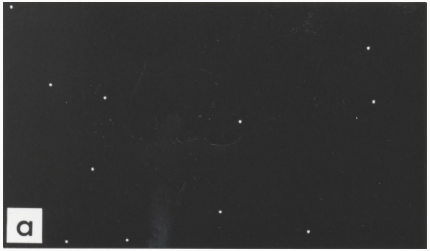

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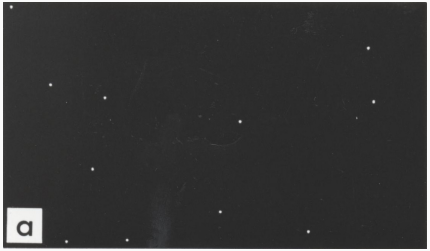

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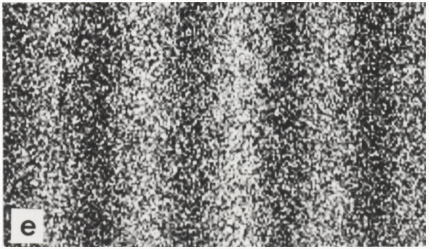

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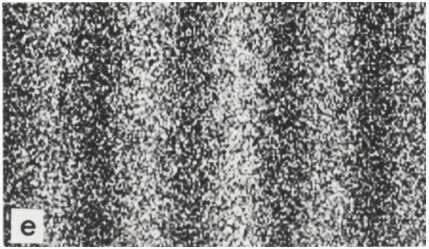

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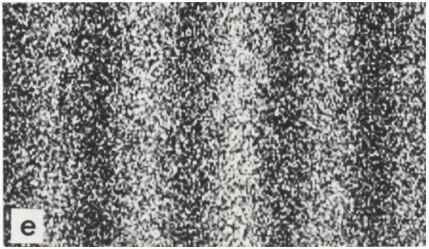

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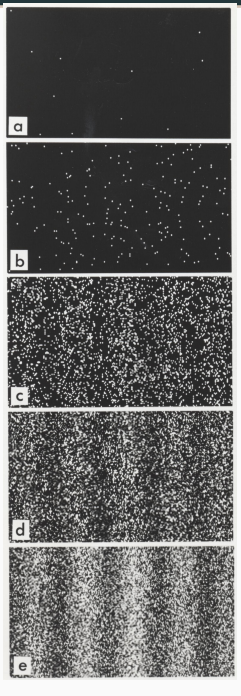

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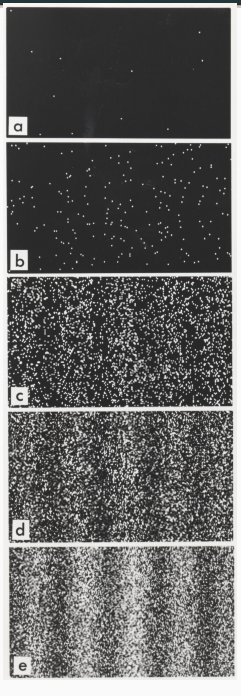

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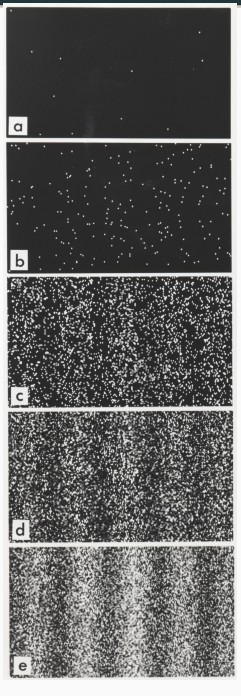

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But, how?!

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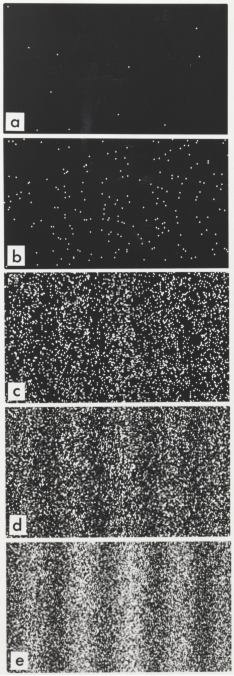

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Bohmian mechanics:

The quantum domain is made of particles with well-defined trajectories.

Bohmian mechanics (BM)

BM is remarkably simple and elegant!

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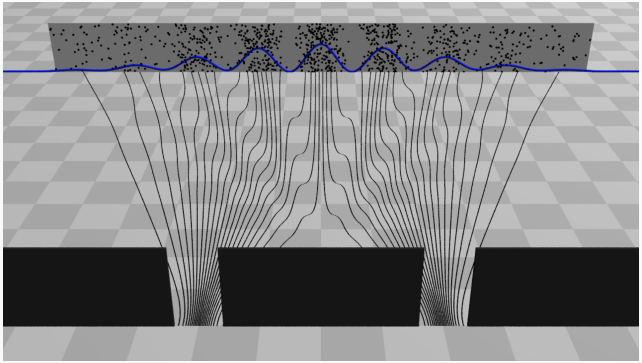

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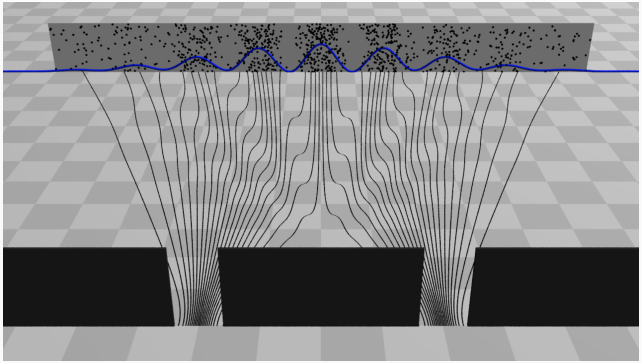

Bohm's ontology:

- We don't need to give up on primitive notions (e.g., particle and wave) in the quantum domain;
- Broader quantum system $\Rightarrow$ broader notion of locality.

An ontological approach to locality

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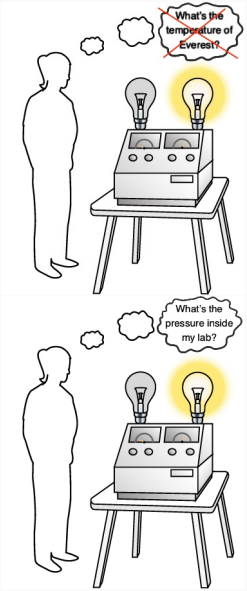
Locality

A physical object is influenced directly only by its immediate surroundings.

The principle of local action (LA):

For two remote systems (A and B), externally influencing A has no immediate influence on B;

What is meant by *system* and *influence*?



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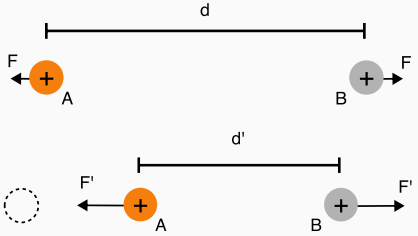

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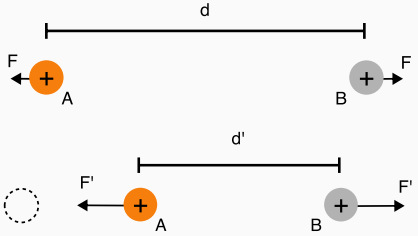

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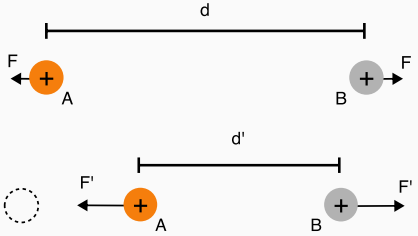

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All reasonable statements, right?

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Again, another hypothesis that seems not to be true: any model able to reproduce the statistics of QM must be non-local.

Conclusion

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- Could this shed light on other fields of science?

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