

# Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: 129

Type: Oral (Non-Student) / Orale (non-étudiant(e))

## The Relativistic Origin of Quantum Indeterminacy

Tuesday 10 June 2025 11:45 (15 minutes)

**Problem:** Indeterminacy is a foundational principle of quantum physics. The fact that pure quantum systems possess properties with no definite single sharp value is a fundamental expression of this quantum indeterminacy. For example, an electron within an atom possesses no definite value of linear momentum. Although, in isolation, indeterminacy is not inherently problematic, there is arguably an inconsistency between quantum indeterminate quantum matter exists of classical relativistic spacetime. We may ask: How is it that indeterminate quantum matter exists within a determinate spacetime? Mariani (1) discusses potential epistemic, semantic and ontological sources of quantum indeterminacy, while Gisin (2) and co-workers have proposed a new principle of "finiteness of information density" as a source of indeterminacy, related to the ontological status of the infinitely precise real numbers.

**Aims:** The aims of this work are to: a) to show that the source of quantum indeterminacy currently stands as an open question; b) to show that there is a fundamental (albeit latent) source of indeterminism arising from the principle of relativity; c) to show that the quantum measurement process has all the properties predicted to manifest this latent indeterminacy.

**Argument in outline:** Within the framework of special relativity, for an ensemble of coexisting inertial observers, there is irreconcilable disagreement on measurements of spatial and temporal intervals. For a classical system, observers remain independent so can "agree to disagree", and the conflict is benign and essentially just epistemic. However, in the corresponding quantum scenario (with each observer now part of one momentum superposition) disagreement at the observer level entails indeterminacy for the system as a whole. The argument turns on issues of spacetime ontology, quantum interpretation and quantum reference frames. **Discussion:** In summary, it is proposed that long familiar relativistic disagreements emerge as the fundamental source of quantum indeterminacy. This is part of a program on a many-spaces quantum spacetime (Sharp, 2024).

#### **References:**

(1) Mariani, The Determinacy Problem in Quantum Mechanics. Foundations of Physics (2024) 54:73

- (2) Del Santo and Gisin 2021, The relativity of indeterminacy arXiv:2101.04134v1).
- (3) A Universe of Spaces (Amazon) J.C. Sharp (2024)

#### Keyword-1

Quantum Foundations

#### Keyword-2

Spacetime

### Keyword-3

Quantum Reference Frames

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Session Classification: (DQI) T1-11 | (DIQ)

**Track Classification:** Technical Sessions / Sessions techniques: Division for Quantum Information / Division de l'information quantique (DQI / DIQ)