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Relativity of Quantum Correlations: Invariant Quantities and Frame-Dependent Measures

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Viewing frames of reference as physical systems, subject to the same laws as the systems they describe, is central to the relational approach in physics. Under the assumption that quantum mechanics universally governs all physical entities, this perspective naturally leads to the concept of quantum reference frames (QRFs). In this talk, I will discuss the perspective-dependence of position and momentum uncertainties, correlations, covariance matrices, and entanglement within the spatiotemporal QRF formalism. We show that the Robertson-Schrödinger uncertainty relations are frame-dependent, and so are correlations and variances, which satisfy various constraints described as inequalities. However, the determinant of the total covariance matrix, linked to the uncertainty volume in phase space, as well as variance-based entanglement criteria, remains invariant under changes of reference frame. Under specific conditions, the purities of subsystems are also invariant for different QRFs, but in general, they are perspective-dependent. These invariants suggest fundamental, robust measures of uncertainty and entanglement that persist despite changes in observational perspective, potentially inspiring dedicated quantum information protocols as well as further foundational studies. To conclude, I will discuss the generalization and application of the presented results within relativistic frameworks.

Primary author: SULEYMANOV, Michael (Bar-Ilan University)

Presenter: SULEYMANOV, Michael (Bar-Ilan University)

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