ICFO

SEMINAR: Measurement Incompatibility Revisited: How State Preparations Shape Quantum Incompatibility

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15:30 to 16:00
Seminar Room

Measurement incompatibility lies at the heart of many quantum advantages and is commonly regarded as an intrinsic property of a set of quantum observables. In this work, we revisit this viewpoint by showing that both the manifestation and the relative strength of incompatibility can depend crucially on how the available quantum systems are prepared. We first investigate qubit spin observables accessed through pairs of spin-1/2 particles prepared in different configurations. In the parallel configuration, where the two spins are prepared identically, the usual restrictions imposed by noncommuting observables remain. Remarkably, in the antiparallel configuration, where one spin is paired with its flipped counterpart, these restrictions can be substantially relaxed: three mutually orthogonal spin components can be predicted simultaneously and exactly. We further explore how this enhanced compatibility extends to larger families of observables and more general state configurations, and discuss connections with quantum retrodiction and information-processing tasks. Going beyond these specific examples, we ask whether incompatible sets of observables admit an intrinsic hierarchy that remains independent of the available preparation resources. We show that this is not the case. Our No-Comparison Theorem establishes that no universal ordering of incompatible sets is preserved across all finite-copy configurations. In particular, two sets of spin observables can reverse their relative degree of incompatibility simply by changing the preparation from identical copies to parallel-antiparallel pairs. Together, these results reveal a configuration-dependent structure of quantum incompatibility, showing that it is determined not only by the observables themselves but also by the global arrangement of the quantum probes used to access them.

Hosted by: Prof. Dr. Antonio Acin