Quantum Incompatibility in Parallel vs Antiparallel Spins

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We investigate the joint measurability of incompatible quantum observables on ensembles of parallel and antiparallel spin pairs. In parallel configuration, two systems are identically prepared, whereas in antiparallel configuration each system is paired with its spin-flipped counterpart. We demonstrate that the antiparallel configuration enables exact simultaneous prediction of three mutually orthogonal spin components—an advantage unattainable in the parallel case. As we show, this enhanced measurement compatibility in antiparallel configuration is better explained within the framework of generalized probabilistic theories, which allow a broader class of composite structures while preserving quantum descriptions at the subsystem level. Furthermore, this approach extends the study of measurement incompatibility to more general configurations beyond just the parallel and antiparallel cases, providing deeper insights into the boundary between physical and unphysical quantum state evolutions. To this end, we discuss how the enhanced measurement compatibility in antiparallel configuration can be observed on a finite ensemble of qubit states, paving the way for an experimental demonstration of this advantage.