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Optimal Experimental Detection and Characterization of SU(2) Decoherence LEE A. ROZEMA, ARDAVAN DARABI, DYLAN H. MAHLER, AEPHRAIM M. STEINBERG, Centre for Quantum Information and Quantum Control, and Institute for Optical Sciences, Department of Physics, University of Toronto, ROBIN BLUME-KOHOUT, Theoretical Division, Los Alamos National Lab & CQuIC, University of New Mexico — Quantum metrology is the art of measuring tiny forces by preparing quantum states, then measuring how much they get displaced by the force. The resulting precision often exceeds classical limits. The best state depends on what we want to detect. N00N states [1] are optimal for U(1) phase shifts. Measuring arbitrary dynamical shifts requires quantum process tomography (QPT)[3], in which the process is applied to a complete set of input states. In this work, we experimentally study the important intermediate case of SU(2) decoherence (SD), fluctuating SU(2) rotations, by probing it with biphotons [2]. We show that N00N states are optimal for detecting SD. Then, we turn to QPT, and examine how accurately SU(2)-covariant sets of states can identify SD. The set of spin-coherent states (generated by SU(2)-displacements of a "highest-weight" state) are sufficient for QPT [4], but exponentially insensitive to some parameters. We show that N00N states (though optimal at detecting SD) generate even less effective input sets, with zero sensitivity to some parameters. Finally, we show evidence that optimal input sets are 2-designs, which can be generated from a fiducial state and SU(2) rotations.

[1] PRL 85,2733(2000) [2] Nature 457,67(2009) [3] PRL 91,120402(2003) [4] Science 322,563(2008)

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