Title:	Experimental studies of quantum contextuality and non locality on an NMR quantum information processor
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Abstract:	This thesis focuses on the experimental study of foundational concepts of quantum theory such as quantum contextuality, and nonlocality on an nuclear magnetic reso- nance (NMR) quantum information processor. Contextuality and nonlocality are cru- cial aspects of quantum mechanics, and their existence demonstrates the fundamental departure from the classical theories such as hidden variable theories. Nonlocality and quantum contextuality can be revealed via a violation of non-contextual inequalities such as the Klyachko-Can-Binicioglu-Shumovski (KCBS) inequality and Bell-type in- equalities such as the Clauser-Horne-Shimony-Holt (CHSH) inequality, respectively. These fundamental ideas have emerged as a crucial tool for enhancing computation and establishing secure quantum communications. Monogamy relationships can be used to examine quantum contextuality and nonlocality simultaneously. Numerous quan- tum information tasks, such as secure communication, self-testing, and randomness certification, have found extensive use for monogamy of correlations. One of the major areas of focus in experimental quantum computing is the experi- mental study of the above quantum correlations. This thesis aims to conduct an exper- imental study of quantum contextual correlations, nonlocal correlations, and monog- amous relationships of these quantum correlations on an NMR quantum information processor. Different types of experimental schemes, suitable for the NMR experimen- tal set-up, have been developed that enable the precise measurement of the relevant observables. Experimental demonstration of fully contextual quantum correlations has been successfully experimentally demonstrated on two-qubit and three-qubit states. A generalized quantum scattering circuit is presented which can be used to perform a non-invasive measurement. Further, Peres-Mermin (PM) inequality is successfully experimentally demonstrated on a three-qubit system. The monogamy relationship be- tween contextuality and nonlocality has been successfully demonstrated on a ququart- qubit system using three NMR qubits. The theoretical protocol has also been developed to evaluate monogamy relationships of entropic non-contextuality (ENC) inequalities, and the theoretical results have been verified experimentally. Finally, experimental im- plementation of variational quantum algorithms is employed to predict the molecular ground-state energy of the H_2 molecule.
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