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Thesis: **"THEORETICAL STUDY OF MULTIPARTITE QUANTUM CORRELATIONS IN A NON-LINEAR SYSTEM "**

Summary:

In recent years, Quantum Mechanics has gained notoriety for challenging our most basic intuition and prior knowledge of the Natural world. Some of the topics that have sparked plenty of interest among the scientific community, as well as the general public, are the so called quantum non-local correlations, from which the better known is quantum entanglement. These intriguing phenomena relate physical entities that are spatially separated and make them behave as a single system in a seemingly instantaneous fashion. Furthermore, quantum non-local correlations are not only relevant in a philosophical sense, they also constitute a fundamental resource for future technologies with applications far beyond our current perspective.

Nevertheless, multipartite quantum correlations have only been recently investigated and still there is plenty of research needed to properly understand them. In this work we strive to contribute to this generation of knowledge by studying the Hamiltonian of a non-linear system in a resonance condition that is believed to correlate four modes of light. Our contribution is focused on attempting to certify multipartite quantum correlations using a specific methodology. More specifically, our analysis is made using mathematical tools known as phase-space methods, in particular one of these, which is called the positive-P representation. We compare our results by performing a similar analysis using the Heisenberg evolution equations. Afterwards, we use these results to test for two quantum non-local correlations, namely, entanglement and steering and we do so by employing mathematical criteria called witnesses. We found the presence of both of these quantum correlations in a regime characterized by the quotient between two quantities, called the coupling parameters..