**Title:** Interference and correlation effects in multimode quantum systems

Sub-title: Multimode systems

KEYWORDS: Interference, quantum computing, multimode systems.

Supervisors: Dr A Konstadopoulou (principal), Prof A Vourdas.

## Abstract

The purpose of this thesis is the theoretical study of interference and correlation effects in multimode and continuum mode quantum systems. We are concerned with interference effects in multiport devices which in a sense are generalised Mach-Zehnder interferometers. It is shown how these multimode devices can be employed for the study of negative result and interaction free measurements.
Interference and coherence effects are also studied in relation to the radiation fields generated by atoms through the process of spontaneous emission. Besides first order interference, higher order coherence effects are investigated with the aid of Glauber's photodetection theory and it is found that detectors that lie in spacelike regions may display nonclassical correlations under certain conditions.
It is well known that the vanishing of field commutators between regions that cannot be connected by subluminal signals reflects the locality of quantum field theory. But is it possible that these spacelike regions exhibit correlations that violate Bell type inequalities? This is the main question and principal concern of the thesis and the answer is affirmative, nonclassical correlations between spacelike regions are indeed possible.
A scheme of four detectors that lie in spacelike points was also studied. In this case we do not consider the radiation field but a free scalar field in vacuum state. Nevertheless the virtual quanta of this field may induce nonclassical correlations if the intervals between the detectors are spacelike but small enough. The fundamental reason for this fact is the nonvanishing of the Feynman propagator outside the light cone. Since this propagator is decaying expotentially with the distance it is demonstrated that for large spacelike intervals field correlations obey classical inequalities. We should also note that different inertial observers will agree on the violation or not of these inequalities since the results are manifestly Lorentz invariant.