corner

CORRELATED NOISE ERRORS IN QUANTUM INFORMATION PROCESSING

SEVENTH FRAMEWORK PROGRAMME

FRAMEWORK PROGRAMME COLLABORATIVE PROJECT

Our Goals

The objective of the project is to develop a general framework for the understanding and management of noise effects in quantum information technologies, paying particular attention to the previously unexplored area of correlated noise errors in space and/or time. Such errors arise in many systems, especially in large scale operations. The project reaches beyond the restricted models that are currently used, which are often inapplicable to real physical systems.

This project will address a variety of problems, including questions about the general properties of quantum communication channels, encoding and decoding methods, and the quantum estimation of correlated noise and environments with memory. The final results of the project, obtained through a concerted theoretical and experimental effort, should pave the way towards implementing quantum information processing and communication in realistic physical platforms.

Partners:

Uniwersytet Mikołaja Kopernika w Toruniu

Università degli Studi di Camerino

Universität Paderborn

Università degli studi di Pavia

University of Cambridge

Technische Universiteit Delft

Gottfried Wilhelm Leibniz Universität Hannover

Universität Ulm

University of Strathclyde

CONTACT:

Institute of Physics
Attn Dr Lidia Tańska
Nicolaus Copernicus University

T: +48 [56] 611 33 12
F: +48 [56] 622 53 97

ul. Grudziądzka 5
PL-87-100 Toruń
Poland

corner@fizyka.umk.pl
http://corner.fizyka.umk.pl

Questions & Answers

What are the carriers of quantum information?

Quantum information is stored in (or carried by) the physical states of a quantum-mechanical system, e.g. in the polarization states of a photon, the spin states of an electron, etc.

Can you give an example of a quantum information source and a quantum channel?

A prototypical example of a quantum information source is a highly attenuated laser that emits individual monochromatic photons. The corresponding quantum channel could be an optical fibre.

Why is data compression possible?

Data compression is possible because an information source typically emits some signals (i.e., messages) more frequently than others. In other words, there is redundancy in the information produced by the source, and this can be exploited to achieve data compression.

How can one combat noise in a communication channel?

The basic idea of encoding is to introduce redundancy in the message, so that upon decoding the received message, the receiver can retrieve the original message with a low probability of error, even if part of the message is distorted due to the effect of the noise in the channel.

What properties of light can be used for quantum information processing?

Optical fields are characterized by their wavelength (i.e. colour), propagation direction, and polarization of the field vector. In principle the encoding of quantum information can be accomplished in each of these properties and they may be used simultaneously. The quantum character of a single light beam arises from the fact that the energy of light fields can only exhibit discrete levels with a finite minimal energy level difference. This energy difference defines a single photon. Quantum information in optical carriers can be understood as the information that is encoded onto a single photon.

What is quantum process estimation?

A quantum process can be described as a transformation of input quantum states into output quantum states. For process estimation one prepares an ensemble of known input states and reconstructs the process (e.g. the transmission of the signal through an optical fibre) by analysing the corresponding output states.

Why do correlations between different degrees of freedom of photonic states play an important role for practical systems?

Noise effects are very likely to couple different properties with each other, and these changes cannot be easily separated at the output.

Background

Quantum theory has been the bedrock of the digital information revolution, making possible the development of the laser and the transistor. However, it is now becoming clear that quantum physics could provide us with even more powerful forms of information processing than had previously been envisaged. This quantum information revolution could in principle lead to vastly improved forms of computation and secret communication, enhanced precision measurements, and a greater ability to model and understand exotic materials such as superconductors. The progress of the quantum information revolution, however, is facing one major obstacle: quantum systems tend to be very susceptible to `noise' – unwanted and uncontrolled disturbances from their environment. To make further advances we need to either fight this `quantum noise' effectively, or design efficient schemes that can tolerate or perhaps even be assisted by the noise present.