Improving Detectors Using Quantum Copiers

Why?

- Everyone likes better detectors.
- A practical use for quantum copiers.

What is a quantum copier?

Classical copier: Measures original, then from the results assembles an arbitrary number of copies.

Quantum copier: Does not measure original, but makes a fixed number of copies by some "unseen" quantum mechanical process.

No cloning theorem: Quantum copiers can only make perfect copies if classical copiers can also.

In a lab, only inefficient photodetectors are available.

Simple model of a photon detector

- Model the inefficiency with two parameters η and ξ:
- Probability of detecting a photon if it's there: η
- Probability of a bogus count if there's no photon: $\xi\eta$

Improved photodetector: The setup

- In effect, get a "second chance" to detect the photon.
- Inputs can be either a photon, or vacum.
- Quantum Copier and detectors are imperfect.
- If detectors were perfect, this scheme would give no gain for a lot of work, but in real life they're not.

A simple model of an imperfect quantum copier

- original can be either a photon or a vacum.

- a perfect copier would destroy the original, and make two duplicates.

- model inefficiency by two parameters ε and μ:

- ε is the probability that the copier doesn't stuff up.

- μ determines what happens if the copying is botched. If $\mu = 0$, a stuff-up produces vacum, if $\mu = 1$, a stuff-up produces random noise. Intermediate values of μ give intermediate stuff-up outputs.

How do you quantify how well a detection scheme works?

- A "photon maker" can send some amount of information to the "photon receiver", by encoding it into a binary sequence of signals:
  "photon" or "no-photon".

- If the detectors were perfect, one bit of information per state would be transmitted for optimum encoding.

- A detection scheme has **Effective efficiency** η^e if it allows the same amount of information to be transmitted, as when the receiver has only a simple photodetector with Quantum efficiency η^e, and bogus count probability $\xi = 0$.

Using more copiers to get better results

Thank You