Optical Devices and Quantum Communications in the Presence of Loss and Noise

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Abstract: Quantum communication is useful in cryptographic communication such as key distribution, fair election, and quantum state transmission, etc. There is no doubt that photons will be used as the quantum information carrier. There still are, however, transmission loss and noise, to which quantum information is more sensitive than classical information. As for the loss, most of the quantum memories need visible light whereas 1.5-micron wavelength is necessary to lower the optical fiber loss during transmission. For this, it is necessary to freely convert wavelength of photons while keeping the quantum information, the entanglement, intact. We recently developed such wavelength-conversion technology using PPLN (periodically poled LiNbO3) [1] crystals. As for the noise, the main noise is the optical phase noise. It is possible to remove the phase noise of a photon using DFS (decoherence-free subspace) approach which is a phase-noise insensitive subspace of the Hilbert space spanned by the set of the given photon and prepared ancilla photon(s). The drawback of this idea is that the total efficiency decreases by $T^n$, where $T$ is the optical transmissivity of the channel and $n$ is the number of the photons used for encoding a qubit. We recently achieved, however, to demonstrate our DFS-noise-removing system keeping the efficiency proportional to $T$ itself [2]. We hope that these ideas and experiments will open the new door to the realization of faithful quantum communication even using lossy and noisy optical channels. In this talk, I will briefly introduce the underlying physics of the above mentioned concepts and discuss our theoretical and experimental results. I will also briefly introduce our experimental improvement of the interface by using superconducting photon detectors


Friday, March 2, 2012 at 2:00 p.m.
Green Hall Room 0120
Host: Dr. Lan Yang

Short Bio: Prof. Nobuyuki Imoto received his BSc and MSc in Applied Physics, and PhD in Engineering, all from Tokyo University, Japan. From 1977 to 1999 he worked at NTT Basic Research Labs first as a researcher then as a group leader. He was with the Graduate University for Advanced Studies (Sokendai) as a full professor between 1999-2004, and since 2004 he is a professor in the Department of Materials Engineering Science, Graduate School of Engineering Science, Osaka University, Japan, leading the quantum optics and quantum information laboratory. He also serves as a visiting professor at the National Institute of Informatics, Tokyo, Japan. Prof. Imoto’s main research interests are within the field of quantum optics, quantum information, communication and Computation, quantum electronics and material physics. He has published over 150 papers in peer-reviewed journals in these topics. His recent works on protecting quantum information from noise, wavelength-conversion for single photons and weak quantum measurements for resolving Hardy’s paradox have found coverage in national and international news media, including the Wall Street Journal and The Economist. Prof. Imoto is a member of Japan Physical Society, Japan Society of Applied Physics, and a lifetime member of the American Physical Society.