Yale Institute for Nanoscience and Quantum Engineering

Friday- November 15, 2013

12:00 to 1:00 p.m.

Becton Seminar Room

Light lunch will be served at 11:45 a.m.

Brandon Redding

Department of Applied Physics, Yale University

"Using speckle to build compact, high-resolution spectrometers"

Spectrometers are widely used tools in chemical and biological sensing, material analysis, and light source characterization. Traditional spectrometers use a grating to disperse light, and the spectral resolution scales with the optical pathlength, imposing a trade-off between device size and resolution. To develop a compact spectrometer without sacrificing resolution we turn to a multimode fiber, where a long pathlength is easily achieved in a small footprint by coiling the fiber. Of course, replacing the grating with a multimode fiber also requires the spectrometer to operate according to a different paradigm. Here, we use the wavelength-dependent speckle patterns formed by interference between the guided modes of a multimode fiber as a fingerprint to identify the input spectra. The spectral resolution is then determined by the change in wavelength required to produce an uncorrelated speckle pattern, which scales inversely with the length of the fiber. Using a 100 meter long fiber, we were able to resolve two lines separated by only 1 pm near λ=1500 nm. We also achieved broad-band operation with a 4 cm long fiber, covering 400 nm – 750 nm with 1 nm resolution. Since the fiber can be coiled into a small volume, the entire device remains compact, lightweight, and low-cost. We applied the same approach of using wavelength-dependent speckle patterns to build an on-chip spectrometer where the device size is particularly limited. In this case, we introduced multiple scattering in a disordered structure by etching holes in a silicon membrane to increase the effective optical pathlength in a fixed footprint. We achieved 0.75 nm resolution at λ=1500 nm in a 25 µm radius spectrometer. Such a high-resolution on-chip spectrometer could enable compact, low-cost spectroscopy for portable sensing or increasing lab-on-a-chip functionality.

Carsten Schuck

Department of Electrical Engineering, Yale University

" High efficiency, low-noise superconducting nanowire single-photon detectors integrated with nanophotonic circuits"

High detection efficiency, low dark count rate and accurate timing resolution are the most desired features of a single photon detector. For quantum optical information processing it is furthermore highly desirable to integrate detectors and optical circuitry on one common and scalable platform. Here I will present how these requirements can be met with NbTiN nanowire superconducting single-photon detectors (SSPD) embedded in nano-photonic waveguides on a silicon chip. Employing a travelling wave design we realize high detection efficiency for single-photons both in the visible (80%) and in the telecom band (70%). By engineering the detector and waveguide dimensions at the nanoscale we furthermore achieve nanosecond electrical output pulses with 50 ps timing jitter and milli-Hz dark count rates, resulting in a noise equivalent power at the 10^{-20} W/(Hz$^{1/2}$) level. To illustrate the attractive low-noise performance of our detector we perform photon-counting optical time domain reflectometry (OTDR) over 263 km of standard telecom fiber. The integration of such low-noise, high-efficiency superconducting single-photon detectors with low-loss optical waveguide devices on a silicon chip is an ideal match for scalable quantum photonic circuitry.

HOST: Paul Fleury