Course Descriptions
CQN Winter School on Quantum Networks
Jan. 2023: M-F, Jan 2-6, 2023

1. The Physics Behind the Quantum Internet: A Gentle Introduction
Instructors: Michael Raymer and Abigail Gookin
Course Summary: This course is a 1-2 level introduction to quantum physics and common applications of the quantum internet. From polarization states to qubits to quantum teleportation, this course covers the foundations of the quantum internet and how we can begin to understand the key point without the use of mathematics.

2. Optical transmission systems for quantum networks
Instructors: Dan Kilper and Shelbi Jenkins
Course Summary: This course is a 1-2 level introductory course aimed at teaching the fundamentals of optical networks and how we can integrate quantum systems with our current optical infrastructure. This course will be largely conceptual and focus on general concepts and applications so students will not be expected to know extensive quantum or math prior to this course.

3. How build a quantum network/ Hardware perspective
Instructors: Ryan Camacho and Ian Briggs
Course Summary: This course is a 1-3 level introductory course aimed at teaching how a quantum network is built. The course will emphasize the description of the necessary hardware components to build the network and how they interface to distribute entanglement. Students are not expected to know extensive math or quantum mechanics prior to this course.

4. Principles of Quantum Networks
Instructors: Don Towsley and Matheus Guedes de Andrade
Course Summary: This course offered at the 2 level, aims to cover the following topics: quantum network architecture, quantum networks and classical networks – similarities and differences, resource allocation in quantum networks, and quantum network management and network tomography

5. Theory of quantum channels: from bosonic modes to single- photons
Instructors: Quntao Zhuang and Anthony Brady
Course Summary: This course offered at the 3-4 level, aims to provide training for quantum network modeling, with the intent to understand basic quantum channel models for photon transmission and covering quantum information trans- mission in different degrees of freedom of photons. Essential topics in quantum information will also be surveyed.

6. Information in a photon
Instructors: Saikat Guha and Christos Gagatsos

Course Summary: This course is a 2-3 level introduction to the mathematical tools necessary to understand the quantum representation of classical laser light, and single- and multi-photon quantum states of light, and using those tools to uncover properties and applications of encoding, transmission and processing of information encoded in light.

7. Classical and Quantum Error Correction
Instructors: Bane Vasic and Narayanan Rengaswamy
Course Summary: This course offered at the 2 level, will introduce the fundamentals of classical and quantum error correction using visual elements as well as necessary linear algebra. The course will start with the basics of classical error correction, linear block codes, generator and parity-check matrices, syndrome, standard array decoding and finish the first part with a discussion of low-density parity-check (LDPC) codes and iterative decoders. Then the course will explain the basics of quantum error correction and draw a parallel to the concepts introduced for classical error correction. The course will end with a discussion of the state-of-the-art quantum LDPC codes and decoders, and some of the challenges that remain for building fault-tolerant quantum systems.

8. Quantum Network Simulation Software
Instructors: Inès Montaño and Jaime Diaz
Course Summary: This course is a 2-3 level introduction to quantum network simulators. We will discuss the purpose and applications of network simulators and provide opportunities for hands-on exploration of core concepts/methods.

9. Programmable photonics in quantum networks
Instructors: Dirk Englund and CJ Xin
Course Summary: This course offered at level 2 is an introduction to photonic integrated circuits (PIC) with an emphasis on their utility for realizing large-scale quantum networks. This course will survey a selection of passive and active photonic components, and explore how these building blocks can be combined into a large-scale programmable PIC. The course will also cover components specific to quantum information applications, such as quantum light sources and solid state quantum memories can be realized in or integrated with PICs.