Institute of Applied Physics

Friedrich-Schiller-Universität Jena

Experimental-based Elective in Quantum Science and Technologies for Master Level Course

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BioQantSense

ETP23-ETP100-25

Outline

- Why experimental based course?
- Course structure & pedagogy
  - Lecture topics
  - Hands-on modules
- Assessment and evaluation
- Outcomes and impact
- Outlook

Why experimental based course?

Requirements of Quantum 2.0

Academia - Research

- Optics and Photonics
  - Laser Science, Fibre optics
  - Nonlinear Optics
  - Single Photon sources and detectors
- Vacuum technologies (HV and UHV)
- Cryo technology
- Programming

towards PhD program

Industry - Development

- Electrical Engineers
  - Low-noise electronics
- Computer Scientists
  - Algorithm development
  - Programming quantum systems
- Mechanical Engineers
- (few) Quantum Physicists

requires Bachelor and Master graduates

Course structure & pedagogy

Lecture topics – 12 hrs

- Fundamentals of Quantum Computing
- Quantum States of Light / Entanglement
- Detection of Quantum Light
- Generation of non-classical light
- Quantum Information
- Superconducting Quantum Technologies

Hands-on modules – 20 hrs

- Quantum computing (3x)
- Properties of photons – wave and particle nature of single photons
- Quantum interference – Hong-Ou-Mandel interference
- Spontaneous parametric down-conversion (SPDC) source development and characterization
- Quantum entanglement and tomography
- Sensing via NV Centers in diamond
- Quantum cryptography – BB84 protocol
- Investigation of superconducting coplanar waveguide resonators coupled with SQUIDs

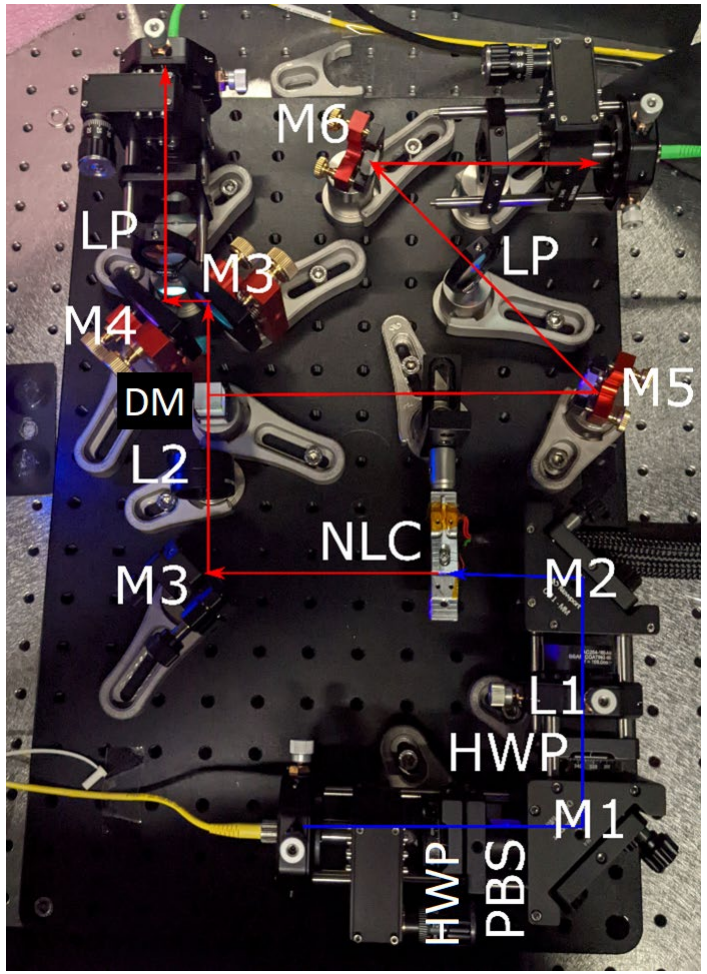
Experimental Quantum Technologies (EQT)

ECTS – 4 credits

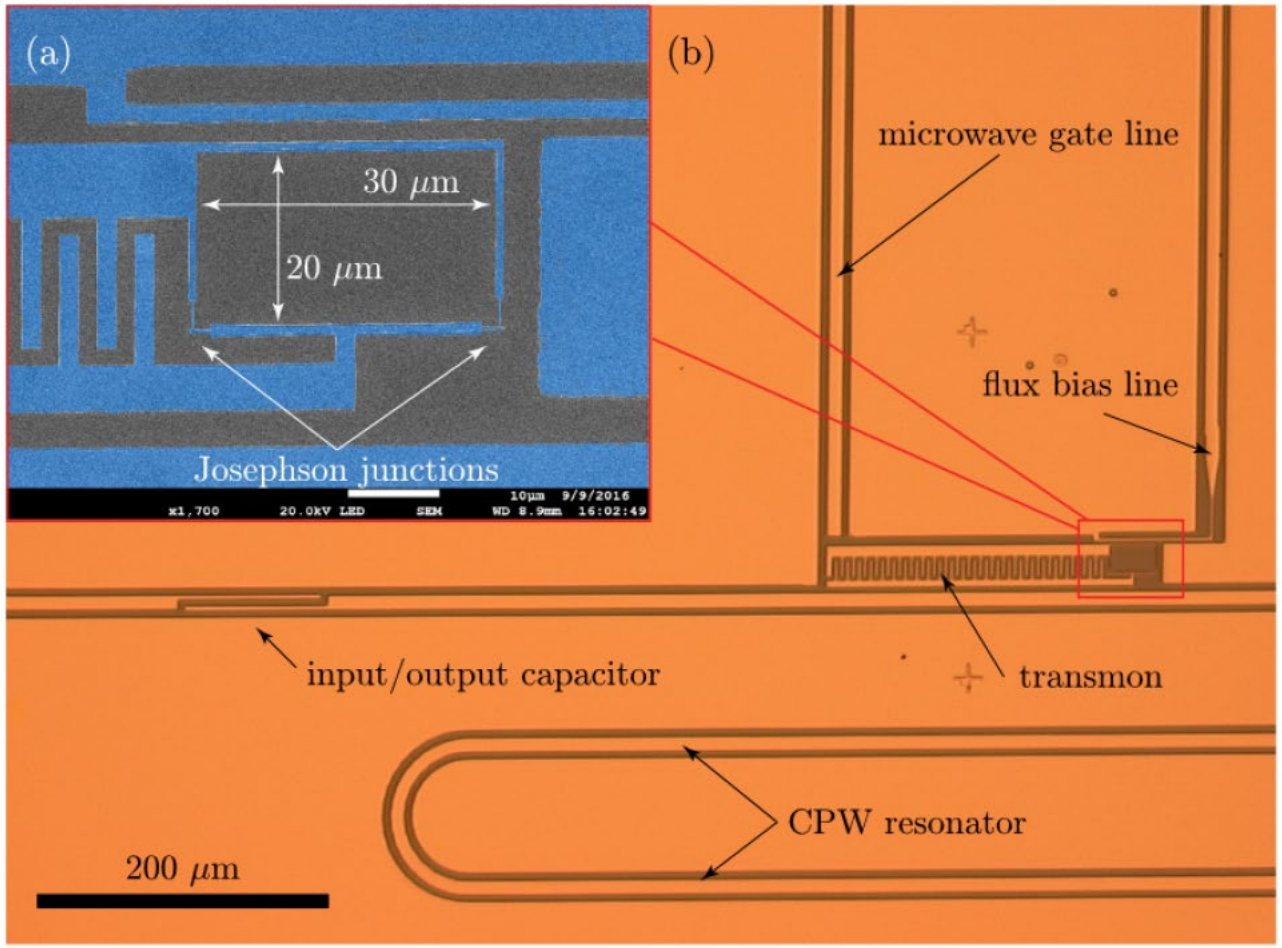
Learning hours – 300 hrs

Home-built set ups

Entangled pair generation by SPDC

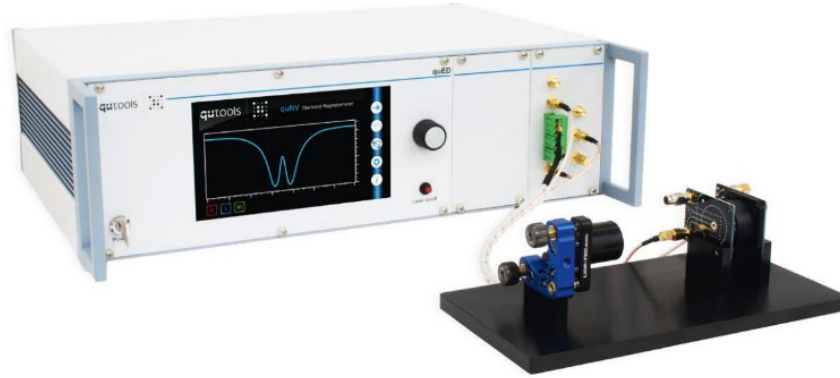


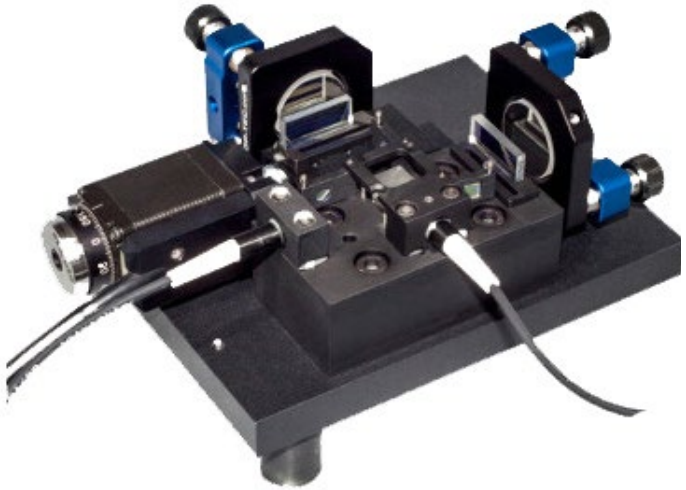
Transmon qubit coupled with the coplanar resonator @ 4K

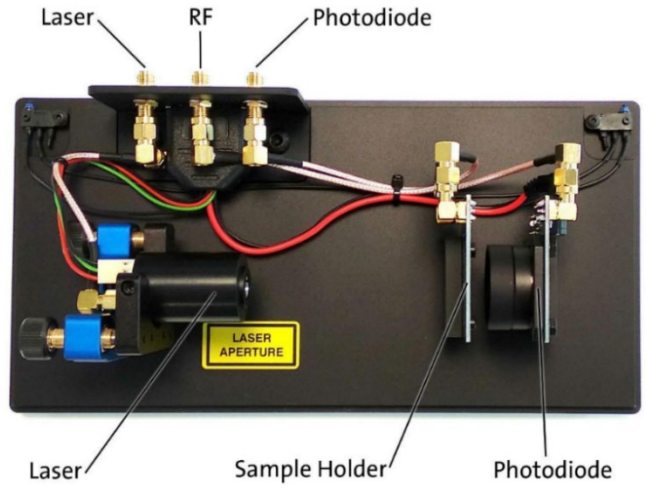


Commercial Educations kits

qutools.com

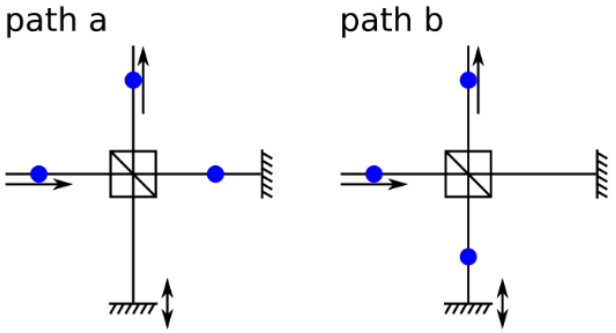


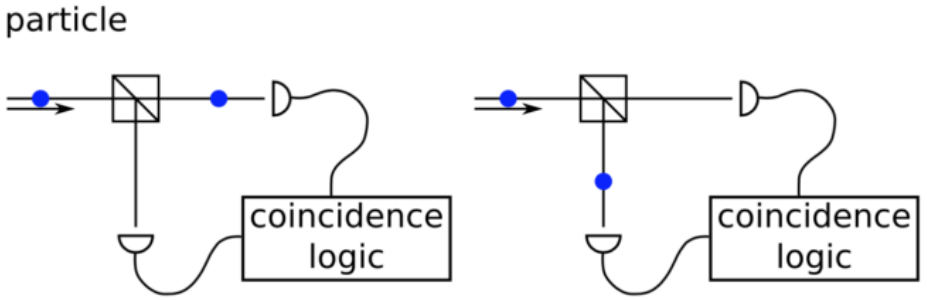


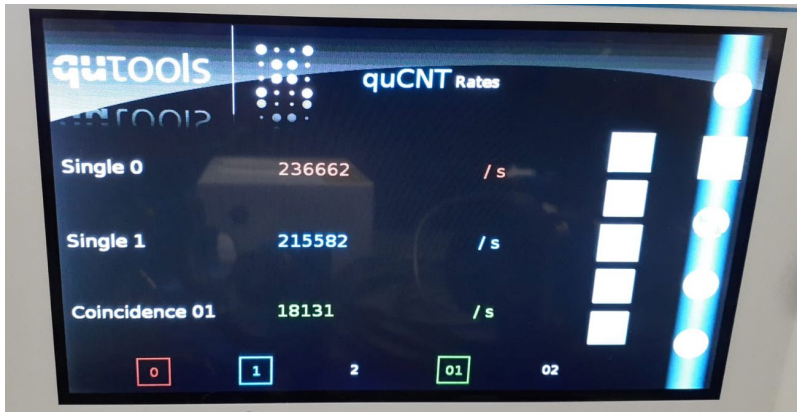


Types of experiments – Wave-Particle duality

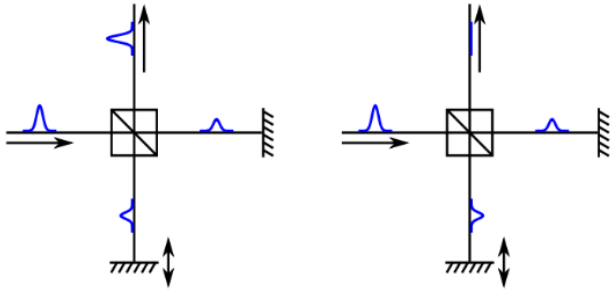
particle

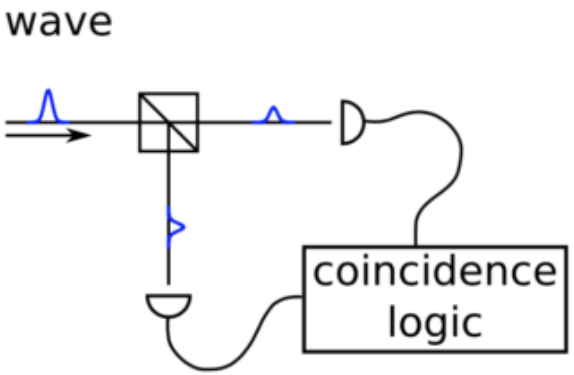


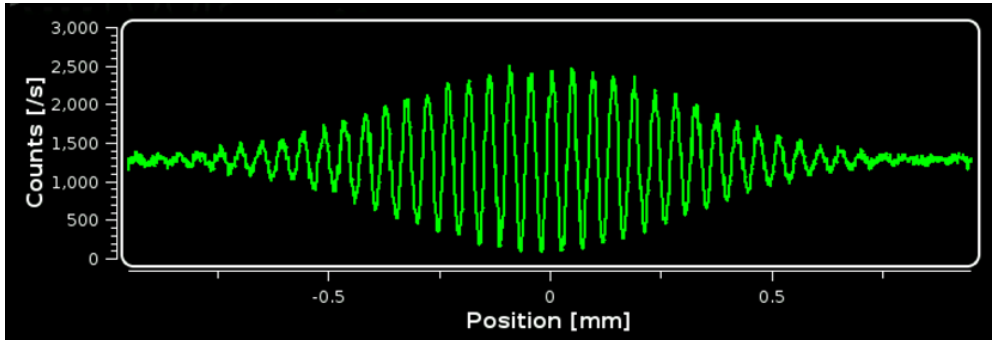




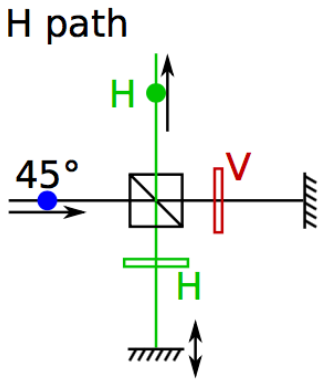
wave

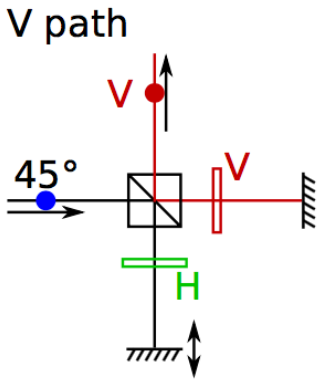


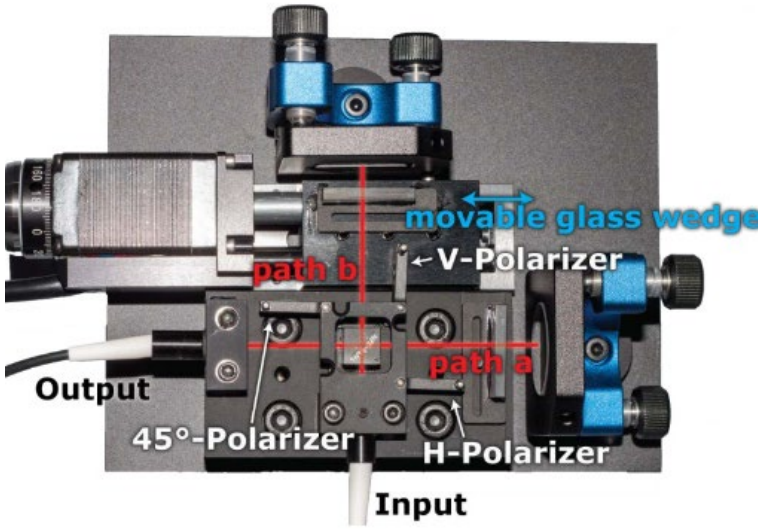


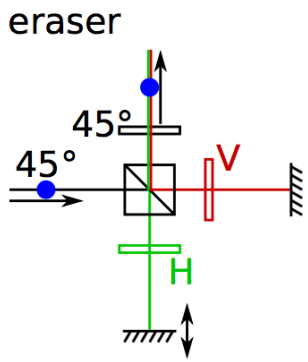


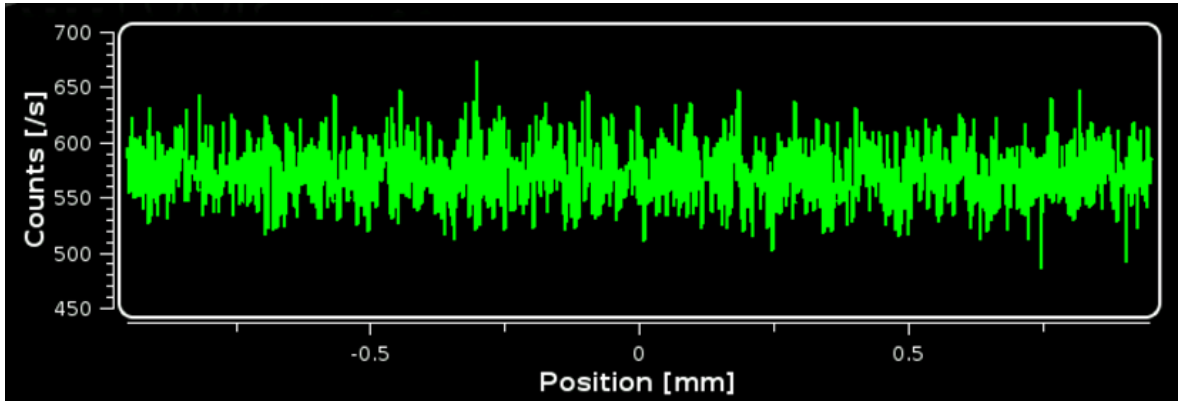
Types of experiments – Quantum Eraser

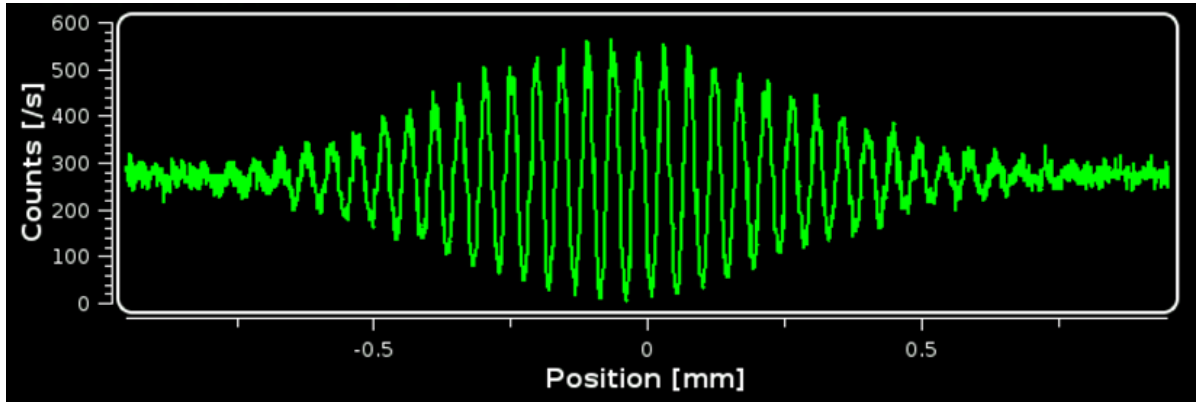












Hands-on modules

- Focus on experimental observations
  - Detailed lab manuals
  - Students in groups of 2
  - Pre-aligned set ups
  - Observe the quantum phenomena
  - Concise report (2-3 pages)

- Grading
  - 50 points for lab work
  - 50 points for report
  - Feedback session on each report

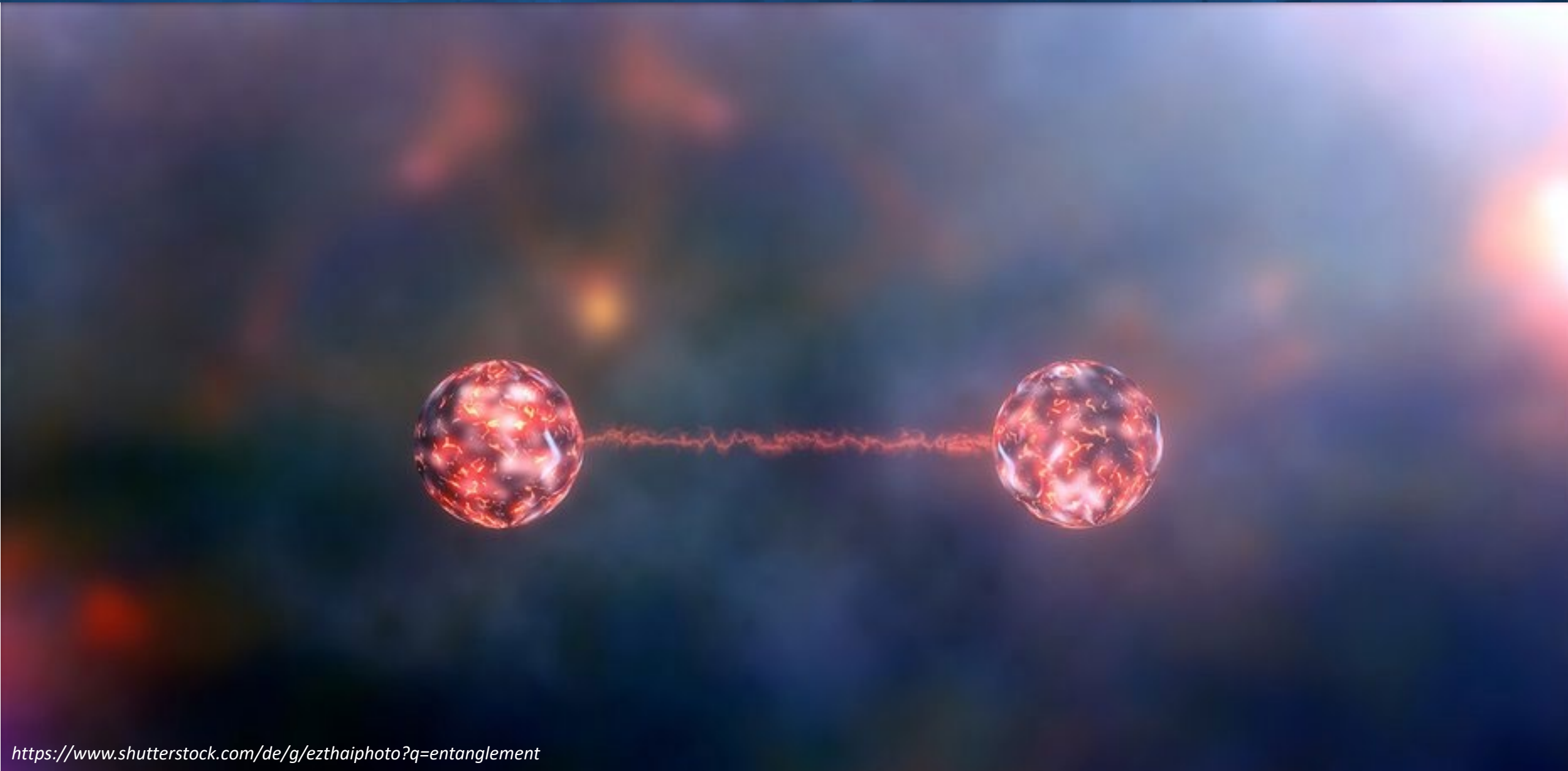
Summary

- Launched new course on Experimental Quantum Technologies
- EQT equips students with essential knowledge and practical skills
  - Fundamentals of quantum optics
  - SPDC source development and characterization
  - Application oriented experiments like cryptography, and random number generation
  - Magnetometry via NV sensing
- Highly resource intensive course

Outlook

- New experiments on
  - Quantum Communication
  - Quantum Imaging
- Explore photonic based quantum computers

Thank you



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