OPTI 596 Special Topics in Optical Sciences

How to Design and Make Quantum Photonic Integrated Circuits

Fall 2022, 3 Units

Instructor

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Office Hours: TBD

Course Description

This course is designed to give graduate students and advanced undergraduates an introduction to how to design, make, and use quantum photonic integrated circuits.

Course Prerequisites or Co-requisites

Knowledge of electromagnetic waves and optics is required. If a prospective student has not taken any undergraduate or graduate course in quantum physics, prior consultation with the instructor is recommended.

Course Format and Teaching Methods

Course will be offered online always and additionally on main campus occasionally. Modality will be live online and/or live in person and asynchronous online. Course component is seminar.

Course Objectives

We will study several of the kinds of photonic integrated circuits necessary to perform quantum computation either as 1) highly scalable classical optical control devices or 2) generators, manipulators, and detectors of on-chip quantum resource states.

Expected Learning Outcomes

- Demonstrate a good understanding of the basic concepts of photonic integrated circuit fundamentals and how they apply to quantum information science.
- Apply their understanding of physics, mathematics, and computer programming to design photonic components and circuits.
- Be able to apply the knowledge gained to their own optics research and interests.

· Effectively communicate their knowledge and understanding to the instructor and others in oral presentations/exams.

Required Texts and Materials

No textbook required. Selected text and reading material will be provided by the instructor.

Schedule of Topics and Activities

Modules

1. Introduction and overview of photonics and photonic integrated circuits (PICs).
    a. What kinds of applications are quantum PICs used for?
    b. How do they work?
    c. How are they made?
2. Passive waveguides
    a. Dispersion, phase and group velocity
    b. Types of losses and modeling losses
    c. Modes
    d. Coupling between waveguides (directional couplers) and coupling between modes of a single waveguide
    e. Coupling on and off of microchips containing PICs
    f. Modeling transmission
3. Passive resonators
    a. Resonator modes
    b. Modeling loss mechanisms and quality factors
    c. Excitation of resonator modes through on-chip waveguides and external waveguide couplers
    d. Coupling between modes
    e. Modeling resonator transmission
4. Reconfigurable waveguides and resonators
    a. Thermo-optic modulation
    b. Optomechanical modulation
    c. Piezoelectric actuation of optomechanical modulation
5. The Mach-Zehnder interferometer and tunable add-drop filter
6. Mach-Zehnder Mesh and Ring-Assisted Mach-Zehnder

Assessments

Each module will have a corresponding project to complete using analytical techniques, COMSOL, and Matlab, constituting 6 projects each accounting for 1/8th of the course grade (for a total of 3/4ths of the course grade). The student will prepare a presentation for each project and present it to the instructor over zoom or in-person.

Final Examination or Project

There will be a final project accounting for 1/4th of the course grade. The final project will be more involved than the others, requiring synthesis of the skills developed over the course of the semester. However, it is otherwise the same; i.e., a presentation will be made and will be presented to the instructor.

Grading Scale and Policies

Regular letter grades will be assigned based in compliance with University of Arizona Grades and Grading System Policy Specify how grades are assigned for your course (see, https://catalog.arizona.edu/policy/grades-and-grading-system).

Each student's final course grade will be based on the total points accumulated over the semester. A grade of "A" will be given for 90-100 total points, "B" for 80-89 points, "C" for 70-79 points, etc.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see:
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

University Policies

All university policies related to a syllabus are available at:
https://academicaffairs.arizona.edu/syllabus-policies. By placing this link in your syllabus, you no longer need to have each individual policy included in your syllabus.

Subject to Change Notice

Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor of this course.

Additional Student Resources

Please consider including a link to the University of Arizona’s Basic Needs Resources page:
http://basicneeds.arizona.edu/index.html