Information for prospective PhD students

Optical Sciences faculty – Optical Physics/AMO/Quantum Information experiments

**Brian P. Anderson**  
Associate Dean for Graduate Academic Affairs, Wyant College of Optical Sciences  
Professor of Optical Sciences  
Please contact for any questions, discussions about PhD program. Bose-Einstein condensation, quantum turbulence, superfluidity, quantized vortices. *(Not currently taking new PhD students.)*

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**Optical Sciences faculty - Optical Physics/AMO/Quantum Information theory**

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Masud Mansuripur  
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Professor of Optical Sciences  
Physical nature of electromagnetic fields physics.  (Not currently taking new PhD students.)

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Jerry Moloney  
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Computational methods, nanophotonics, VECSEL design, extreme nonlinear optics (also directs experimental research)

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Femtosecond pulse propagation, ultrafast nonlinear optics, theory of ultracold dilute gases physics.  (Not currently taking new PhD students.)

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Optical physics research groups outside of Wyant College of Optical Sciences

Optical Sciences graduate students may join research groups and do their PhD research outside of the Wyant College of Optical Sciences.

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Attosecond microscopy, electron dynamics experiments

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Vanessa Huxter  
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Oliver Monti

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Arvinder Sandhu

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See also:

All research specialties at the Wyant College of Optical Sciences
https://www.optics.arizona.edu/research/research-specialties

Research areas of the Department of Physics
http://www.physics.arizona.edu/physics/research.php

Physical Chemistry Faculty in the Department of Chemistry and Biochemistry
http://www.cbc.arizona.edu/faculty_physical
Graduate courses in Optical Sciences involving Optical Physics, Quantum Physics, Quantum Information

OPTI 501 Electromagnetic Waves – (Mansuripur)
OPTI 503A Mathematical Methods for Photonics and Optics – (Mansuripur)
OPTI 507 Solid-State Optics – (Binder)
OPTI 511L Lasers and Solid State Devices Laboratory – (Wilson)
OPTI 511R Optical Physics and Lasers - (Jones) – An introductory course in Quantum Mechanics. Not usually necessary for most optical physics students*
OPTI 541A/B/C Introduction to Lasers – (Jones)
OPTI 544 Foundations of Quantum Optics – (Jessen)
OPTI 547 The Beam Propagation Method – (Kolesik)
OPTI 549 Atom Optics – (Anderson) (not available every year)
OPTI 551 Computational Optics: Nonlin. Light-Matter Interact. – (Kolesik)
OPTI 557 Laser Engineering and Applications – (Polynkin)
OPTI 560 Quantum Nanophotonics – (Fan)
OPTI 561 Physics of Semiconductors – (Binder)
OPTI 570 Quantum Mechanics – (Anderson)
OPTI 571L Optical Physics Computational Lab – (Wright)
OPTI 583 Computational Optics – (Kolesik) (not available every year)
OPTI 595B Information in a Photon – (Guha)
OPTI 600G/K/L Optical Resonators and Cavity Optomechanics – (Wilson)
OPTI 646 Quantum Information and Computation – (Jessen)
OPTI 647 Photonic Quantum Information Processing – (Gagatsos)
OPTI 792 Directed Introductory Graduate Research – (all professors)

Independent Study of topics not listed is also possible (up to 6 credits will count towards PhD coursework requirements).

For a full list of Graduate courses in Optical Sciences, see: https://www.optics.arizona.edu/osc-students/courses

PhD Course and Exam Requirements

All students must take 8 or 9 “core” courses (generally in the first two years of the program). The Qualifying Exam tests the material on four topics covered in the core courses taken during the first year. This exam is taken in the week before the fall semester of the second year of the PhD program.

The specific core courses and the order in which they are taken will slightly depend on the chosen research area and advisor’s recommendations, and may be different than another student’s core courses. Optical Physics and Quantum Information students will take a sequence of courses that places emphasis on quantum mechanics and quantum optics. For these students, a typical course sequence is listed below, spanning the first two years of the PhD program; this example sequence satisfies core course requirements and other first-year academic requirements. Other course sequences are possible. Specific courses that satisfy core course requirements are listed in bold.
**EXAMPLE COURSE SEQUENCE for first two years** for Optical Sciences PhD students doing research in *Optical Physics or Quantum Information*

**Fall, First year**
- **OPTI 501** – Electromagnetic Waves (*tested on Qualifying Exam*)
- **OPTI 502** – Optical Design and Instrumentation (*tested on Qualifying Exam*)
- **OPTI 570** – Quantum Mechanics (*tested on Qualifying Exam*)
- **OPTI 792** – Directed Introductory Graduate Research (1 to 3 credits)

**Spring, First year**
- **OPTI 544** – Foundations of Quantum Optics (*tested on Qualifying Exam*)
- **OPTI 505R** – Diffraction & Interferometry (*tested on Qualifying Exam*)
- Elective course, such as **OPTI 595B** – *Information in a Photon*
- **OPTI 792** – Directed Introductory Graduate Research (1 to 3 credits)

**Fall, Second year**
- **OPTI 507** – Solid-State Optics
- **OPTI 541A** – Introduction to Lasers (1 unit)
- A 1-unit lab course: **OPTI 511L** – Laser laboratory or **OPTI 571L** – Optical Physics Computational Lab
- Elective course, such as **OPTI 646** – Quantum Information and Computation, or **OPTI 647** – Photonic Quantum Information Processing

**Spring, Second year**
- **OPTI 503A** – Mathematical Methods for Photonics and Optics
- Electives, independent study, labs, or thesis units

**Qualifying Exam**

The qualifying exam is to be taken by all PhD students after the first full year in the PhD program, and is offered at the beginning of the second year in the program during the week before classes start in the fall. The qualifying exam is a written exam that covers 4 topics:
- Electromagnetic Waves (**OPTI 501**),
- Optical Design and Instrumentation (**OPTI 502**),
- Diffraction and Interferometry (**OPTI 505R**),
- Optical Physics (**OPTI 511R**, or **OPTI 570 and OPTI 544**).

**Comprehensive Exam**

The comprehensive exam is comprised of a written portion and an oral presentation in front of a committee of four faculty members. The exam involves the preparation of a written report and oral discussion and questioning of a research topic typically involving the student’s research, and how the research relates to various topics in optics. The exam is typically given only after a student has become fully engaged in a research group, and is typically taken in the third full year in the PhD program.
Coursework requirements for the PhD

45-54 credit hours of coursework must be completed for the PhD. This does not include thesis credit hours. The 45 credit-hour minimum is allowable with the permission of the research advisor. Optical Physics and Quantum Information advisors typically approve this waiver for their students. Up to 6 of credit hours may be taken through independent study rather than formal courses. Assuming the 45-credit-hour waiver is obtained, one possible full set of courses (and associated number of credit hours) that would satisfy the coursework requirements is as follows:

Core courses (25 credit hours in this list)

OPTI 501 Electromagnetic Waves (3)  
OPTI 502 Optical Design and Instrumentation (3)  
OPTI 570 Quantum Mechanics (3)  
OPTI 505R Diffraction and Interferometry (3)  
OPTI 544 Foundations of Quantum Optics (3)  
OPTI 595B Information in a Photon (3)  
OPTI 541A Introduction to Laser Physics (1)  
OPTI 507 Solid-State Optics (3)  
OPTI 503A Mathematical Methods for Photonics and Optics (3)

Lab requirements (2 lab courses are required. 2 credit hours in this list)

OPTI 511L Lasers and Solid State Devices Laboratory (1)  
OPTI 571L Optical Physics Computation Laboratory (1)

OPTI 792 – 2 units are required, but strongly recommended to take 4-6 units in Year 1

Electives

Assuming

- that the 27 units of core and lab courses listed above are taken
- 6 total units of OPTI 792 are taken in the first year,

then 12 additional credit hours would be needed. The following courses are often of interest to optical physics and quantum information students.

OPTI 541B/C Introduction to Lasers (2 – Spring)  
OPTI 547 Beam Propagation Method (3 – Spring)  
OPTI 561 Physics of Semiconductors (3 – Fall)  
OPTI 600G/J/K Cavity Optomechanics (2 – Fall)  
OPTI 646 Quantum Information and Computation (3 – Fall)  
OPTI 647 Photonic Quantum Information Processing (3 – Fall)  
OPTI 560 Quantum Nanophotonics (3 – Spring)  
OPTI 595B Information in a Photon (3 – Spring)  
OPTI 599 Independent Study courses on topics of your choice (1-6 units)

Please feel free to contact the Assoc. Dean for Graduate Academic Affairs, Prof. Brian Anderson, bpa@optics.arizona.edu, for any questions.