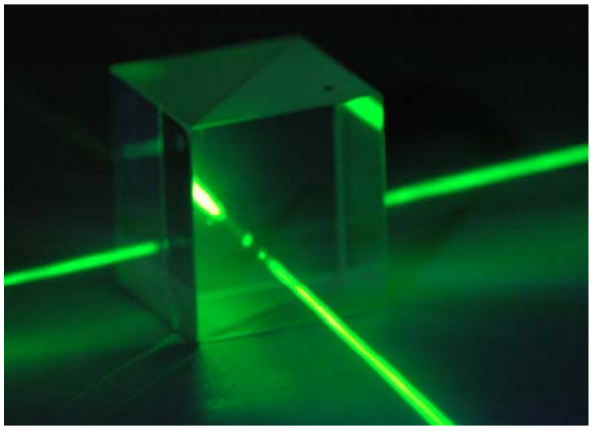
ROYAL INSTITUTE OF TECHNOLOGY

Joint Research Center of Photonics

International Master of Science Program in Photonics



International Master Program in Photonics

Photonics is an area in information technology that crosses the border between optics and electronics to provide technology and infrastructure for the global internet and for high-speed communications. It is also extensively used for many other applications such as optical storage, display, bio-photonics, and sensors.

Stockholm has become one of the Photonics capitals of the world due to both the academic research and the industry. The research is producing outstanding results, ranging from fast and efficient devices for transforming information between light and electrical signals, to fiber optical communication systems using light to transfer information over large distances. The demand for highly qualified engineers trained in Photonics in research and industry is expected to increase significantly in the coming decade, and the Royal Institute of Technology (KTH) and Zhejiang University (ZJU) have therefore decided to expand the education in the Photonics area.

Thus the 'Joint Research Center of the Royal Institute of Technology and Zhejiang University' offers a Master Program in Photonics since 2005. The program is intended as a continuation after a Bachelor degree in science or engineering, and it consists of two academic years of study divided between three semesters of courses and one semester for thesis work. Students divide their time of study between KTH and ZJU. Lecturers from KTH teach throughout most of the program. Students completing this track will receive a double M.Sc. degree in Photonics issued by KTH and ZJU respectively. The program is open for international students; all courses given by KTH lecturers will be taught in English.

Visions and Goals

The area of Photonics has undergone dramatic changes during the last few years. From a situation with low visibility and little hope for expansion photonics has become a key area of technology, along with mobile communications, both in large companies and through a number of new enterprises, so called "startups".

The Master Program provides a specialization in photonics and optical networking, which is suitable both for industry work and research, where the student after graduation will be attractive on the international job market. The primary direction of the education is towards photonics for data and telecommunications. Other areas of applications, such as biophotonics, are also included.

KTH and the Kista Campus

The Royal Institute of Technology (Kungliga Tekniska Högskolan, KTH) in Stockholm, Sweden, has 1/3 of the Swedish engineering research and university engineering education. The research and education are of high international standard in subjects ranging from all areas of engineering to architecture. KTH is located at several different sites in the Stockholm area, and the KTH departments working in information technology which form the School for Information and Communication Technology, located at the satellite campus in Kista in the northern part of Stockholm. The School of Information and Communication Technology consists of the following departments:

- Computer and Systems Science
- Applied IT with Entrepreneurship
- Microelectronics and Applied Physics
- Electronics and Computer Systems
- Communication Systems

At the Kista campus the Kista Photonics Research Center is also located. The Kista Photonics Research Center is an umbrella organization promoting and giving a structure to the collaboration in the field of Photonics between the private research institute Acreo and the Royal Institute of Technology (KTH), in Kista. It regroups about 120 researchers, PhD students and technicians with activities ranging from basic research and education to commercialization of research results and creation of spin-off companies. The KPRC is one of the major centers for Photonics in Europe and is expected to grow in importance with the present coordination of efforts of its two complementary components.

Stockholm and Kista

The School of Information Technology is, as mentioned, located in Kista which is the northernmost borough of the city of Stockholm. The dynamics of this "Scandinavian Silicon Valley" are in themselves a lifetime experience. Moreover, its location in Stockholm, the capital of Sweden, adds more excitement. Despite the fact that Stockholm is a comparatively small city with around 1.8 million people in the greater Stockholm area, it provides a full range of activities and attractions from culture to sports. The beautiful city is built on islands and the surrounding water has a special impact on Stockholm. There are lakes, rivers, the sea and the largest archipelago in the world with approximately 24,000 islands.

Zhejiang University

Zhejiang University (ZJU) is one of the few top-rank research institutions of higher learning in China. It is a center of high-level teaching and research, where renowned academics from China and other countries work together contributing to the economic development and social progress of China and the world.

ZJU is located in the coastal city Hangzhou, the capital of Zhejiang Province. It is a major research university comprised of 21 colleges and has about 43000 full-time students (including undergraduates, graduate students working for master degree, doctoral candidates, and foreign students).

In September 1998, a new Zhejiang University was established on the basis of the amalgamation of the four former individual universities, namely Zhejiang University, Hangzhou University, Zhejiang Agricultural University and Zhejiang Medical University, which were all located in the garden city of Hangzhou. Approved by the State Council, the founding of the new Zhejiang University has been a significant move in the reform and development of China's higher education. The four universities have grown out of the same ancestry, the Qiushi (with the literal meaning of "seeking truth" in Chinese) Academy, which was founded a century ago as one of the earliest institutions of higher learning in China. As a result, they have all inherited from it the spirit of "Qiushi" and at the same time, built up their own distinctive features in teaching and research.

ZJU is also home to the Center for Optical and Electromagnetic Research, one of the best academic institutes in China in the field of photonics.

Hangzhou

Hangzhou, the capital of Zhejiang province, is renowned as one of the most beautiful cities in China, partly due to the magnificent West Lake. Hangzhou is known as one of the six ancient capitals of China having been the capital of the Wu Yue Kingdom (893-978 AD) and of the Southern Song Dynasty (1127-1279 AD). Marco Polo claimed to have visited the city, saying that it was "the finest and most splendid city in the world." Hangzhou is also famous for its silk and tea production.

Hangzhou, which currently developing rapidly, is located about 180 km southwest of Shanghai in the head of the Hangzhou bay. It is a part the dynamic economic region surrounding the Hangzhou bay, the strongest economic region in China. The population of the greater Hangzhou area is about 6.2 million.

Joint Research Center of Photonics

The Joint Research Center of Photonics of the Royal Institute of Technology and Zhejiang University (JORCEP) is joint collaboration in research and education between KTH and ZJU. The mission of JORCEP is to enable KTH and ZJU to stay in the forefront of photonics research and acts as a center of excellence in the area of photonics of both universities. As excellence in research can only be maintained by excellence in learning, the center collaborates on both research and education. Thus JORCEP conducts joint research, collaborates on PhD education and offers an international masters program on photonics. JORCEP was founded in 2003 and has already established itself as one of the most comprehensive Sino-European research collaborations in existence. The center is headed by two Chief Scientists Prof. Lars Thylen and Prof. Sailing He, with the Presidents of the two universities serving as Co-chairmen of the board.

Further information

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Curriculum and course descriptions

The program consists of 2 years of study divided between 1.5 academic year of courses and 6 months of thesis work. The courses will be taught at ZJU and KTH mainly by teachers from KTH. The thesis work will be done in Sweden under the supervision of KTH.

Semester 1 @ ZJU	Semester 2 @ KTH	Semester 3 @ KTH	Semester 4 @ KTH or ZJU
• Optics • Principles of Communication • Quantum Electronics • Microwave engineering	• Fiberoptic communication • Advanced Semiconductor Materials • Photonics • Optical Networking	• Thesis work @ KTH	• Elective courses

- Optics

Aim

The course has primarily two goals

- to give a deeper and broader insight into optics as a science and a technology, its basic physics and phenomena and their importance for technical applications
- to be a starting point for the following, more specialized courses within the special area of optics and photonics.

The course aims to give the participants the ability of using literature to penetrate most of the problems in optics, be they scientific or technical problems in nature.

Syllabus

Electromagnetic fields, propagation in vacuum and matter. Wave optics. Polarization, interference, optics of thin films, optical measurement techniques. Diffraction, Fourier optics, optical information processing. Coherence. Quantum phenomena, lasers and current applications, non-linear optics. Geometrical optics and image formation, optical analysis and design, image quality. Transfer of energy and information; radiometry and photometry.

- Microwave Engineering

Aim

After the course the participants should be able to:

- Understand the theory and characteristics of wave guides and transmission lines
- Describe, analyse and design simple microwave circuits and devices e g matching circuits, couplers, antennas and amplifiers
- Describe and coarsely design common systems such as radar and microwave transmission links
- Handle microwave equipment and be able to make measurements

Syllabus
Circuit theory, wave guides, scattering parameters, impedance transformation, matching, antennas, resonators, passive and active microwave devices, microwave communication systems, radar, microwave measurements.

- Principles of Communications

Aim
The course gives a basic knowledge of the principles of communications. It deals with analogue and digital modulation methods, random signals and noise, binary data transmission, information theory and coding.
After the course the participants should be able to:
- Describe and analyze e.g. signal to ratios in linear and angle modulated systems with additive white Gaussian noise
- Describe and analyze e.g. bit error rates in digitally modulated systems with additive white Gaussian noise
- Describe basic information theory and coding

Syllabus
Review of signal and linear systems analysis.
Linear, angle, and pulse modulation
Random signals and noise (additive white Gaussian noise)
Signal to noise ratios in modulations systems
Bit error rates in data communication systems
Introduction to information theory and coding

- Quantum Electronics

Aim
The aim of the course in quantum electronics is to give the students a solid basis in modern quantum electronics, ranging from electromagnetic fields and propagation, to the interaction of light and matter, and its application in linear and non-linear optical systems such as lasers and modulators. By employing an internationally widespread textbook, the students will acquire a "standard" knowledge in the area. After the course you should be able to follow the engineering literature on the subject, such as IEEE Journal of Quantum Electronics.

Syllabus
Optical resonators, interaction between radiation and atoms, laser oscillation, basic non-linear optics, electro optical modulation, noise in optical systems, detection of light, quantum optics

- Fiberoptic Communications

  Aim

  The course content is knowledge of fiber-optical components, links, and systems. The systems relevant parameters of devices are derived from a physical description, and this forms the basis for designing fiber-optic links. After a completed course the participants should be able to:

  - Understand, describe, analyze, and compare the most important devices: light sources, fibers and detectors.
  - Design of digital fiber-optic links.

  Syllabus

  Dielectric wave guides: Attenuation, wavelength dispersion. Light sources: Semiconductor laser, light-emitting diode, rate equations, output power, modulation, noise, laser amplifiers, chirp. Detectors: PIN diode, avalanche diode, responsitivity, bandwidth, noise Systems: Direct detection systems, heterodyne systems, attenuation limitations, dispersion limitations, signal dependent noise, additive noise, bit error rate, optical networks, solitons.

- Advanced Semiconductor Materials

  Aim

  After the course the participants should be able to distinguish between elemental and compound semiconductors in their band structures, understand the various bulk and epitaxial techniques used to fabricate the semiconductors, appreciate the use of heterostructures in the fabrication of several optical and electronic components.

  Syllabus

  Elemental and compound semiconductors, band structures, crystal structures, mechanical, thermal, electrical and optical properties, dopants and their diffusion, bulk and epitaxial crystal growth, heterostructures, quantum wells, quantum wires and quantum dots, optical and electronic components.

- Photonics

  Aim

  To give in depth knowledge of optical communication technology and devices (including photonic integrated circuits, optical amplifiers, semiconductor laser s and optoelectronic integration), and introductory knowledge in some other important areas of photonics (including near-field optics, liquid crystals, sensors and bio-photonics*).*

  Syllabus

  Optical thin film technology, Near-field optics , Photonic integrated circuits, Photonic crystals, Semiconductor lasers, Optical amplifiers, Optical modulators, Optoelectronic integration, Liquid crystals, Optical sensors, Bio-photonics and bionanophotonics.

- Optical Networking

Aim

The aim is to make the students familiar with optical networks and transmission systems engineering, give examples of implemented systems and knowledge of future development including networking issues, limitations and possibilities of the fibre medium and the relevant device technology. The course starts with a review of point-to-point links and describes transmission properties and important optical devices. It is assumed that the student has a prior knowledge in fibre optics systems, e.g. Agrawal: Fibre-optical communications systems or similar. With this review as a background second generation optical networks are described. Such as network attempts to perform functions in the optical domain, such as routing and switching, and eventually routing and switching packets in optical form. The network constitutes an optical layer providing services to higher layers, and is a complement to the underlying electronics layers. Second generation networks using wavelength routing are emerging from research laboratories today.

Syllabus

Transmission system engineering. First generation optical networks. Broadcast and select networks and virtual topology design. Wavelength routing networks and test beds. Control and Management. Access networks, deployment considerations and packet switching. International, European, and Swedish views in the optical networks area.