

# Preface

This book presents an account of the NATO Advanced Study Institute on “Nano-structures for Optics and Photonics: Optical Strategies for Enhancing Sensing, Imaging, Communication, and Energy Conversion,” held in Erice, Sicily, Italy, from 4–19 July 2013. This meeting was organized by the International School of Atomic and Molecular Spectroscopy of the “Ettore Majorana” Center for Scientific Culture.

Nanotechnology, by taking advantage of the special properties of nano-scale matter, imitates nature that designs its structures at the molecular level. As pointed out by one of our lecturers (Novotny), “the power of optics is based on the simple fact that the energy of light quanta lies in the energy range of electronic and vibrational transitions in matter. Pushing the optical interaction to the nano-meter scale opens new perspectives, properties and phenomena.” The growing connection between optics and electronics, due to the increasing important role played by semiconductor materials and devices, find their expression in the term Photonics, which also reflects the importance of the photon aspect of light in the description of the performance of several optical systems. Nano-structures have unique capabilities that allow the enhanced performance of processes of interest in optical and photonic devices. In particular, these structures permit the nano-scale manipulation of photons, electrons and atoms; they represent a very hot topic of research and are relevant to many devices and applications.

Nanotechnology, optics and photonics are key technologies of the twenty-first century. The rapidly increasing possibilities of nano-science enable a completely new level of molding the flow of light and controlling light-matter interaction, nearly on the atomic scale. This has for instance led to nano-antennas for light that can modify spontaneous emission of nearby molecules or that can act as high-figure-of-merit sensors. Antennas combined with emitters can also be used as novel nano-lasers (spasers). Other interesting areas are artificial optical materials called metamaterials and nano-plasmonic structures. Here, applications include but are not limited to ultra-compact and ultra-fast optical telecommunication devices, efficient sustainable solar energy conversion, and bio-photonics. Transformation optics expands the concept of metamaterials towards intentionally spatially

inhomogeneous structures, e.g., invisibility cloaks. Conversely, optics and photonics also fuel nanotechnology, e.g., by novel super-resolution approaches in optical microscopy and lithography.

This Institute introduced the students to the field of nano-structures and provided a comprehensive overview on experiments and theory, basic physics and applications as well as on nano-fabrication and optical characterization. It brought together physicists, chemists, and engineers. In the best tradition of our past Institutes, it started from the consideration of fundamental principles, and reached the frontier of research in a systematic and didactic fashion.

The participants came from 25 different countries: Italy, United States, Germany, Belgium, Sweden, Belarus, Switzerland, France, Ukraine, Czech Republic, Estonia, Russia, United Kingdom, Canada, The Netherlands, Slovak Republic, Spain, Finland, Greece, Hungary, Israel, Morocco, New Zealand, Poland, and Turkey. Over the 2 weeks of the course, participants were given numerous opportunities to interact with one another, at both formal (poster sessions, seminars) and informal (e.g. dinners, excursions) events. The goal was to allow the participants to learn from one another about their scientific work and to expose them to other researchers from various cultures.

Two roundtable discussions were conducted during the course. The first discussion, conducted early in the course, allowed for the organizers and lectures to get immediate feedback from the participants regarding the organizational aspects of the course. The second roundtable meeting, held on the last day of the course, assessed the overall effectiveness of the course from the points of view of the participants. All participants filled out an evaluation form of the course and were given the opportunity to express their views regarding the meeting. The discussion and the evaluation forms indicated that the participants overwhelmingly felt that the course was a success. They appreciated the didactic nature of the course, and found some of the lecturers very inspiring. They felt that the scientific level of the course was very high, and that both the breadth and balance of the subjects covered were appropriate. They believed the atmosphere of the course helped to promote interaction between all participants, especially between students and lecturers, and that these interactions often led to creative discussions. They also appreciated that the lectures were made available to all the participants online. The evaluations provided many helpful suggestions that we will implement in the next course. Several participants suggested that additional information be made available online regarding some practical aspects of the coming to Erice (accommodations, food, climate, etc.). Another frequent suggestion was for more and/or longer poster sessions, something that can be easily accommodated in the next course. They expressed a great appreciation for those lecturers who included interactive exercises to their presentations, and expressed a desire for more such activities. This was a very useful comment, and we will seek to encourage all of our lecturers of the next course to include such activities, especially to help students understand better the related fundamental physical principles. Finally, some students requested lectures on methods of computer modelling of physical systems and on experimental techniques.

The students were enthusiastic about the meeting and felt there were ample opportunities to discuss their work not only with the lecturers, but also with one another. They indicated that their discussions with graduate students, post-doctoral researchers, and professors from other countries working in the same field, or in related fields, would likely enhance their own work. Finally, we anticipate that many of the friendships and contacts that were established at the school will lead to new collaborations and the enhancement of their research work in nanostructured materials. The following quotes from the evaluation forms give insights into how the students viewed their experience at the Institute. “Gathering high-level scientists and students in such an ‘open mind way of being’ is really great and stimulating for our future research life.” “In general I enjoyed the lectures and especially the interaction with the other students it led to new knowledge and good ideas for my project.” I wish to thank Academician Aleksandr Voitovich for his support and collaboration, Prof. John Collins, Dr. Maura Cesaria, the secretary of the Course Luciano Silvestri, and Ms. Elena Buscemi for the help they gave me during the Course. I wish to acknowledge the sponsorship of the meeting by the NATO Organization, Boston College, the Italian Ministry of Scientific Research and Technology, and the Sicilian Regional Government.

I am looking forward to our activities at the Ettore Majorana Center in years to come, including the next 2015 meeting of the International School of Atomic and Molecular Spectroscopy.

Boston, USA  
December, 2013

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Nano-Structures for Optics and Photonics  
Optical Strategies for Enhancing Sensing, Imaging,  
Communication and Energy Conversion

Di Bartolo, B.; Collins, J.; Silvestri, L. (Eds.)

2015, XXXVI, 586 p. 253 illus., 167 illus. in color.,

Hardcover

ISBN: 978-94-017-9132-8