NATO Science for Peace and Security Series - C:
Environmental Security

Polarimetric Detection, Characterization, and Remote Sensing

Edited by
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Polarimetric Detection, Characterization, and Remote Sensing

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Contents

Preface
Polarimetric detection, characterization, and remote sensing

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The NATO Advanced Study Institute (ASI) on "Special Detection Technique (Polarimetry) and Remote Sensing" took place in Kyiv, Ukraine, 12–25 September 2010. The main focus of the meeting was photopolarimetry, a rapidly developing, multidisciplinary topic with numerous military, ecological remote-sensing, astrophysical, biomedical, and technological applications [1–9]. Typical remote-sensing instruments measure the total intensity of the light scattered by a system of interest. Although the results of such measurements can be extremely valuable, they carry only a fraction of potentially useful information contained in the scattered light. The remaining information is coded in the polarization state of the light. As the need for accurate optical characterization and diagnostic techniques is increasing, it is important to find improved ways of extracting the additional information contained within the polarization state of the measured light. Advanced polarimetric methodologies are currently being used to

- detect the presence of biological-warfare-agent aerosols that may threaten military and civilian populations,
- monitor environmental effects and climate of our own planet Earth,
- detect the extent of cancerous regions within the human body,
- characterize nano-structures on substrates, and
- characterize structural elements of astrophysical bodies like comets and satellites.

Various polarization techniques have largely been developed independently by small research groups within specific scientific disciplines. Because the field is extremely interdisciplinary and the number of research groups actively utilizing polarization information often represents only a small fraction of the scientists within a remote-sensing, *in situ*, or laboratory optical-characterization discipline,

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The conference venue: resort *Koncha-Zaspa* located in the picturesque and quiet "green zone" of Kyiv.

no single conference or workshop had been organized to address this field in general. With any interdisciplinary field, it is important for the players to meet and interact, so that they can discuss and build on the methods that were successful, and especially to teach students these techniques. It was, therefore, anticipated that bringing this diverse group of scientists together to teach and discuss different aspects of this one specific topic would encourage future collaborative efforts among scientists working on similar problems in different fields of research who otherwise would not have this opportunity.

The ASI was organized in such a way that much of the key research was presented by experts most familiar with the respective major topics. Additional contributed presentations dealing with aspects related to the feature talks were made by scientists and students having deep working knowledge of the particular nuances. As with any new interdisciplinary line of research, it was anticipated—

ASI Director Yaroslav Yatskiv welcomes the participants
at the Main Astronomical Observatory.

The conference facility of the resort *Koncha-Zaspa*.

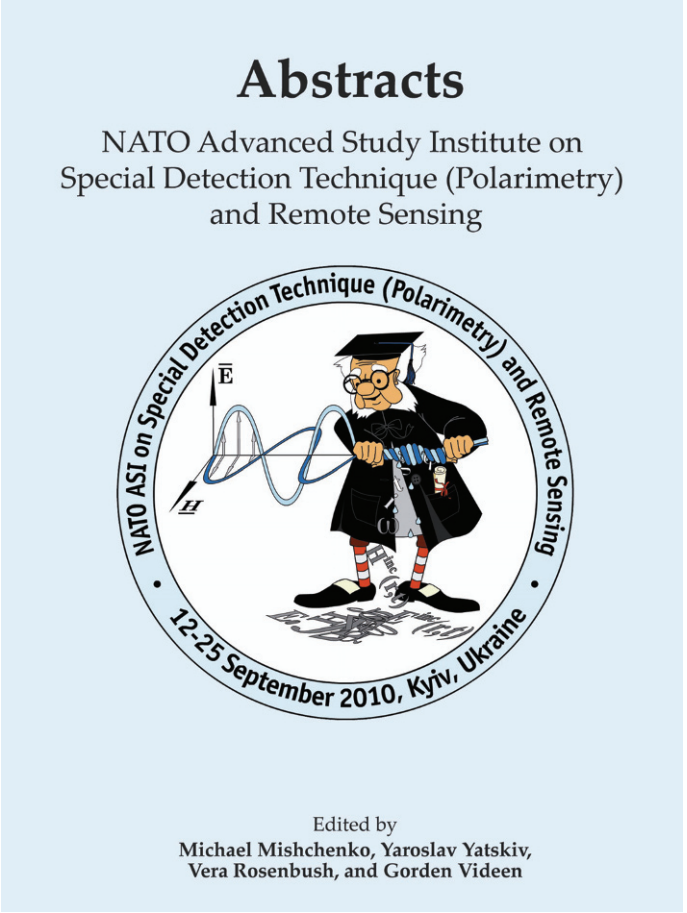
correctly—that some of the key barriers in one discipline had been worked out in other disciplines. This made the specific ASI format especially appropriate and extremely beneficial to all participants. We then identified and discussed the key common problems that we are trying to solve in this field along with what research needs to be performed to acquire the knowledge and research techniques to solve these problems.

While the formal lectures, shorter oral talks, and three poster sessions were key components of the ASI, another critical component was providing opportunities for direct personal interactions. Not only was this important for lecturers to further clarify key points of their tutorials and provide detailed explanations on a

NATO ASI poster.

more personal level, but it was also imperative to provide ample time for communications and exchanges of ideas that could ultimately lead to long-term collaborations helping advance the field into the future. The Local Organizing Committee (LOC) of the ASI worked hard to arrange such activities, which included an opening reception, two formal conference dinners, a field trip to the Main Astronomical Observatory (MAO), a *JQSRT* Session and Reception, and two tours of Kyiv.

It was especially appropriate that this meeting took place in Ukraine. First of all, the 2010 ASI built on the great success of the 2003 ASI on "Photopolarimetry



The official ASI logo and book of abstracts.

in Remote Sensing" convened in Yalta [3,4]. Second of all, Ukrainian astrophysicists have performed pioneering research in both measuring and interpreting photopolarimetric signals from remote astronomical objects [9]. These techniques have subsequently been extended to numerous other fields, including environmental remote-sensing of aerosol loading and terrestrial changes, such as the effects of pollution, erosion, and desertification. In this regard, the field trip to MAO, concluded by a lively picnic, was particularly instructive and productive.

In summary, the goal of the ASI was to present high-level tutorial courses on the most recent advances in polarimetric detection, characterization, and remote sensing, including military and environmental monitoring as well as terrestrial, atmospheric, and biomedical characterization. We discussed and taught techniques developed in various disciplines to acquire information from the polarization signal of scattered electromagnetic waves. We identified techniques that have been

Gorden Videen, Hal Maring, and Pinar Mengüç (from left to right) enjoy their time in Kyiv.

Michael Mishchenko, Nikolai Khlebtsov, and Vera Rosenbush (from left to right) discuss planetary opposition phenomena during the picnic at MAO.

especially successful for various applications and the future needs of the research communities. It is hoped that the inclusion of researchers from various disciplines will lead to cross-pollination of ideas and foster collaborations that will improve research efficiency. We did our best to provide the necessary elements to commence fruitful collaborations, i.e., food, drink, and discussion, and are confident that the participants were able to turn this great opportunity to their advantage.

An integral part of the ASI was the presentation of two memorable peer awards. The first one, the Special Prize of the LOC, was given to Professor Jim Hough for his exceptional lecture course on high-sensitivity polarimetry and its applications. The second one, the Young Scientist Award of the *Journal of Quan-*

titative Spectroscopy and Radiative Transfer (*JQSRT*) was presented to Dr. Pavel Litvinov for his outstanding contributions to the field of electromagnetic scattering by particles. We wholeheartedly congratulate both awardees on the well-deserved distinctions. The award ceremony was part of the second conference dinner, which also featured an utterly brilliant and rousing concert given by the enthusiastic members of the Ukrainian Folk Band of the Kyiv Taras Shevchenko National University.

Given the growing importance of polarimetry and the large amount of useful material presented at the ASI, it was essential to archive the well-established and new knowledge in the form of appropriate publications available to the entire scientific community. By its very design, this volume contains only tutorial reviews of specific fields of research, with a minimum of original material. Recent original results as well as a few additional reviews will be published in a special issue of *JQSRT* in the form of full-size peer-reviewed papers.

We thank all lecturers for the willingness to contribute their time and extensive knowledge and to provide instructive and illuminating tutorials that formed the backbone of this ASI. We also thank all the student participants (ranging from actual PhD students to senior researchers) for their energy and enthusiasm without which this ASI would not have happened. Special recognition is owed to the MAO research staff who were responsible for all aspects of local organization, overcame numerous obstacles, and made possible all the good things that happened during the two memorable weeks in Kyiv. We also thank the management and staff of the resort *Koncha-Zaspa* for fine cooperation and warm hospitality at their beautiful facility. Last but not least, we thank all contributors to this volume for providing outstanding chapters and responding to our numerous editorial requests in a timely manner.

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Major logistical assistance was provided by Carl Codan, Patricia Formosa, and Nadia Zakharova of Sigma Space Partners, LLC (New York, NY). Nadia Zakharova provided comprehensive editorial assistance in the preparation of this book.

The second conference dinner featured Ukrainian folk dances and songs.

The lively *JQSRT* reception sponsored by Elsevier.

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Tour of the Museum of Ukrainian Folk Architecture.