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IMAGING and ELECTRON PHYSICS

Volume 158

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Edited by

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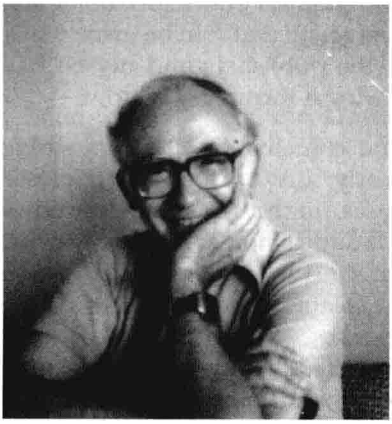
Preface



Ben Kazan, 1982

Before describing the contents of this volume, let me first say a few words about Benjamin Kazan, one of the Honorary Associate Editors of these Advances, whose death on January 14 2009 was mentioned briefly in the preface to volume 157. He was editor of the Academic Press series, *Advances in Image Pickup and Display* from 1974 to 1983, after which the title was absorbed into *Advances in Electronics and Electron Physics* (the earlier title of these *Advances*).

Ben Kazan, born in New York in 1917, received his B.S. degree from the California Institute of Technology, Pasadena, in 1938 and his M.A. from Columbia University, New York, in 1940. In 1961, he was awarded the D.Sc. degree by the Technical University of Munich. From 1940 to 1950, he was Section Head at the Signal Corps Engineering Laboratories, working on the development of new microwave storage and display tubes. For the next eight years, he was engaged in work on colour television tubes and solid-state intensifiers at the RCA Research Laboratories. From 1958 to 1962, he was head of the Solid-state Display Group at Hughes Research Laboratories, after which he moved to Electro-Optical Systems, an affiliate of the Xerox Corporation, again working on solid-state and electro-optical systems. From 1968–1974, he was employed at the IBM Thomas J. Watson Research Center. His last position was head of the Display Group at the Palo Alto Research Center of the Xerox Corporation. A dinner was held in his honour at Xerox, as the person holding the most patents at Xerox.

In addition to his editorship of *Advances in Image Pickup and Display*, he was co-author of two books (notably, *Electronic Image Storage* with M. Knoll, Academic Press, New York 1968) and was also editor of the *Proceedings of the Society for Information Display*. He was a Fellow of this Society as well as a member of the American Physical Society.

In his leisure hours, he played the violin and enjoyed books about music and medical topics, biographies and many other subjects. He was man of great kindness and generosity and will be greatly missed by his family and friends. On behalf of the publishers and myself, we extend our sincerest condolences to Gerda Mosse-Kazan, his widow.

The present volume contains six chapters on very different subjects, ranging from the early history of the microscope to mathematical morphology, time lenses, fuzzy sets and electron acceleration. We begin with a study of surface-plasmon-enhanced photoemission and electron acceleration using ultrashort laser pulses by P. Dombi. This is a very young subject and P. Dombi explains in detail what is involved and the physics of these complicated processes.

This is followed by a fascinating article on the development of (light) microscopy by B.J. Ford, with the provocative title 'Did physics matter to the pioneers of microscopy?' He has chosen to work back to Hooke and van Leeuwenhoek, starting with the microscopes we know today. I do not need to do more than urge all readers of these Advances to plunge into this chapter, which is truly 'unputdownable'!

How can an image be decomposed into its various structural and textural components? This is the subject of the chapter by J. Gilles, who provides a very lucid account of recent progress in this area. The mathematical preliminaries, which cover all the newer kinds of wavelets – ridgelets, curvelets and contourlets – form an essential basis on which the remainder reposes.

The fourth chapter, by S. Svensson, brings together two different topics: fuzzy distance transforms and electron tomography. Once again, the opening sections provide a solid mathematical basis for the application envisaged and I am certain that this full introductory account to these techniques will be heavily used.

The next chapter will appeal to mathematical morphologists: here, M. van Droogenbroeck describes the notion of anchors of morphological operators and algebraic openings. This concept is placed in context and the chapter forms a self-contained account of this particular aspect of mathematical morphology.

The volume ends with another new subject, time lenses for optical transmission systems, by D. Yang, S. Kumar and H. Wang. Spatial imaging has a perfect analogy in the time domain and this is exploited for temporal filtering. The authors introduce us to the subject before going more deeply into the possible ways of pursuing this analogy.

As always, I thank the authors for all the trouble they have taken to make their work accessible to a wide readership.

Peter W. Hawkes

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Chapter 1

Surface Plasmon-Enhanced Photoemission and Electron Acceleration with Ultrashort Laser Pulses

Péter Dombi

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1. INTRODUCTION

It was shown recently that ultrashort, intense laser pulses are particularly well suited for the generation of electron and other charged particle beams both in the relativistic and the nonrelativistic intensity regimes of laser-solid interactions (Irvine, Dechant, & Elezzabi, 2004; Leemans et al., 2006, and references therein). One method to generate well-behaved, optically accelerated electron beams with relatively low-intensity light pulses is surface plasmon polariton (SPP)-enhanced electron acceleration. Due to the intrinsic phenomenon of the enhancement of the SPP field (with respect to the field of the SPP-generating laser pulse), substantial field strength can be created in the vicinity of metal surfaces with simple, high-repetition-rate, unamplified laser sources. This results in both SPP-enhanced electron photoemission and electron acceleration in the SPP field. SPP-enhanced photoemission was demonstrated in several experimental publications. Typical photocurrent enhancement values ranged from $\times 50$ to $\times 3500$ achieved solely by SPP excitation (Tsang, Srinivasan-Rao, & Fischer, 1991).

In addition to SPP-enhanced photoemission, the electrons in the vicinity of the metal surface can undergo significant cycle-by-cycle acceleration in the evanescent plasmonic field. This phenomenon, termed *SPP-enhanced electron acceleration*, was discovered recently and was experimentally demonstrated to be suitable for the production of relatively high-energy, quasi-monoenergetic electron beams with the usage of simple femtosecond lasers (Irvine et al., 2004; Kupersztych, Monchicourt, & Raynaud, 2001; Zawadzka, Jaroszynski, Carey, & Wynne, 2001). In this scheme, the evanescent electric field of SPPs accelerates photo-emitted electrons away from the surface. This process can be so efficient that multi-keV kinetic energy levels can be reached without external direct current (DC) fields (Irvine and Elezzabi, 2005; Irvine et al., 2004). This method seems particularly advantageous for the generation of well-behaved femtosecond electron beams that can later be used for infrared pump/electron probe methods, such as ultrafast electron diffraction or microscopy (Lobastov, Srinivasan, & Zewail, 2005; Siwick, Dwyer, Jordan, & Miller, 2003). These time-resolved methods using electron beams can gain importance in the future by enabling both high spatial and high temporal resolution material characterization at the same time. They will become particularly interesting if the attosecond temporal resolution domain becomes within reach with electron diffraction and microscopy methods, as suggested recently (Fill, Veisz, Apolonski, & Krausz, 2006; Stockman, Kling, Krausz, & Kleineberg, 2007; Varró and Farkas, 2008). Moreover, studying the spectral properties of femtosecond electron beams has the potential to reveal ultrafast excitation dynamics in solids and to provide the basis for a single-shot measurement tool of the carrier-envelope (CE) phase (or the optical waveform) of ultrashort laser pulses, as we suggested recently (Dombi and Rácz, 2008a; Irvine, Dombi, Farkas, & Elezzabi, 2006). Other waveform-sensitive laser-solid interactions that have already been demonstrated (Apolonski et al., 2004; Dombi et al., 2004; Fortier et al., 2004; Mücke et al., 2004) suffer from low experimental contrast; therefore, it is necessary to look for higher-contrast tools for direct phase measurement.

Motivated by these possibilities, it was shown numerically (and also partly experimentally) that surface plasmonic electron sources can be ideally controlled with ultrashort laser pulses so that they deliver highly directional, monoenergetic electron beams readily synchronized with the pump pulse (Dombi and Rácz, 2008a; Irvine et al., 2004, 2006). We developed a simple semiclassical approach for the simulation of this process analogous to the three-step model of high harmonic generation (Corkum, 1993; Kulander, Schafer, & Krause, 1993). In this chapter, we review the basic elements of this model and prove that it delivers the same results as a much more complicated treatment of the problem based on the rigorous, but computationally time-consuming, solution of Maxwell's equations. Results gained with this latter method showed very good agreement with experimental electron spectra (Irvine, 2006). We also provide new insight into the spatiotemporal dynamics of SPP-enhanced electron acceleration, which is also important if one intends to realize adaptive emission control methods (Aeschlimann et al., 2007).

2. ELECTRON EMISSION AND PHOTOACCELERATION IN SURFACE PLASMON FIELDS

2.1. Emission Mechanisms

Laser-induced electron emission processes of both atoms and solids are determined by the intensity of the exciting laser pulse. At low intensities where the field of the laser pulse is not sufficient to distort the potential significantly, multiphoton-induced processes dominate at visible wavelengths. These nonlinear processes can be described by a perturbative approach in this case. Light-matter interaction is predominantly non-adiabatic and it is governed by the evolution of the amplitude of the laser field, or, in other words, the intensity envelope of the laser pulse.

Tunneling or field emission takes over at higher intensities. This emission regime is determined by the fact that the potential is distorted by the laser field to an extent that it allows tunneling (or, at even higher intensities, above-barrier detachment) of the electron through the modulated potential barrier, the width of which is determined by the laser field strength. The interaction is determined by the instantaneous field strength of the laser pulse; the photocurrent generated in this manner follows the field evolution