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## ***Problems of Theoretical and Applied Electron and Ion Optics***

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*Chair/Editor*

**Inna S. Gaidoukova**

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## Introduction

The Eighth Seminar on Problems of Theoretical and Applied Electron and Ion Optics was held in Moscow, Russia, 29–31 May 2007. The seminar was hosted by the RD&P Association ORION, the State Scientific Center, and supported by the Scientific Council on Charged Particle Accelerators of Russian Academy of Science, the Scientific Council on Relativistic and Heavy-Current Electronics of Russian Academy of Sciences, and SPIE. The Joint Institute for Nuclear Research and All-Russian Electro-technical Institute also brought their valuable contribution to the seminar.

The biannual seminar gathered together scientists involved in theoretical and applied research in electron and ion optics. Traditionally, the scientific program of the seminar has included four sessions:

1. Theoretical electron and ion optics, aberration analysis of electron-optical elements and systems, electron and ion optics of high-intensity beams, and computer modeling
2. Electron-optical devices and equipment for analytical and technological purposes (analytical electron/ion beam instrumentation, technological electron-beam facilities, ion-beam and plasma technological equipment, image intensifiers, mass- and energy-analyzers, etc.)
3. Injectors of charged particles for accelerators; electron beams for electron cooling; and electron beam energy recuperation systems
4. Technological aspects of interaction of electron and ion beams with matter.

This year the seminar was held to commemorate the 100th anniversary of Jury Markovich Kushnir's birth. Yu. M. Kushnir was one of the pioneers of developing electron-optical instrumentation, namely, the scanning and reflective electron microscopes, electron diffraction cameras, and the technological electron-beam equipment in Russia.

About 100 technical papers were presented at the seminar. Their authors represent 49 leading scientific organizations in Russia, Ukraine, Byelorussia, and Kazakhstan. Participants of the seminar included representatives from 12 institutes of the Russian Academy of Sciences, 10 scientific centers, and 16 universities.

For the first time, a round-table discussion devoted to software for computer modeling of electron-optical systems and particle-matter interaction was held as part of the seminar. Several program packages were presented by the participants. The program for automatic measurement of beam size, BEAMETER, and the electron scattering simulation tool, CHARIOT, were presented by S. Borisov, et al. (Abeam Technologies, USA). A.A. Trubitsyn (Ryazan State Radio Engineering University) presented the algorithms and characteristics of his software FOCUS designated for modeling axisymmetric electron-optical systems. O.N. Petrovich from Polotsk State University, Byelorussia, introduced her program of numerical analysis of dynamic electron-optical systems with a plasma emitter. The software package MASIM 3D for CPO simulation was presented by D.E. Greenfield and M.A. Monastyrskiy from RD&P Association ORION and Prokhorov General Physics Institute of RAS, respectively. The submitted software caused brisk discussion, and seminar participants found the software demonstration session constructive.

The session "Theoretical and computational electron and ion optics and computer simulation" gathered about 50 presentations. We can distinguish three major topics: intensive electron beam formation, modeling of the field-emission systems, and high resolution energy- and mass-analyzers. The scientific level of most of the presented papers was very high. Great interest was attracted by the presentations of V. M. Sveshnikov titled "Numerical modeling of intensive charged-particle beams using quasi-structured rectilinear meshes" (Institute for Computational Mathematics and Mathematical Geophysics, Novosibirsk, Russia) and the presentation by S.V. Poljakov and V.A. Fedirko, "Modeling of the semiconductor field-emission micro-unit" (Institute for Mathematical Modeling and STANKIN University, Moscow). Strict requirements for accuracy in the electron-optical simulations are dictated by the exclusively important role played by electron-optical equipment in nanoscale technology. In this connection we recognize the paper by V.A. Zhukov titled "The limiting resolution in FIB with the chromatic aberration being compensated." The author has shown that one can obtain 1 nm resolution of an analytical or technological focused ion beam (FIB) machine with a field-emission cathode, provided that the chromatic aberration is compensated with a combined electron mirror.

In the session "Electron- and ion-beam equipment," the paper "Proton scanning microprobe with integrated probe-forming system" by A.G. Ponomarev, et al. (Institute of Applied Physics, Ukraine) deserves special mention. The instrument was developed on the basis of the electrostatic accelerator "Sokol" with a maximum proton energy of 2 MeV. Local non-destructive element analysis with high sensitivity appeared possible due to the remarkable parameters of the ion beam, the scanning system with dynamic displacement of the beam axis, and the three-channel signal registration with the sensors of secondary electrons, backscattered protons, and characteristic x-ray radiation.

As in years previous, interesting papers were presented by the team from the Joint Institute for Nuclear Research (JINR, Dubna, Russia). The paper "Formation and stability of high intensive cooled ion beam in synchrotron at injection energy" by E. M. Syresin (JINR) and K. Noda (National Institute of Radiological Science, Japan) presented experimental and numerical results on formation and stability of the intensive cooled ion beams obtained with the specialized medical synchrotron HIMAC. In the presentation, "The pulse injector of the low-energy positrons," V.F. Bykovskiy, et al. introduced the 2-10 keV positron injector capable of generating pulses containing  $10^8$ - $10^9$  particles and having durations less than 300 ns, a relative energy spread less than  $2 \times 10^{-3}$ , and a beam radius of 0.5 cm. Dynamics of the low-energy positrons in the injector and physical phenomena during their accumulation were discussed.

A large number of papers presented at the session on heavy-current electronics were devoted to the problems of modeling and design of microwave systems. Several papers were devoted to computer simulation of charged particles interacting with condensed media in the session "The problems of interaction of the electron and ion beams with matter."

Among the papers with practical value, we should distinguish the work "Electron-beam methods of induced current and potential contrast in the failure analysis of front-end matrix for IR photodetectors" presented by the RP&D Association ORION's team. The authors, V.M. Akimov, N.N. Dremova, and S.N. Yakunin, managed to elucidate the main sources of defects which lead to failures of integrated multiplexers. Their detailed analysis of the nature of the defects allows for fixing problems in the technological process of multiplexers manufacturing.

It is our pleasure to note the high quality of papers contributed to the Eighth Seminar on Problems of Theoretical and Applied Electron and Ion Optics. These papers represent a high theoretical level in the sphere of electron optics and the successful development of new electron- and ion-optical equipment for scientific research and technological applications, including nanotechnology.

**Anatoly M. Filachev**

