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APPROACHES TO ENHANCING THE PERFORMANCE OF ELECTRON-OPTICAL SYSTEMS FOR CHARGED PARTICLE FLOW ANALYSIS

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Various methods of electron spectroscopy are currently used to analyse the surface of solids, and new instruments are constantly being developed to meet technological needs. An important element of experimental schemes is an energy analyser, which allows measuring the current density of charged particles in a given energy range. In this work, three directions for improving the corpuscular-optical characteristics of electro-optical devices are considered. The first direction is related to the modification of the deflecting field by changing the shape of the outer electrode of the cylindrical mirror (CM), which allows increasing its energy resolution. The second direction involves the use of additional electron-optical elements (lenses, mirrors), which leads to the improvement of focusing properties of analysers. The third direction concerns the development of mathematical methods of processing of output signals, which allows to reconstruct spectra of investigated sources more accurately. Improvement of electro-optical systems for the analysis of charged particle fluxes includes both calculations of new designs and modernisation of existing devices, and the development of algorithms for processing experimental data, which provides an increase in the accuracy and efficiency of spectrometric studies.

Keywords: Electron spectroscopy, energy analyzer, electrostatic field, charged particles, signal processing.

Modern electron spectroscopy offers a wide range of techniques for analyzing the surface of solid materials. With growing technological demands, new methods and instruments are continuously being developed. Electrostatic devices based on various field geometries—such as spherical, cylindrical, hyperbolic, and uniform fields, as well as their superpositions—are widely utilized for energy analysis of charged particle flows [8]. A crucial component of experimental setups is the energy analyzer, a device that measures the current density of charged particles within a specific energy range from E to E+ΔE [1].

This study highlights three key approaches to enhancing the corpuscular-optical characteristics of electrostatic devices.

The first approach involves modifying the deflecting field by altering the shape of the outer electrode in a cylindrical mirror (CM) (Fig.1). The CM is one of the most commonly used elements in electronic spectrometers due to its high energy resolution and simple construction. Its operation is based on the focusing and dispersing effects of the electrostatic field between two coaxial cylindrical electrodes, influencing the charged particle beam. The theoretical foundations and practical applications of the CM were extensively studied by a research group led by Professor V.V. Zashkvara [6].

Wannberg [11] proposed an electrostatic energy analyzer with a field configuration similar to a cylindrical one, focusing on the angular focusing of particle beams with different energies near the inner cylindrical electrode. In this design, the focal surface for inner electrode focusing is nearly cylindrical.

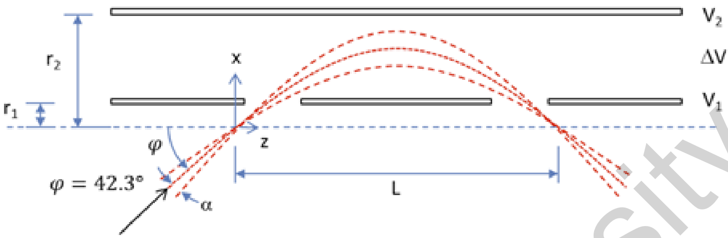

Fig.1 Cylindrical mirror

In [7, 12], V.V. Zashkvara and N.N. Tyndyk introduced and classified a new class of potential fields known as multipole-cylindrical fields (MCFs). These fields arise from the superposition of a cylindrical electrostatic field and a circular multipole of varying contributions. The field is generated between two axisymmetric coaxial electrodes, where the inner cylinder is grounded and the outer electrode, featuring a curved profile, is held at a potential of the same sign as the charge of the particles within the field.

A novel approach to synthesizing energy analyzers, based on inverse mechanics problems, was proposed in [3]. This led to the development of the two-dimensional "Tutankhamun" energy analyzer, which exhibits ideal angular focusing in the symmetry plane and possesses dispersion ten times higher than conventional systems.

Building upon inverse problem-solving techniques and new basis series for electrostatic fields, researchers have designed and calculated various modifications of axisymmetric energy analyzers that significantly outperform traditional CM designs [4]. This class of quasi-conical systems has already gained traction in analytical instrumentation.

The second approach to enhancing spectrometer performance involves incorporating additional electron-optical elements such as lenses and mirrors. A two-stage system, consisting of sequentially arranged cylindrical and spherical mirrors, was presented in [5]. This configuration enables second-order focusing with respect to the divergence angle of the charged particle beam.

In [10], researchers proposed the insertion of a coaxial cylindrical electrode within the CM, positioned between the inner and outer cylinders. By carefully selecting the ratio of cylinder radii and their respective potentials, third-order angular aberrations were eliminated, resulting in a substantial increase in the device's luminosity without compromising resolution.

The work in [2] introduced an energy analyzer composed of sequentially arranged hyperbolic and cylindrical mirrors. In the first-order focusing mode, this system exhibits significant angular and linear energy dispersion coefficients.

The third approach to improving energy analysis systems focuses on the mathematical processing of output signals obtained from electron spectrometers. For the first time, a universal integral relationship between the spectrometer's output signal and the true spectrum of the analyzed source was derived in [9]. The developed spectral reconstruction algorithms play a crucial role in optimizing the performance of modern spectrometers.

Thus, advancements in electron-optical systems for charged particle flow analysis are achieved through two primary means: first, by designing new and refining existing devices, and second, by enhancing mathematical methodologies for processing output data. While both approaches contribute significantly to improving spectral analysis accuracy and efficiency, the first method presents greater technological challenges and demands higher implementation efforts.

Overall, the improvement of electron-optical systems for charged particle analysis is achieved through a combination of advanced engineering solutions and sophisticated data processing techniques. While the development of new devices poses greater technological challenges, the integration of mathematical processing methodologies offers a comparably significant impact on improving measurement accuracy and efficiency. These advancements pave the way for further innovation in spectroscopy and analytical instrumentation.

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THE HEAVY-ATOM EFFECT ON SINGLET OXYGEN GENERATION IN THE PRESENCE OF PLASMONIC SILVER NANOPARTICLES

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The effect of heavy atoms on singlet oxygen generation in the plasmon field of silver nanoparticles was investigated. Rhodamine 123 and dibromo-rhodamine 123 dyes embedded in polyvinyl butyral films were selected as sensitizers. The dye films were deposited via spin coating onto silver island films synthesized on quartz substrates. The results indicate that the presence