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ABSTRACTS OF REPORTS

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"PLASMA ELECTRONICS AND NEW METHODS OF ACCELERATION"

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CONTENTS

SECTION 1.
NON-RELATIVISTIC PLASMA ELECTRONICS

Features of new cyclotron resonances, as well as conditions for resonant acceleration of charged particles in a vacuum without a magnetic field

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It is shown that the known conditions for cyclotron resonances are strictly valid only under autoresonance conditions or in the nonrelativistic case. In other cases, it is necessary to use the conditions written out in the work. The results of the main features of the dynamics of charged particles under new resonant conditions are presented. The main feature of particle dynamics is their stepwise nature. The temporal width of these steps was determined, as well as the moments of particle hopping from one step to another. The high sensitivity of the particle dynamics to small changes in the wave parameters is demonstrated. Conditions are found for practically unlimited acceleration of electrons by a transverse electromagnetic wave in a vacuum without a magnetic field. It is shown that such an acceleration can be carried out by a field whose strength parameter is less than unity. The results of acceleration of particles by the field of a Gaussian beam in vacuum are presented.

The role of higher moments on the distribution of particles in the space of impulses at cyclotron resonances

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The results of the study of particle dynamics at cyclotron resonances are presented. The main attention is paid to finding the particle distribution function in the momentum space. The material is presented in two parts. In the first part, the conditions for the emergence of regimes with dynamic chaos are found. These are the conditions for the overlap of nonlinear resonances at sufficiently low field strengths. At high field strengths, this is the condition for the appearance of steps in particle dynamics. In the second part, the conditions are defined under which the values of higher moments can exceed the values of lower moments. It is shown that only even moments are nonzero. In this case, the generalized Fokker-Planck equation is constructed. The generalization consists in taking into account higher moments in this equation. The results of analytical and numerical studies of this generalized equation are presented.

Do the dispersion properties of electromagnetic surface waves at the sharp boundary plasma-metal in slab Voigt geometry represent the limiting case of those for the interface of two plasmas?

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Electromagnetic surface waves in Voigt geometry are considered to resolve the contradiction between two classical studies. One investigated the waves at the plasma-plasma interface. These waves were reported not to propagate with frequencies below the ion cyclotron frequency. The other approach studied the waves at the metal-plasma interface. Dispersion properties of the waves with frequencies below the ion cyclotron frequency were investigated. The contradiction is valid despite the fact that the structure metal-plasma is the natural limiting case of the boundary of two plasmas in which the two plasma particle densities differ significantly. The contradiction is analyzed and explained.

Frequency of parametric X-ray radiation

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The exact solution of the equation for frequency of parametric X-ray radiation of relativistic charged particles moving in a crystal is obtained. The exact solution is compared to approximate solution, which is often used for comparison to experimental data. It is found that exact solution is very close to the approximate solution and that the approximate solution for frequency of parametric X-ray radiation is practically correct for comparison to experimental data. The different situation at radiation of relativistic particle in macroscopic periodical structures is discussed.

Slow electromagnetic waves in planar three-component waveguide structure with mu-negative metamaterial

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We present the results of the study of slow electromagnetic waves that propagate along the planar waveguide structure that consists of semi-bounded

plasma region, metamaterial slab and semi-bounded region of ordinary dielectric. It is studied the case when all media are homogeneous and isotropic. The dispersion properties and spatial attenuation, the phase and group velocities, as well as the electromagnetic field spatial structure of the eigen TE and TM modes are studied in the frequency range where the metamaterial possess negative permeability. The obtained results can be used for practical applications as in laboratory experiments, as in various technologies.

Drift-kinetic equations in magnetized current-carrying plasmas

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Kinetic models of magnetized current-carrying plasma have been developed to study the influence of magnetic drift effects on the wave-particle interactions in tokamaks and cylindrical plasma columns. The helical equilibrium magnetic field and the steady-state distribution functions of plasma particles are self-consistent. The drift-kinetic equations are derived for the perturbed distribution functions of both the trapped and untrapped particles in a two-dimensional axisymmetric toroidal plasma, taking into account their bounce oscillations and the finite orbit-widths of their banana-trajectories.

Including the own fields of quantum emitters in describing generation regimes

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The paper discusses three different modes of electromagnetic field generation by an ensemble of quantum emitters placed at the radiation wavelength in the one-dimensional case. The excitation of the resonator field is considered, which, as a rule, is determined by the geometry of the system, with and without taking into account the eigenfields of the emitters. The superradiance mode of the same ensemble of emitters is also analyzed. Since the main indicator of generation is the level of energy output from the system, the position of the maximum of this indicator determines the operating point of the device. Taking into account the intrinsic field of the emitters enhances the generation intensity and significantly changes the position of the operating point.

SECTION 2.
NEW METHODS OF CHARGED PARTICLE ACCELERATION

Investigation of parameters of electron and positron bunches in a plasma-dielectric wakefield accelerator

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The results of numerical PIC simulation of the dynamics of test positron and electron bunches under wake acceleration in a dielectric waveguide filled with plasma with a vacuum channel are presented. The wake field was excited by an electron bunch in a quartz dielectric tube inserted into a cylindrical metal waveguide. The inner region of the dielectric tube was filled with plasma with a vacuum channel along the waveguide axis. The difference in energy and spatial characteristics, acceleration efficiency, emittance, and energy spread for positron and electron bunches is studied for different radii of the vacuum channel.

Excitation of wake surface plasmon-phonon oscillations by a relativistic electron bunch in a polar semiconductor waveguide

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The process of surface wakefields excitation by the relativistic electron bunch in a polar semiconductor waveguide with a vacuum channel for electron bunch transportation is studied. The spectra and spatio-temporal structure of the excited surface wakefield in such system are investigated. It is shown that the excited full surface wakefield in the terahertz and infrared frequency ranges consists the fields of LF and HF hybrid surface plasmon-phonon oscillations. The amplitudes of the excited LF and HF surface plasmon-phonon waves are determined.

Wake excitation of plasma and electromagnetic oscillations by a relativistic electron bunch in a plasma resonator

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An expression for the electromagnetic field excited by a relativistic electron bunch in a plasma cavity is obtained and studied. This expression has the form of a superposition of eigen electromagnetic oscillations of a plasma cavity with discrete frequencies.

It is shown also that the total wake field of plasma oscillations excited in a plasma cavity includes both a bulk traveling plasma wave and fields of surface plasma oscillations. The fields of surface plasma oscillations are pressed against the input and output ends of the plasma cavity. Only in the aggregate all these oscillations provide the fulfillment of the boundary conditions at the ideally conducting ends of the plasma cavity.

Simultaneous compensation of second and third order dispersion in CPA laser systems

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This scientific article presents a theoretical investigation focused on solving the problem of compensating for second and third order dispersion in a CPA laser systems temporal compressor. The study examines the propagation of light pulses through a stretcher and an amplifier after being generated on Ti-Sa by a master oscillator. Wave equation and dispersion balance equations are employed to analyze different amplifier configurations consisting of Ti-Sa crystals. The research findings include the deviation values of the temporal compressor length and the angle of incidence of the light pulse on the compressor diffraction grating. Various amplifier variations differ in the number of passes of the light pulse through Ti-Sa crystals and the geometric profile of the crystals. The obtained results are presented in a table, which also incorporates the dispersion of the Pockels cell and two Glan prisms. This study holds significance for the development of more efficient and precise temporal compression systems in laser applications.

Simulation of the identical plateaus formation on plasma wakefield for long driver-bunch and witness-bunches

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We formulate scenarios for the simultaneous increase of the charge of accelerated electrons, the transformer ratio, high efficiency, low energy spread, and emittance of bunches of accelerated electrons in the blowout regime at the simultaneous achievement of the identical plateaus on the accelerating wakefields and other identical plateaus on the decelerating wakefields.

A method for maintaining the acceleration rate and increasing the energy of self-injected bunch due to the use of inhomogeneous plasma

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The paper considers the process of excitation of a wakefield in a plasma by a laser pulse. The plasma density corresponds to the density of free electrons in the metal. A method is demonstrated for keeping self-injected bunch in the accelerating phase of the wakefield as laser pulse and bunch move in plasma with an increasing density gradient. Thus, the rate of acceleration of self-injected bunch is maintained.

This work is supported by National Research Foundation of Ukraine "Leading and Young Scientists Research Support", grant agreement # 2020.02/0299.

Profiling and variation of laser pulse parameters as a way to preserve the stability of self-injected bunches during excitation of a wakefield in plasma

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The paper considers the excitation of a wakefield in a metal-density plasma using a chain of X-ray laser pulses. The profiling parameters and the necessary parameters of laser pulses for obtaining stable high-quality bunches are found. An essential problem is the destruction of self-injected bunches in the course of their motion. The results of the study are one of the ways to solve the problem of transverse betatron oscillations, which lead to the destruction of bunches.

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Regularization of wakefield in a weakly nonlinear regime

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In blowout regime of wakefield excitation, strong chaotization of wake occurs. However, for electron-positron colliders and X-ray microscopes, a weakly nonlinear regime is proposed with the formation of a regular short chain of bubbles. To increase the efficiency of the wakefield accelerator, it is necessary that

not separate bunches participate. In this paper in 2D plane geometry, the dependence of the number of formed bubbles and their regularization on the degree of wake non-linearity and parameters: driver current, ion mobility, transverse plasma size and profile - is studied. We will show that in a weakly nonlinear regime the regular chain of bubbles becomes longer.

Electron cyclotron resonance accelerator – eCRA

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Simulations have shown that far greater electron accelerations than previously predicted can be achieved using a TE_{-111} rotating-mode microwave cavity with an axial static magnetic field. A proof-of-principle version of this accelerator (eCRA) is being built to demonstrate its capability as the driver for a potent MeV-scale X-ray source to replace radioisotopic sources.

Technology development for modern SRF accelerators

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Superconducting RF (SRF) linear accelerators are widely used for scientific application. Challenges, status, breakthroughs and progress in SRF technology for accelerator application are discussed.

SECTION 3.
HIGH-CURRENT RELATIVISTIC ELECTRONICS

Excitation of durable VHF oscillations in ferrite-filled coaxial lines

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Effective methods have been suggested for exciting gigahertz-range oscillations in coaxial lines that contain gyrotropic inserts involving ferrite rings and isotropic material. The structure is non-uniform along the radial and the longitudinal directions. Within the ferrite-filled section, the primary voltage pulse coming from an external source as a TEM mode gets transformed into the TM_{01}. Its further development has been analyzed through real-life and numerical experiments offering velocity synchronism conditions for the waves in the ferrite and its adjacent isotropic layer. Attention has been concentrated on amplitude variations of the TM_{01} mode owing to a nonlinear response of the ferrite.

The simulation of emergency action on construction materials by high current relativistic electron beams

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At present, it is obvious that the development of many innovative areas in energy, mechanical engineering, aircraft building and other industries is limited by the strength of materials under the action of temperature gradients. In this regard, the problem arises of finding and justifying technical means that would model a complex of influencing factors characteristic of operating conditions. High-current relativistic electron beams reasonably belong to such means. As a result of their impact, pulsed electric and magnetic fields arise in the irradiated targets, temperature gradients are created, and shock waves are generated. The paper investigates the patterns of change in the internal structure of the blades of gas turbine engines, engineering materials, subjected to the action of an electron beam.

A method for measuring the power of a high-amplitude pulsed-modulated microwave signal for the ECR plasma heating

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This paper describes a technique for measuring the power of the microwave source of the "VOLNA" setup, designed to study the ECR of plasma. The purpose of this work was to increase the electric field strength in the plasma, leading to an increase in the number of ECR resonances, which in turn directly depends on the power of the microwave power source.

The source of the microwave installation "VOLNA" is a microwave pulse magnetron MI-125 with a maximum power of 1 MW per operating at a frequency of 2.7 GHz with a duration of 2 μs pulses with a pulse repetition rate of 1 Hz.

To measure the total microwave power of 1 MW per pulse, an M3-13/1 calorimetric wattmeter was chosen, and for preliminary measurements, instead of a microwave power source, a "LUCH-58" microwave generator was used.

As measurements of the Luch-58 microwave power with the M3-13/1 wattmeter showed, satisfactory measurement accuracy with an error of 10% can be achieved by increasing the average microwave power to 10-20 W by increasing the pulse repetition rate from the MI-125 magnetron from 1 Hz to 5-10 Hz.

Magnetic field dynamics in plasma opening switch: inhomogeneous plasma density distribution

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Computer simulations in electron magnetohydrodynamics (EMHD) approximation for magnetic field and current density spatio-temporal dynamics in plasma opening switch (POS) are presented for various initial plasma density distributions. The current channel formation in the POS's inhomogeneous plasma and its passage through the plasma bridge are studied. It is shown, that the penetration of the magnetic field into the POS's plasma and current channel formation are strongly depends on the spatial distribution of the plasma density in the POS. By changing the spatial distribution of the plasma density in the POS, which is determined by the operation of plasma guns, it is possible to change the mechanism of penetration of the magnetic field into the plasma.

Effect of electron collisions with residual neutral gas on characteristic oscillation frequencies in systems of electron flows with a virtual cathode

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A system of the hydrodynamic equations describing the electron flows in a diode with a virtual cathode is considered. Collisions are taken into account by introducing the corresponding braking force into the equations of motion. The stationary states of the electron flows are described. In a linear approximation, formulas are obtained for the frequencies of electron oscillations in a diode with a virtual cathode, taking into account the effective frequency of electron collisions. The expression for the decrement of oscillations due to the presence of collisions is obtained.

Influence of the energy parameters of the primary circuit on the current characteristics of the DIN-2K accelerator

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Accelerators with an inductive energy storage device and a plasma current interrupter are used to create sources of high-power microwave radiation. The time and place of the break depends on the time delay between the operation of the plasma guns and the voltage supply to the cathode of the accelerator, the charging voltage of the plasma guns and the pulsed current generator. A series of experiments was carried out, which made it possible to identify the optimal parameters of the primary circuit of the installation, at which the maximum pre-break currents and break currents are realized. Vacuum conditions sufficient for realization of the maximum currents are determined. The conditions for obtaining the maximum X-ray doses are established.

Excitation of TM mode by a relativistic electron beam in an azimuthally corrugated waveguide

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The excitation of an electromagnetic TM mode by a relativistic electron beam in a cylindrical waveguide with a sinusoidal-corrugated azimuth conducting wall in a constant uniform external guiding magnetic field is theoretically studied. We consider a thin annular electron beam moving along the waveguide axis and rotating at an equilibrium radius around its axis. In the approximation of a small corrugation depth, the analytical dependences of the growth rate of instability and resonant frequencies on the parameters of the beam and waveguide are determined.

SECTION 4.
ION BEAMS FOR INERTIAL CONFINEMENT FUSION, MATERIALS SCIENCE AND OTHER APPLICATIONS

Effect of transient layers on energy transfer to different surfaces at the plasma-surface interaction in QSPA

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Exhaust of energy and particles, including their transfer to plasma-facing materials and components, is crucial for the successful implementation of future fusion reactor projects and, therefore, requires extensive studies. Analyses of plasma surface interaction features have been performed under Quasi-Stationery Plasma Accelerator (QSPA) exposures of reference plasma-facing materials. The parameters of the plasma streams imitated conditions of transient events in a fusion reactor. The influence of an external magnetic field on the energy balance during the plasma-surface interaction is also discussed.

Modernization of the helium ion accelerator microwave power supply system

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The high-voltage rectifier modernization, which is part of helium accelerator (PSS-4) high-frequency system, is described. The rectifier supplies the pulse modulator with direct current energy. The valves of the modulator used are mercury thyratrons. Modernization involves replacing thyratrons with semiconductor diodes. In the article, a comparative analysis of the parameters of thyratrons and diodes, which are supposed to be replaced by thyratrons, is carried out, and the expediency of such a replacement is substantiated.

Features of structural damages of surface of tungsten as a result of irradiation with helium ion beams with energy 4 MeV

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The use of helium ion beams with energies of 0.12 MeV and 4 MeV for irradiation of tungsten, which is the material of the first wall of a thermonuclear reactor, was considered. Ion beams reproduced the radiation-thermal effect of neutrons. The use of helium ion beams makes it possible, in a short time, to irradiate the material in modes close to the conditions of exposure to plasma radiation. The samples were pure 99.5% and 99.7%. We studied how the characteristics of the tungsten surface changed depending on the energy of the helium ion beam. It has been experimentally obtained that the amount of tungsten fuzz is greater by 20% in the case of irradiation with ions with energies of 0.12 MeV than in the case of irradiation with helium ions with energies of 4 MeV. Using the SRIM code, the sputtering coefficients on the surface of tungsten are obtained. A high coincidence with the experimental results (difference no more than 15%) was obtained.

New concept of the main part of multicharged ions linear accelerator on the combined RF focusing basis

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The new concept of the main part of multicharge ions linear accelerator (MILAC) NSC KIPT on the combined RF focusing (CRFF) basis is proposed. In CRFF acceleration and focusing of the charged particles occurs at the expense of the same accelerating field. Absence of an external focusing field sources a design and operation of the accelerator main part considerably simplifies. The construction principle accelerating&focusing channels with CRFF is considered. The mathematical modeling findings of a beam dynamics for particles with the mass-to-charge ratio of A/q=5 in a range energies of 1 … 9.2 MeV/u are resulted. Realization of this focusing method on a basis interdigital H type accelerating structure is proposed.

TiO_2-2 radiating damages as a result of the irradiation helium ions with energies of 0.12 and 4 MeV on the linear accelerator

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On the linear accelerator of helium ions the irradiation of samples TiO_2-2 with ions energy of 0.12 MeV and 4 MeV to doses $\approx 1 \cdot 10^{18}$ ion/sm^2 is executed. The elemental composition of samples TiO_2-2 is made roentgen-fluorescence method. After an irradiation change of electrophysical characteristics is investigated (electroresistance, dissipation factor, dielectric constant), microscopic researches on electronic and optical microscopes are conducted. Numerical calculations of atoms dispersion factors taking into account of "input" corners of helium ions in the sample, and also phonons formation, atoms redistribution (segregation), formation of vacancies and displacement in sample TiO_2-2 are made. Processes of blistering and flaking formation are investigated, and also presence of "metallization" effect and "long-range interaction" effect in the irradiated samples is shown.

Conceptual design of a radiation-free 800 MeV proton linac

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Presented is the concept of a 800 MeV proton linear accelerator as a result of long-term research in ion linacs based on alternating-phase focusing (APF) in H-mode structures. Particle motion stability in the medium energy range of 5…100 MeV where the space charge effects are essential and main radiation losses occur, is provided by a combination of modified APF and magnetic focusing. This combined focusing technique can effectively prevent emmittance growth and minimize radiation losses.

High-voltage modulator for ion linac injector with smooth pulse duration control

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The ion linear accelerators stable operation essentially depends on the ion injector. To ensure maximum capture of the ion beam injected into the accelerating structure, the injector must be able to adjust the beam parameters. The paper describes the developed new injector power supply system, built on modern assemblies, which allows smoothly changing the modulator pulse duration in the range of 300 μs – 2000 μs. The analysis was carried out and the shortcomings of the first systems were eliminated. The expected increase in the accelerated ion beam current is 15-20%. Related results include a decrease in the parasitic load capacitances of pulsed devices, a reduction in size, and the rejection of high-voltage isolation transformers, which increases the reliability of the accelerator.

Isolation of electrons by the magnetic field of a cusp for ion acceleration

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A 2.5D simulation of the isolation of electrons by the magnetic field of the cusp before the entry of a neutralized high-current ion beam into the accelerating gap depending on the set of initial parameters of the ion beam and the magnitudes of the external electric and magnetic fields has been carried out. The range of parameters under which such an acceleration scheme can be implemented has been found. Threshold values of the magnetic field and the ion beam current, exceeding which the scheme loses its suitability for accelerating a high-current ion beam when solving the problem of inertial thermonuclear fusion, have been determined.

Lens for focusing beams of negative hydrogen ions by means of a field of positive ions bulk charge

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The ways of creating a positive volume charge in the lens area to focus the beam of negative hydrogen ions are being discussed in the work.

SECTION 5.
COLLECTIVE PROCESSES IN SPACE PLASMAS

Cosmic ray source and solar energetic particles

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Energization of matter in the cosmos as on earth require several phases: ionization, injection, and acceleration at high energy. Supernova remnants, as observed by gamma ray telescopes, appear to be excellent accelerators or re-accelerators through the shock waves they induce in the interstellar medium. All the mystery condenses in the injection mechanism.

The similarities between the composition of galactic cosmic rays at the sources (i.e. corrected for spallation) and solar energetic particles and solar wind compositions suggest that stars in galactic superbubbles are the cosmic injectors and supernovae the cosmic accelerators, at least a GeV energies.

Structures of vortexes near the poles of planets of the solar system

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It is known that in the vicinity of the poles of the planets of the solar system, various ordered crystals of vortices and intermittency are observed. This work investigates the formation of vortex structures in the vicinity of the poles of the planets of the solar system. And also the influence of these structures on the dynamics of the environment in the vicinity of the poles of the planets of the solar system. The conditions for the formation of vortex perturbations are considered. A nonlinear equation was found that describes the vortex dynamics of electrons and its consequences were studied taking into account the finite length of the region of existence of these structures.

Self-consistent equilibrium of a helical magnetic flux rope

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We present a model of self-consistent equilibrium of a magnetic flux rope in cylindrical coordinates. A nonlinear equation for the current density is obtained and its analytical solution is found. The remaining equilibrium quantities, namely, the azimuthal magnetic field and plasma pressure are determined in a self-consistent way through the found current density. By minimizing the energy functional, we show that the found equilibrium state is stable. The obtained results are compared with the results obtained in the model of a cylindrical tokamak. It is shown that the analytically predicted radial plasma pressure profile is in good agreement with the experimental data for a number of tokamaks.

Temporal evolution of the plasma density cavity caused by inhomogeneous stochastic electric fields

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The time evolution of the formation of a plasma density cavity caused by inhomogeneous stochastic electric fields is investigated. The Fokker-Planck equation, which governs the temporal evolution of the plasma electron density due to localized stochastic inhomogeneous electric fields in the frequency range of lower hybrid oscillations, is solved numerically. The spatial dependence of the plasma electron density for various times is obtained.

Modeling the interaction of Jupiter's magnetospheric plasma ions with satellites

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Jupiter's moons are constantly bombarded by ions produced by the giant planet's plasma magnetosphere. The influence is considered as one of the main sources of the moons' atmosphere and surface modification. The investigation is an attempt to explore the interaction of space ions with Ganymede's magnetosphere. Computer simulations are performed using electromagnetic fields that are close to experimentally observed fields in previous Jupiter space missions.

SECTION 6.
BEAM-PLASMA DISCHARGE. PLASMA CHEMISTRY

Two stage plasma source for large scale beam generation

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The operation of a cylindrical plasma accelerator with an anode layer in the mode of ion space charge accumulation and the use of an ion flux accelerated by a space charge is investigated. In particular, the presence of high-voltage and diffusion modes with the formation of a secondary flow has been established.

Penning-type H^- ion source with metal hydride cathode in pulsating regime

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The features of H^- ion emission from gas-feed-free Penning-type ion source with metal hydride cathode have been studied in pulsating regime. The metal hydride cathode provided local injection of hydrogen in activated state and impacts on Penning discharge ability to emit H^- ions in the longitudinal direction. For stimulation of pre-excited hydrogen desorbtion from metal hydride the voltage pulse (4.5 kV, $\tau \approx 15$ μs) was performed against the back-ground constant voltage of 6 kV on the anode of the discharge. The H^- ion current of about 0.2 mA was obtained.

Study of the dependence of the characteristics of the pulse negative corona on the parameters of the combined high voltage power supply

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Numerical simulations of the negative corona in oxygen-containing gases under varying voltage are carried out. It is shown that by changing the values of constant voltage and duration of its application, between high voltage pulses, it is possible to control the electric field strength near the cathode, during the pulse. Quantitative characteristics of the ozone generation process are experimentally investigated. It is found that the agreed choice of the values of the constant component of the applied voltage and the frequency of the high voltage pulses can significantly increase the productivity and energy efficiency of ozone generators.

Study of the fungicidal properties of ozone treatment, Ag and Cu nanoparticles and their combined action on the model sanitary significant mold saprophyte *Aspergillus flavus*

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A study was conducted to determine the fungicidal activity of a sanitary contaminant of fodder - representatives of the genus Aspergillus Mich. – species of Aspergillus flavus by the ozone method of solution treatment, the composition of Ag and Cu metal nanoparticles and the combined effect of these methods. When studying the combined effect of ozone and NPAg and NPCu, it was established that at a concentration ratio of nanoparticles of 100:100 μg/cm^3, there is a fungicidal effect on museum strains of Aspergillus flavus test cultures, i.e. the combination with ozone enhanced the antifungal properties of the nanocomplex.

Effect of plasma chemical oxidation of ethylene impurities on the efficiency of kiwifruit storage

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The effectiveness of plasma chemical technology in reducing the concentration of ethylene impurities in order to extend the shelf life of kiwifruit has been studied. When storing kiwifruit using the plasma chemical system, the level of ethylene was twice lower than that measured in the control batch. Air treatment of kiwifruit storage environment resulted in the fact that ripening mechanism was delayed and the loss of fruits during their further transportation and storage was almost completely prevented. Thus, high efficiency of plasma-chemical method for extending kiwifruit shelf life was shown as well as the prospects of its application. Storage period can be doubled while preserving the subtle aroma of fruits.

Numerical simulation of reproduction of the development conditions of the next Trichel pulse in negative corona

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Numerical simulations of the negative corona at a constant applied voltage in the Trichel pulse mode are carried out for different contents of an electronegative gas component. The dependences of the total current peak value and the time interval between pulses on the values of the applied voltage and the content of electronegative components are obtained. The results are somewhat explained with consideration of simplified models of the pulse development.

The physico-topological simulation of a transmission X-ray tube with induction heating of the cathode

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The physico-topological simulation of a transmission X-ray tube (TRT) with induction heating of the cathode was performed with taking into account the physical properties of the functional elements and their construction and topology. The simulation is based upon Newton's and Maxwell's equations, the laws of conservation of particles, charge, energy and momentum, as well as boundary and initial conditions. Calculation results for distributions of the electromagnetic field and currents, thermal fields, as well as the trajectory of the emitted electrons are given. The analysis of electron trajectories made it possible to optimize the topology and design of the TRT.

Direct water treatment by APGD with rotating electrodes

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The effect of atmospheric pressure glow discharge (APGD) in a highly inhomogeneous electric field between a rotating star-shaped electrode and the surface of water as a second electrode on the antimicrobial properties of water was investigated. A significant decrease in the number of microorganisms and a high concentration of hydrogen peroxide in the water was revealed. The rotating electrode provided a stable discharge despite high humidity.

SECTION 7.
APPLICATIONS AND TECHNOLOGIES

Temperature dynamics of the microdroplet fraction of metal plasma in plasma-optical devices with fast electrons

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Using the computer simulation, it was shown that for a plasma filter with fast electrons, the main source of droplet heating is thermal electrons from the plasma, while the role of fast electrons is reduced mainly to transferring energy to slow electrons. It is also shown that thermal emission from the drop plays a significant role in the process of droplet heating. The processes of drop charging in the presence of an electron beam and the effective emission of electrons due to the bombardment of a drop by charged particles, that significantly affects the droplet potential, are also considered.

Generation of compensated ion-electron flow in the combined magnetron-ion-plasma system

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The design and characteristics of the combined Magnetron-Ion-Plasma System (MIPS) are presented. The system includes a magnetron sputtering system and a Hall-type ion source with a common magnetic system and common power supply allowing the generation of quasi-neutral ion-electron flow, which provides complete charge neutralization on the processed dielectric surface. The formation of the anode electron layer and the energy spectra of ions are experimentally investigated. A phenomenological model of the combined discharge in EH fields is proposed. Theoretical calculations and experimental data are in reasonable agreement.

Simulation of capacitively coupled RF discharge in argon

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In this report, the time-averaged profiles of electron and ion density, average electron energy, plasma potential, and electric field in a radio-frequency capacitive discharge in argon are calculated using the one-dimensional hydrodynamic code SIGLO-rf. The time dependences of the current densities of each type of charged

particles on the electrodes are also found. It is shown that, within one RF period, intense ionization in the argon discharge occurs due to the stochastic heating of electrons during the layer expansion.

Properties of a secondary discharge plasma supported by a rotating gliding discharge

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The paper presents the results of an experimental study of the parameters of the atmospheric pressure secondary discharge plasma supported by a low-power (~ 100 W) rotating gliding discharge in the air flow under the conditions of a significant excess of the length of the plasma channel of the secondary discharge from the length of the self-dependent gliding discharge channel in the range of 1 ÷ 100. Determination of plasma parameters were carried out by methods of plasma emission spectroscopy using the SpecAir code. An estimate of the electric field in the plasma of the secondary discharge was made based on the dependence of the voltage drop on the discharge from the length of the current channel of the discharge.

Disproportionation reactions of ferrocene in a plasma-liquid system with a rotating gliding discharge

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Plasma activation of a 0.1 M solution of ferrocene in organic solvents (ethanol, acetonitrile) in a plasma-liquid system with a rotating gliding discharge was investigated. It was found that cyclopentadiene ligands of ferrocene disproportionate into saturated cyclic hydrocarbons (cyclopentane and pentane). Also, as a result of plasma chemical synthesis, aromatic compounds (benzene and its derivatives) are formed. The research was carried out using various plasma-forming gases (Ar, N_2, CO_2). Determination of plasma parameters was carried out by methods of plasma emission spectroscopy. The study of the physico-chemical properties of the synthesis products was carried out by the methods of adsorption, luminescence analysis, polarimetry, chromatography-mass spectrometry and NMR.

On the possibility of obtaining a beam of heavy ions in the form of an "open umbrella" with subsequent deposition in the separator manifold

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The paper considers a multicomponent, low-energy "umbrella" ion beam. Its density decreases as it flows out of the ionization region (magnetic field up to 3 T) into the drift region (magnetic field up to 0.5 T). To randomize the particles of the jet plasma, a reflecting magnetic field is further placed on the axis. The plasma flows in a hollow magnetic force tube around a solenoid with a reverse magnetic field. In this region, the ions are drawn out in the radial direction towards the annular hole of the “pocket”. Target ions follow umbrella trajectories and, being neutralized, are deposited in a "pocket" on the inner walls.

Simple pulse microwave waveguide calorimeter with temperature sensor LM 35

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A waveguide calorimeter designed for measuring the total energy of a long sequence of electromagnetic pulses of plasma and dielectric generators. The calorimeter is placed in a circular waveguide section. The energy is absorbed by the coordinated water load. The increase in water temperature is registered directly by a precision temperature sensor LM 35 with an integrated circuit and a linear output voltage. The relative accuracy of the measurement in the working area is up to 0.01 °C. The dynamic range of energy measured by calorimeters is from 1 to 100 J. The calorimeter can be used repeatedly without waiting for equilibrium to be established. Calorimeter readings are transmitted by a 30 m long cable.

Determination of charged and neutral particles activation yields for fundamental research and instrumental elemental analysis

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During the analysis of experimental data about medical radioisotope production by different accumulation routes, the absolute values of their activation yields are necessary to compare. The problem consists of differences between the physical processes depending on the primary particles' interaction (neutrons,

gamma-rays, protons, ...) with experimental targets (thin or thick). The mathematical formalism of activation yields of nuclear reactions induced by charged and neutral particles was presented and discussed.

Application features of the electrostatic systems for measuring the secondary electron emission yield

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The analysis of experimental systems for research on the secondary electron emission induced by an electron beam is presented. The evolution of the experimental measuring systems and their improvement from simple to three-electrode systems with pass-through collectors is considered. The peculiarities of recording the secondary electrons current emitted from the studied target surface depending on the structural features of the target device are considered too. Application results of the developed three-electrode measuring system for research thin foil emission characteristics have been discussed.

Aluminum thin foil heating dynamics during high energy pulsed electron beam passage

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The results of thin aluminum foil (50 μm) heating modeling by a 15 MeV electron beam passing in the vacuum are presented. For a constant foil irradiation regime (electron beam current up to 1 mA, 2 μs pulse duration, and 50 Hz repetition rate) the thermal distribution evolution was determined including the measured electron beam density distribution data. The possibilities of supplementing the software code for modeling are discussed in order to optimize calculations of thin foil thermal distribution induced by ionization losses of high energy beams passage and expand functionality.

Plasma treatment of titanium dioxide film for black TiO2

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The results of the treatment of TiO2 film in volume discharge with an Ar/H2 mixture are presented. The treated film demonstrates the changes in transparency and conductivity. Raman spectra show no changes in the phase state of the film after plasma treatment.