Summaries of all articles

A. I. Besportochnyy

Asymptotic regimes of the hydrodynamic contact of the elastic cylinder and rigid half-space

The lubricating fluid flow between the elastic cylinder and rigid half-space is considered. The fluid viscosity depends on pressure. The lubricant film thickness and pressure distribution within the area of the heavy loaded hydrodynamic contact are investigated. Different asymptotic regimes of elastohydrodynamic lubrication are examined. Ranges of applicability for a number of formulas for calculating the film thickness are suggested.

Key words: lubrication, hydrodynamic contact, elastic cylinder, film thickness, asymptotic regimes.

V. N. Brazhko, A. V. Vaganov, V. I. Neiland, M. A. Starodubtsev, V. I. Shalaev

Navier-Stokes based CFD simulation of windward surface flow peculiarities arising near a delta wing with blunt leading edges

On the basis of numerical solutions by the finite volume method of steady Navier-Stokes equations for a compressible viscous heat-conducting gas, a hypersonic flow over the delta wing - cone configuration is studied. The laminar, turbulent flows and the laminar-turbulent transition regime are considered. Spatial flow structures near the windward surface are of particular interest for the investigation. The obtained results allow us to qualitatively explain qualitatively the origin of peak heat-flux local zones on the wing, which is observed in wind tunnel experiments. A set of computational meshes containing from 4 to 100 mln nodes and ANSYS CFX solver installed on DAFE MIPT cluster are used for the flow simulation.

Key words: hypersonic flow, delta wing with blunt leading edges, numerical simulation, heat fluxes.

E. V. Varyukhina

Efficiency analysis of economic mechanisms for raising flight safety

The efficiency economic-mathematical analysis of natural market mechanisms for raising flight safety, the flight safety State control mechanism and their combination is made. It is shown that natural market mechanisms are considerably less effective than the State control mechanism.

Key words: flight safety, air traffic, economic interest, control mechanism, economic-mathematical modeling, flight safety state control.

G. N. Dudin, A. V. Ledovskiy, Y. N. Soe

Propagation of disturbances in a hypersonic boundary layer in the vicinity of the inflection point of the wing leading edge

The spatial laminar boundary layer flow on a thin wing with an inflection point in the leading edge is investigated in the strong viscous-inviscid interaction regime. The pressure induced by displacement thickness is determined by the tangent wedge. Formula generalized to the nonstationary case. Based on the theoretical analysis of boundary layer equations, the integral relationship for determining the characteristic surface connected with induced pressure is obtained. From the numerical analysis of boundary layer equations the velocity of disturbance propagation and radiation patterns are defined at different values of the temperature factor and the sweep angles of leading edges.

Key words: flat wing, boundary layer, hypersonic flow, strong interaction, propagation of disturbances.

L. S. Kukushkin, V. V. Vyshinsky

Aerial refueling modeling on a flight simulator with account taken of atmospheric turbulence and wake turbulence behind an air refueller

The paper presents mathematical models of the aircraft refueling and tanker's fueling cone counteraction, with account taken of the atmospheric turbulence and tanker vortex wake in the aerial refueling process. Simulation is performed on the pilot simulator of Department of Aeromechanics and Flight Engineering of MIPT by the mathematical models of the fueling cone and hose motion, docking and undocking processes. Algorithms are realized using C++, which alleviates their introduction into other simulators. The results of simulation are given.

Key words: aerial refueling, aircraft vortex wake, flight safety, atmospheric turbulence, mathematical simulation on flight simulator.

Z. M. Malikov, A. L. Stasenko

Asymptotics of a submerged jet and transport processes in it

The solution of the stationary Navier–Stokes equation is derived for an axisymmetric jet of incompressible fluid ejecting into the bulk medium with accuracy up to the third power of the reciprocal distance from a point source. The zero-rate paradox arising in this approach with finite momentum is overcome by introduction of the finite solid-angle cone of the turbulent flow for an ≪intensive jet≫. The spatial evolution of the circulation of a viscid swirling jet is investigated as well as the passive mixture and heat diffusion.

Key words: laminar, viscose, swirl, turbulent flow; heat and admixture transport.

Z. Y. Myo Myint, A. Yu. Khlopkov

Calculation of complex aircraft aerodynamics in the hypersonic flow regime

The effect of the molecular boundary condition on the aerodynamic characteristics of flight vehicles is one of the most important problems in modern aerospace science and in practice. Especially, it is important when the aircraft moves at high altitude in the molecular distribution function regime. This is an orbital flight and the movement of spacecraft systems in the upper atmosphere regime. In this paper, we consider molecular gas-surface interaction models with various potentials and their influence on the aerodynamic characteristics in a wide range of flow regime. The present results are the aerodynamic characteristics of an earth -to -orbit vehicle in the free molecular transitional and continuum regime.

Key words: aerodynamics of aircraft, boundary conditions, molecular gas-surface interaction, Reynolds numbers, aerodynamics in various flow regimes, hypothesis of locality.

G. B. Sizykh

Bernoulli criterion for plane-parallel steady flow of viscous incompressible fluid

The known sufficient condition for Bernoulli trinomial conservation along a streamline, i.e. a zero gradient of vorticity magnitude, is proved to be necessary in the case of a plane-parallel steady flow of viscous incompressible fluid in a potential field of mass forces. Key words: viscous effects, Bernoulli integral, vortices convection speed, Bernoulli theorem, Bernoulli trinomial.

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Vu Than Chung, V. V. Vyshinskiy

Research of the effect of heat transfer on the lift force of a rectangular wing model at subsonic speeds

This paper presents the results of parametric calculations and exiperiments of the influence of the surface heat exchange on the wing model lift force at subsonic speeds. The illustrative explanation of the observed phenomenon is given.

Key words: heat exchange, aerodynamic characteristics, calculation, experiment, wing.

D.A. Kravchenko

Kinetic simulation of the near-wall plasma layer of a stationary plasma thruster

The paper presents an investigation of interaction between plasma and the surface of ceramic discharge chamber walls in a stationary plasma thruster. The one-dimensional non-stationary kinetic model of the near-wall plasma area is described. The secondary electron-electron emission and external magnetic field influence are taken into account in this model. Analysis of plasma parameters and material properties influence on the near-wall layer structure are provided. An impact of interactions between electrons and the ceramic surface on their average energy and velocity distribution function is studied. The nature of the magnetic field influence on near-wall layer formation is determined.

Key words: numeric simulation, near-wall layer of plasma, plasma and material interaction, secondary electron-electron emission, Hall thruster, stationary plasma thruster.

V. P. Legostaev, A. V. Subbotin, S. N. Timakov, A. V. Zykov

Research on the dynamics of the controlled angular motion of a spacecraft with a rotating solar sail

This investigation aims to research the dynamics of the angular motion of a spacecraft with double-rotation and a concealed angular momentum using mathematical simulation. Principles for controlling the angular motion of the spacecraft are demonstrated using a base structure consisting of an instrument module, a solar sail resembling a large rotating membrane disk, and a compensating powered gyroscope. The sail is in a tense-deformed state due to centrifugal forces and the gyroscope-generated moment. This moment arises when the rotational axis of the hard insert, located in the center of the membrane disk, turns during angular maneuvers performed by the spacecraft. We give the results of the analytical and numerical research of the dynamic behavior of the spacecraft with a rotating solar sail in two modes: planned maneuvers and damping of initial angular rates.

Key words: stability of motion, spacecraft with double rotation, solar sail.

T. I. Morozova, S. I. Kopnin, S. I. Popel

About abnormally high polymerical microparticle destraction due to their abnormally high charging

A possibility of fine particle destruction and separation of monomineral fractions from polymineral particles by dusty plasma methods is considered. The destruction is attained by means of anomalously high charging of the particles as a consequence of their irradiation by hard electromagnetic rays of high intensity. The given consideration and its technological development are of practical interest from the viewpoint of enhancement of the efficiency of development of lowgrade deposits and reprocessing of ore dumps and tailings, which contain a certain amount of noble metals in the form of finely disseminated fractions.

Key words: dusty plasma processes, dust particle charging, electromagnetic radiation, destruction of fine particles.

A. A. Aduenko, N. I. Amelkin

Limit movements of a top with internal dissipation in a homogeneous gravitational field

A top which is modeled by a carrying body with a motionless point and a homogeneous ball is studied. The ball is placed into a globular cavity inside the carrying body. The radius of the cavity is the same as that of the ball placed in it. The dissipation is supposed to be caused only by internal forces arising when the ball moves relative to the carrying body. It is shown that the limit movements of the top are stationary rotations around the vertical axis. A set of limit movements and the character of their stability are defined and studied in detail when the top's mass center lies on one of the main top's axes of inertia. It is established that the rotation stability condition for a symmetric top with internal dissipation and the mass center radius vector directed vertically upwards differs from the Maevsky stability condition.

Key words: limit movements, stationary rotations, character of stability, internal dissipation, Maevsky condition.

N. N. Erdakova, A. P. Ivanov

On the mathematical simulation of the impact of a double pendulum against an obstacle

An algorithm for investigation of a mathematical model of the impact of a double pendulum against an obstacle is constructed and realized on a computer. This algorithm allows calculation of impact loads and restitution coefficients at the contact point and hinges. The main goal of this investigation is to minimize the negative impact conditions in the hinges.

Key words: double pendulum, equations of motion, mathematical model, numerical investigation.

V. M. Agafonov, K. A. Afanasiev, A. B. Yashkin

Direction definition on moving object using seismic module containing molecular electronic motion sensors

We develop the seismic module prototype of the security system which is a device containing a linear motions sensor and, which is a specific feature, two rotary motions sensors. Records of seismic signals are obtained. Main attention is given to a problem of detecting the direction on a seismic signal source. The basic preconditions and laws on which the analysis of the received signals is based are given. The trajectory of movement of the experimenter is constructed. On the basis of the obtained results, we make conclusions on a possibility to develop qualitatively new safety systems and the territory control by molecular electronic motion.

Key words: measuring devices, seismic sensors, location, Rayleigh wave, digital signal processing, amplitude frequency characteristic.

V.G. Baidin

Seismic image building of EAGE BP2004 Benchmark Model

We consider the reverse time migration (RTM) method. This seismic imaging task is a computationally expensive problem of prospecting seismology. On the example of EAGE BP2004 Benchmark model — a two-dimensional acoustic velocity model created by EAGE community and having size 82.5×12 km^2 — we test the acoustic RTM code developed at SMR. One of the typical problems of migration tasks (including RTM) is limitation and discretization of the observation system. We analyze problems of building images by RTM and consider different ways of their solution by using test calculations with acoustic RTM code. On the other hand, these test calculations are used for validation and improvement of the code. One of the specific features of the code is the possibility of calculating spatial derivatives by implicit difference operators. We the results of accuracy and performance tests of the algorithm while using different computational options. Also, the ways of improving image quality such as different types of normalization and high-pass filtering are considered.

Key words: reverse-time migration, Prospecting seismology, Inverse problem, computational methods, high-performance computing.

A.G. Birjukov, A.I. Grinevich

Methods for rounding errors estimation in the solution of numerical problems using arbitrary precision floating point calculations

This paper is devoted to the error analysis of numerical algorithms using arbitrary precision floating point numbers. We describe a new approach for esitmating the rouding errors based on a series of solutions with growing mantissa length and formulate rules for achieving the required accuracy.

Key words: accuracy and precision, numerical algorithms, arbitrary precision arithmetic, guaranteed precision, floating point arithmetic, finite and infinite numerical algorithms, numerical K-solution.

L.E. Dovgilovich, I.L. Sofronov

Analysis of implicit and explicit central-difference operators for calculating the second derivative on uniform grids

The paper discusses the problem of calculating the second derivative of a smooth function by high-order finite differences on an interval with uniform grid. Criteria for comparison of the numerical algorithms against accuracy, memory, and floating point operations are formulated. Two families of the finite-difference operators are analyzed: central-difference and implicit central-difference ones, with 4th to 20th order of approximation. It is demonstrated that the high order implicit central-difference operators with the three-diagonal matrix at the left hand side have advantages for considered criteria. Also it is shown that these operators can be efficiently implemented on high-performance systems with distributed memory by domain decomposition approach.

Key words: second derivative, approximation, central-difference operators, implicit central-difference operators, compact schemes, wave equation.

S.N. Gorbach, L.A. Makarevich, K. Yu. Taletsky, V. A. Petrukhin, V.I. Sholomova

Organization of electronic documents exchange in order to improve the educational process quality

The method for organization of electronic documents exchange for educational institutions is proposed. The system development aimed to simplify this process is considered. In this study various solutions of the problem are analyzed, quantative result cryteria are suggested. Also, the architecture of this system is developed and the efficiency of the deployed system is analyzed.

Key words: document management system, data storage system, network architecture, user interface, distributed system of public printing, web server, proxy server, virtual private network, PDF, PCL, PJL, PostScript, Linux, IPP, SMB, CUPS.

M. V. Shovkun, A. I. Korovin, V. Yu. Vostokov

On the problem of using the step-by-step calculation method for unit, engine and aggregate sets wear in the estimation of the emergency situation frequency iat a hazardous facility

Analysis leads to the conclusion that in the edtimation of the emergency situation frequency at the facility of explosives and toxic substances storage and/or operation, the wear of unit, engine and aggregate sets can be taken equal to the wear of the «long-life» equipment of the facility.

Key words: incident rate, set of units, machinery and assemblies, wear, physical wear of object.