# 10th International Conference on Aerophysics and Physical Mechanics of Classical and Quantum Systems (APhM 2016)

Journal of Physics: Conference Series Volume 815

Moscow, Russia 5 – 9 December 2016

**Editors:** 

Sergey T. Surzhikov Daniil Andrienko Yacine Babou Gianpiero Colonna Alexey S. Dikaljuk Michael K. Ermakov Igor A. Kryukov Eduard V. Teodorovich

ISBN: 978-1-5108-3900-7 ISSN: 1742-6588 Printed from e-media with permission by:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2016) by the Institute of Physics All rights reserved. The material featured in this book is subject to IOP copyright protection, unless otherwise indicated.

Printed by Curran Associates, Inc. (2017)

For permission requests, please contact the Institute of Physics at the address below.

Institute of Physics Dirac House, Temple Back Bristol BS1 6BE UK

Phone: 44 1 17 929 7481 Fax: 44 1 17 920 0979

techtracking@iop.org

#### Additional copies of this publication are available from:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571 USA Phone: 845-758-0400 Fax: 845-758-2633 Email: curran@proceedings.com Web: www.proceedings.com

## **Table of contents**

### **Volume 815**

10th International Conference on Aerophysics and Physical Mechanics of Classical and Quantum Systems

5-9 December 2016, Moscow, Russian Federation

Accepted papers received: 21 February 2017 Published online: 6 April 2017

#### Preface

011001 OPEN ACCESS 10th International Conference on Aerophysics and Physical Mechanics of Classical and Quantum Systems

011002 OPEN ACCESS Peer review statement

#### Papers

#### **Physics of Gas Discharge**

012001 OPEN ACCESS Numerical Investigation of Penning Discharge Characteristics using 2D/3V Particle-In-Cell Method

A S Dikalyuk and S E Kuratov.....1

012002 OPEN ACCESS Numerical simulation of the kinetics of dissociation and ionization of molecular hydrogen in the penning discharge plasma with the use of the reduced kinetic model

D A Storozhev and S E Kuratov.....15

012003

OPEN ACCESS

Quasi-stationary convection in a periodic-pulsed optical discharge in high pressure rare gas

V P Zimakov, V A Kuznetsov, N G Solovyov, A N Shemyakin, A O Shilov and M Yu Yakimov.....21

012004 OPEN ACCESS Numerical simulating the two-dimensional structure of the Penning discharge using the modified drift-diffusion model

S T Surzhikov.....32

012005 OPEN ACCESS Surface electromagnetic actuator in rarefied hypersonic flow

S T Surzhikov.....42

012006 OPEN ACCESS The spectral characteristic investigations of normal glow discharge

M A Kotov, P V Kozlov, L B Ruleva, S I Solodovnikov, S T. Surzhikov and V A Tovstonog.....58

#### **Physical-Chemical Kinetics**

012007 OPEN ACCESS Comparison of two-dimensional and quasi-one-dimensional scramjet models by the example of VAG experiment

R K Seleznev.....67

012008 OPEN ACCESS Stabilization of solid fuel combustion in a ramjet engine

S A Rashkovskiy, S E Yakush and A A Baranov.....73

012009 OPEN ACCESS On the influence of state-resolved rates of Zeldovich reactions on shock heated air flow parameters

O Kunova and E Nagnibeda.....81

012010 OPEN ACCESS Mathematical simulation of kinetic processes in moving irradiated by neutrons gas medium containing uranium nanoparticles

I V Alexeeva, A P Budnik, A V Sipachev and M N Slyunyaev.....89

012011 OPEN ACCESS State-to-state models of vibrational relaxation in Direct Simulation Monte Carlo (DSMC)

G P Oblapenko, A V Kashkovsky and Ye A Bondar.....101

012012 OPEN ACCESS SPH simulation of boron carbide under shock compression with different failure models

S A Dyachkov, A N Parshikov and V V Zhakhovsky.....108

012013 OPEN ACCESS The Model of Masstransfer Intensification in Channels Using Nanowiresets inside and Nanostructures on the Wall

A A Markov.....114

#### **Theoretical and Computational Fluid Dynamics**

012014 OPEN ACCESS Diffusion of a passive impurity in a random velocity field

E V Teodorovich.....120

012015 OPEN ACCESS Numerical solution of the Navier-Stokes equations by discontinuous Galerkin method

M M Krasnov, P A Kuchugov, M E Ladonkina, A E Lutsky and V F Tishkin.....129

012016 OPEN ACCESS Supercomputer modeling of flow past hypersonic flight vehicles

M K Ermakov and I A Kryukov.....138

012017 OPEN ACCESS Turbulent flow over an axisymmetric body with annular cavity

I E Ivanov, I A Kryukov, E V Larina and G S Glushko.....143

012018 OPEN ACCESS Influence of Energy Input on the Flow Past Hypersonic Aircraft X-43

Ya V Khankhasaeva, V E Borisov and A E Lutsky.....151

012019 OPEN ACCESS On the concept of the interactive information and simulation system for gas dynamics and multiphysics problems

O Bessonov and P Silvestrov.....160

012020 OPEN ACCESS Mode intermittence in a wake from two cylinders

G V Gembarzhevskii, A K Lednev and K Yu Osipenko.....168

012021 OPEN ACCESS Natural oscillations of a gas in an elongated combustion chamber

S V Nesterov, L D Akulenko and V G Baydulov.....176

012022 OPEN ACCESS Numerical simulation of the flow over a hypersonic waverider using the method for splitting into physical processes

D S Yatsukhno.....184

012023 OPEN ACCESS Validation of computational code UST3D by the example of experimental aerodynamic data

S T Surzhikov.....191

012024 OPEN ACCESS Approximate method for calculating convective heat flux on the surface of bodies of simple geometric shapes

V V Kuzenov and S V Ryzhkov.....203

012025 OPEN ACCESS Experimental and numerical study of supersonic flow over two blunted wedges

M A Kotov, L B Ruleva, S I Solodovnikov and S T Surzhikov.....211

#### Nonequilibrium Processes in Gas Dynamics

012026 OPEN ACCESS Investigations of vibrational kinetics relaxation within air shock wave plasma

W Su, D Bruno and Y Babou.....223

012027 OPEN ACCESS Vibrational-Chemical Coupling in mixtures CO<sub>2</sub>/CO/O and CO<sub>2</sub>/CO/O<sub>2</sub>/O/C

A A Kosareva and E A Nagnibeda.....238

012028 OPEN ACCESS Kinetic modelling of primary and secondary interstellar oxygen atom fluxes in the heliosphere

I I Balyukin, V V Izmodenov, O A Katushkina and D B Alexashov.....249

012029 OPEN ACCESS <u>Shock-induced ejecta from a layer of spherical particles. Part I: SPH meso-scale</u> <u>simulation</u>

M S Egorova, S A Dyachkov, A N Parshikov, V V Zhakhovsky, A A Serezhkin, I S Menshov, D B Rogozkin and S E Kuratov.....258

012030 OPEN ACCESS Shock-induced ejecta from a layer of spherical particles. Part II: modeling with the nonequilibrium two-phase model of a granular medium

A A Serezhkin, I S Menshov, M S Egorova, S A Dyachkov, A N Parshikov, V V Zhakhovsky, D B Rogozkin and S E Kuratov.....267

#### **Methods in Experimental Physical Mechanics**

012031 OPEN ACCESS On using of gas detonation for spraying of biocompatible films onto the carbon nanocomposites

P A Tsygankov, A S Skriabin, E Yu Loktionov, V D Telekh and R I Chelmodeev.....277

012032 OPEN ACCESS Plasma airflow jets diagnosis by means of time-resolved tomography

Y Babou, F Cannat, D Lequang and Ch Rond.....283

012033 OPEN ACCESS Experimental investigation of nitric oxide radiation in the shock-heated air

P V Kozlov.....295

012034 OPEN ACCESS Extinction and growth of cylindrical hotspots in AB model explosive: molecular dynamics studies

S A Murzov and V V Zhakhovsky.....308

#### **Magnetic Hydro Dynamics**

012035 OPEN ACCESS <u>Two-jet structure of the flow produced by magnetized hypersonic spherical source into</u> the steady unmagnetized medium

E A Golikov, V V Izmodenov and D B Alexashov.....313