

Institute of Theoretical Physics and Astronomy

12 A. Goštauto, LT-01108 Vilnius

Tel. 219 3251, fax. 212 5361

E-mail: tfai@tfai.vu.lt

www <http://www.tfai.vu.lt/>

Director - Dr. Habil. *Gediminas Juzeliūnas*

STAFF

60 research fellows, one emeritus and five affiliated scientists (12 habilitated doctors, 3 doctors with the habilitation procedure, 35 doctors), and 14 doctoral students. Full staff comprises 95 people.

DEPARTMENTS OF THE INSTITUTE

[Astronomical Observatory](#)

[Department of the Theory of Atom](#)

[Department of the Theory of Nucleus](#)

[Department of the Theory of Processes and Structures](#)

[Planetarium](#)

RESEARCH AREAS

Analysis of Atoms, Subatomic Particles or their Ensembles, Complex Systems, Electromagnetic Radiation and Cosmic Objects

DOCTORAL DISSERTATIONS MAINTAINED IN 2013

E. Stonkutė. Chemical composition of kinematically identified Galactic stellar group.

MAIN CONFERENCES ORGANIZED IN 2013

International conference *Structural Change Promoting Gender Equality in Research* (under the auspices of the Lithuanian Presidency to the EU Council), Vilnius, November 21–22, 2013.

2nd International TLL-COLIMA-FOTONIKA joint workshop *Manipulation of Light by Matter and Matter by Light*, Vilnius, September 1–5, 2013.

Prof. A. Jucys Readings, September 17, 2013, Vilnius.

MAIN SCIENTIFIC ACHIEVEMENTS IN 2013

- A new technique has been proposed and analyzed for producing two- and three-dimensional Rashba-type spin-orbit couplings for ultracold atoms using atom chips. The method relies on a sequence of pulsed inhomogeneous magnetic fields imprinting suitable phase gradients on the atoms. For sufficiently short pulse durations, the time-averaged Hamiltonian well approximates the Rashba Hamiltonian for the spin-orbit coupling.
- A detailed chemical composition of stars in a newly discovered kinematic group of stars in the Galactic disc was determined. We conclude that a gas-rich satellite merger scenario is the most likely explanation of its origin. The chemical composition of stars in this group and Galactic thick-disc stars is similar and might suggest that their formation histories are linked.
- A new method based on joint experimental and theoretical studies of the excitation dynamics and spectroscopic classification of autoionizing states in lithium, sodium, potassium, rubidium and cesium was developed for direct measurements of the absolute value of the excitation-autoionization cross section and analyzing the processes contributing to it.

ASTRONOMICAL OBSERVATORY

12 A. Goštauto, LT-01108 Vilnius
Tel. 219 32 50, fax 261 53 61
E-mail: grazina.tautvaišiene@tfai.vu.lt

Head – Dr. Habil. *Gražina Tautvaišienė*

STAFF

Chief Researchers: Dr. Habil. G. Tautvaišienė, Dr. K. Černis, Dr. A. Kučinskas, Prof. Emeritus Dr. Habil. V. Straižys, Prof. Dr. Habil. A. Bartkevičius (affiliated), Dr. Habil. K. Zdanavičius (affiliated).

Senior Researchers: Dr. R. Janulis, Dr. A. Kazlauskas, Dr. E. Pakštienė, Dr. J. Zdanavičius.

Researchers: Dr. Y. Chorniy, Dr. V. Laugalys, Dr. E. Puzeras, E. Stonkutė.

Junior Researchers: G. Barisevičius (part time), V. Čepas (part-time), A. Černiauskas (part-time), V. Dobrovolskas (part-time), J. Klevas (part-time), M. Maskoliūnas, Dr. Š. Mikolaitis, K. Milašius (part-time), D. Prakupavičius (part-time), R. Ženovienė (part-time).

Doctoral students: V. Čepas, A. Drazdauskas, J. Klevas, M. Macijauskas, K. Milašius, D. Prakupavičius, R. Ženovienė.

Lecturers: S. Lovčikas.

Engineers: A. Drazdauskas (part-time), M. Macijauskas (part-time), Š. Mikolaitis (part-time), G. Valiauga.

Technicians: V. Bertašius (part-time).

Administrator: V. Kakarienė.

Manager: R. Mikutavičienė.

RESEARCH INTERESTS

Galactic structure and chemical evolution

Stellar photometry, stellar classification, multicolour photometric systems

Interstellar reddening and extinction

Chemical analysis of stellar atmospheres, mixing in stellar atmospheres

Stellar asteroseismology

Dynamical phenomena and non-equilibrium radiative transfer in stellar atmospheres

Chemo-dynamical histories of oldest Galactic populations

Search and positional observations of comets, asteroids and near-Earth objects

RESEARCH PROJECTS CARRIED OUT IN 2013

Project Supported by University Budget

Characteristics of atmospheric chemical composition and asteroseismic activity of stars and chemical evolution of galaxies. Dr. Habil. G. Tautvaišienė. 2011–2015.

Detailed chemical composition of stars in the kinematic Group 3 of the Geneva-Copenhagen survey was determined. We conclude that a gas-rich satellite merger scenario is the most likely explanation of its origin. The chemical composition of stars in Group 3 and Galactic thick-disc stars is similar and might suggest that their formation histories are linked. Investigations of C, N and O element abundances were continued in clump stars. For stars of about two Solar masses a modelling of rotationally induced mixing should be considered.

Main publications:

E. Stonkutė, G. Tautvaišienė, B. Nordström, R. Ženovienė, Stellar substructures in the solar neighbourhood: II. Abundances of neutron-capture elements in the kinematic Group 3 of the Geneva-Copenhagen survey, *Astronomy & Astrophysics*, 555, A6, p. 1–8 (2013)

G. Tautvaišienė, G. Barisevičius, Y. Chorniy, I. Ilyin, E. Puzeras, Red clump stars of the Milky Way – laboratories of extra-mixing, *Monthly Notices of the Royal Astronomical Society*, 430, 621–627 (2013).

G. Tautvaišienė, G. Barisevičius, S. Berdyugina, I. Ilyin, Y. Chorniy, Chemical composition of photospheres in RS CVn stars, *Proc. of the International Astronomical Union*, 294, 207–208 (2013).

Star formation and dust clouds in the Orion and Perseus arms of the Galaxy. Prof. V. Stražys. 2011–2015

Three open clusters, NGC 7129, NGC 7142 in Cepheus and M29 in Cygnus were investigated determining their interstellar extinction, distances and ages. Using seven-colour photometry of 1650 stars in two Milky Way areas in the direction of the Camelopardalis dark clouds, their

spectral and luminosity classes and interstellar reddenings were determined. The results will be used to determine distances to the dark clouds and to investigate interstellar extinction.

Main publications:

Straižys, V.; Boyle, R. P.; Janusz, R.; Laugalys, V.; Kazlauskas, A., The open cluster IC 1805 and its vicinity: investigation of stars in the Vilnius, IPHAS, 2MASS, and WISE systems, *Astronomy & Astrophysics*, 2013, vol. 554, id.A3, 9 pp.

Čepas, V.; Zdanavičius, J.; Zdanavičius, K.; Straižys, V.; Laugalys, V., Seven-color Photometry and Classification of Stars in the Vicinity of the Dark Cloud Tgu H994 (LDN 1399, 1400 and 1402), *Baltic Astronomy*, 2013, vol. 22, p. 243-258.

Čepas, V.; Zdanavičius, J.; Zdanavičius, K.; Straižys, V.; Laugalys, V., Seven-color Photometry and Classification of Stars in the Vicinity of the Emission Nebula Sh2-205, *Baltic Astronomy*, 2013, vol. 22, p. 223-242.

Positional Astrometry of Unusual Asteroids and Comets. Dr. K. Černis. 2011–2015.

48 new asteroids have been discovered, two of them are quite unusual (Koiiper belt asteroid 2013 CB33 and Trojan 2013 RO26). New orbits were determined for our earlier discovered objects NEO Amor type 2012 XH16 and Centaur 2012 VU85. The near Earth object 2012 XH16, diameter of which is 170 m, can approach the Earth to the distance of 0.08 AU. A diameter of Centaur 2012 VU85 is about 180 km and the rotational period around the Sun is 159 years. Five asteroids were named: Donelaitis, Mindaugas, Kodaitis, Janulis and Utena.

Main publications:

K. Černis, Observations and Orbits of Comets [152 Molėtai Astronomical Observatory], *The Minor Planet Electronic Circuliars* 2013-v07 (2013 Nov. 3)

K. Černis, Minor Planet Observations [152 Moletai Astronomical Observatory], *Minor Planet Circular* 83282, 7 (2013)

K. Černis, Comet observations [152 Moletai Astronomical Observatory], *Minor Planet Circular* 82407, 8 (2013)

National Research Projects

Research Council of Lithuania. **The role of turbulence in stellar atmospheres** (PRO-05/2012-AB). Dr. A. Kučinskas. 2012-2013.

The aim of this project was to investigate the impact of small-scale turbulence on the thermal structure of stellar atmospheres and the processes of spectral line formation. The investigation was done using state-of-the-art 3D hydrodynamical model atmospheres of red giant stars. We found that small-scale turbulent features notably influence on the atmospheric structure and significantly strengthen spectral lines, with the largest effects seen in the case of strongest lines that are most sensitive to velocity fields.

Main publications:

A. Kučinskas, M. Steffen, H.-G. Ludwig, V. Dobrovolskas, A. Ivanauskas, J. Klevas, D. Prakupavičius, E. Caffau, P. Bonifacio, Three-dimensional hydrodynamical CO5BOLD model atmospheres of red giant stars II. Spectral line formation in the atmosphere of a giant located near the RGB tip, *Astronomy & Astrophysics* 549, A14 (2013).

Research Council of Lithuania. **Convection and radiation transfer in the stellar atmospheres: connections between the 3D hydrodynamical and non-local thermodynamical equilibrium effects** (TAP LZ 06). Dr. A. Kučinskas. 2013-2014.

The aim of this project is to study the role of convection and non-local thermodynamic equilibrium radiation transfer in the spectral line formation taking place in stellar atmospheres. The first results obtained show that these phenomena play a significant role in the atmospheres of metal-poor stars. A comprehensive 3D NLTE analysis of the oxygen infrared triplet spectral line formation in solar photosphere supports previous claims for a relatively low solar oxygen abundance.

Research Council of Lithuania. **Connections between the chemical and dynamical evolution of Galactic star clusters** (MIP-065/2013). Dr. A. Kučinskas. 2013 – 2015.

The aim of this project is to investigate a possible link between stellar dynamical properties and abundances of light chemical elements in the atmospheres of stars belonging to Galactic globular clusters of different mass, age, and metallicity. Our preliminary results show that there is a hint of increased concentration of Na-rich/O-poor stars towards the center of globular cluster 47 Tuc which is in agreement with new chemo-dynamical evolution scenarios of Galactic globular clusters.

Research Council of Lithuania. **Interstellar extinction in the selected dust clouds and star-forming regions** (MIP-061/2013). Dr. V. Laugalys. 2013 – 2015.

This research project is accomplished by scientific cooperation of astronomers from the Institute of Theoretical Physics and Astronomy, the SOFIA Science Center (NASA) and the Vatican Observatory Research Group (VORG). The main purpose of the investigation is to determine distances and interstellar extinctions of several selected star-forming regions in the Milky Way. Three fields, including open clusters NGC 7142, NGC 7129 and M29 were investigated in 2013. The distances, ages and interstellar extinction of the open clusters NGC 7142 and NGC 7129 were determined.

Main publications:

Straižys, V.; Maskoliūnas, M.; Boyle, R. P.; Zdanavičius, K.; Zdanavičius, J.; Laugalys, V.; Kazlauskas, A., The open cluster NGC 7142: interstellar extinction, distance and age, *MNRAS*, 2013, DOI: 10.1093/mnras/stt1995.

Milašius, K.; Boyle, R. P.; Vrba, F. J.; Janusz, R.; Straižys, V.; Černis, K.; Laugalys, V.; Zdanavičius, K.; Zdanavičius, J.; Kazlauskas, A.; Smilgys, R., Seven-color Photometry and Classification of Stars in the Direction of Open Cluster M 29 (NGC 6913) in Cygnus, *Baltic Astronomy*, 2013, vol. 22. p. 181-221.

International Research Projects

FP7 project **Researchers' Night 2013: Researchers on and off work** (Night2013). Dr. A. Kazlauskas. 2013.

This project was carried out in Lithuania together with seven other universities and three scientific institutions. The main purpose of this project was a meeting of scientists with general public. Such meetings took place on the 27th of September at the Molėtai Astronomical Observatory. The programme included lectures, tours to professional telescopes, physical experiments, stargazing, science videos. Almost all staff of the Observatory and several scientists from other departments have met with 600 people visiting the Observatory.

Long-term international project **The Whole Earth Telescope**. Dr. R. Janulis, Dr. E. Pakštienė.

In May of 2013 the WET XCOV 29 campaign was going on at the Molėtai Observatory. The main target was the pulsating white dwarf WDJ 1518+0658, the secondary target observed was GD358. More than 20 observatories around the world participated in these observations. Physical parameters were determined for the ZZ Ceti star PG 2303+243, observed during another mini campaign carried out with three telescopes.

Main publications:

E. Pakštienė, Identification of PG 2303+243 pulsation modes, 40th Liège International Astrophysical Colloquium "Ageing Low Mass Stars: From Red Giants to White Dwarfs", edited by J. Montalbán, A. Noels, V. Van Grootel; EPJ Web of Conferences, Volume 43, id.05012 (2013)

Long-term international project **The European Space Agency Satellite Gaia**. Prof. V. Straizys, Dr. Habil. G. Tautvaišienė.

Gaia is a space mission to chart a three-dimensional map of our Galaxy, in the process revealing the composition, formation and evolution of the Galaxy. *Gaia* will provide positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy and throughout the *Local Group*. The launch date of *Gaia* is December 20, 2013. A preparation of computing codes for the automated data analysis was going on at the institute throughout 2013.

International programme **Gaia-ESO Spectroscopic Survey** (ESO project 188.B-3002). Dr. Habil. G. Tautvaišienė. 2012 – 2016.

Gaia-ESO is a spectroscopic survey, targeting $\geq 10^5$ stars, systematically covering all major components of the Milky Way, from halo to star forming regions, providing the first homogeneous overview of the distributions of kinematics and elemental abundances. The main atmospheric parameters and chemical element abundances for more than 1700 stars were determined by the Vilnius group during 2013, three scientific papers were submitted for publication.

MAIN R&D&I (RESEARCH, DEVELOPMENT AND INOVATION) PARTNERS

Astrophysical Institute Potsdam (Germany)

Copenhagen University (Denmark)

Kiepenheuer Institut für Sonnenphysik (Germany)

Landessternwarte – Zentrum für Astronomie der Universität Heidelberg (Germany)

Vatican Observatory (USA)

OTHER SCIENTIFIC ACTIVITIES

Dr. K. Černis –

- member of the Lithuanian Astronomical Olympiad Council;
- member of the International Astronomical Union (IAU).

Dr. A. Kučinskas –

- member of the Board of Directors of the international journal *Astronomy and Astrophysics*.

Prof. V. Straizys –

- editor-in-chief of the international journal *Baltic Astronomy*;
- member emeritus of the Lithuanian Academy of Sciences;
- member of the working group on stellar classification of the ESA Gaia project;
- member of the International Astronomical Union (IAU);
- member of the European Astronomical Society.

Dr. Habil. G. Tautvaišienė –

- vicepresident of the Lithuanian Physics Society;
- member of the International Astronomical Union (IAU);
- secretary of Astrophysics Commission at the International Union of Pure and Applied Physics;
- executive board member of the international *Astronet* project;
- member of scientific working group *Reference Stars* of GAIA Space Observatory (ESA);
- founding member of the European Astronomical Society;
- editorial board member of the journal *Baltic Astronomy*;
- editor-in-chief of the annual astronomical almanac *Lietuvos dangus (Sky of Lithuania)*;
- chair of the *LT Presidency Priorities Committee* for the international conference *Structural Change Promoting Gender Equality in Research Organisations*, November 21–22, 2013, Vilnius;
- member of the organizing committee of the international conference *XXVII Texas Symposium on Relativistic Astrophysics*, December 8–13, 2013, Dallas, USA;
- member of the organizing committee of the international conference *Dig Sites of Stellar Archeology: Giant Stars in the Milky Way*, September 4–6, 2013, Izmir, Turkey;

- member of the organizing committee of the international conference *Astronomy Education & Public Outreach: the European perspective*, June 17–18, 2013, Heidelberg, Germany;
- member of the Programme committee of the *40th National Physics Conference*, June 10–12, 2013, Vilnius;
- member of the organizing committee of the international conference *Baltic Applied Astroinformatics and Space Data Processing*, May 15–16, 2013, Ventspilis, Latvia.

DEPARTMENT OF THE THEORY OF ATOM

12 A. Goštauto, LT-01108 Vilnius
 Tel. 219 3270, fax 261 5361
 E-mail: alicija.kupliauskiene@tfai.vu.lt

Head – Dr. *Alicija Kupliauskienė*

STAFF

Chief Researchers: Prof. Dr. Habil. P. Bogdanovičius, Prof. Dr. Habil. G. Gaigalas, Prof. Dr. Habil. R. Karazija (affiliated), Dr. A. Kupliauskienė,

Senior Researchers: Dr. V. Jonauskas, Dr. R. Karpuškienė, Dr. R. Kisielius, Dr. S. Kučas, Dr. G. Merkelis, Dr. J. Tamulienė.

Researchers: Dr. R. Juršėnas, Doc. Dr. A. Kynienė, Dr. A. Momkauskaitė.

Junior Researchers: Dr. R. Kivilšienė (part-time), Š. Masys, P. Rynkun, A. Alkauskas (part-time).

Technicians: G. Kerevičius (part-time), D. Stonys (part-time).

Doctoral student: L. Radžiūtė.

RESEARCH INTERESTS

Theoretical atomic spectroscopy

Methods of the theory of complex atomic and ionic spectra

Development of quantum many-body theory

Development and application of algorithms and computer programs for plasma physics, astrophysics and other fields

Development of quantum mechanics and quantum electrodynamics for the transitions in atoms, molecules and molecular complexes

Investigation of the processes of interaction of atoms with electrons and radiation

Investigation of the spectroscopic characteristics of the molecular compounds

History of physics

RESEARCH PROJECTS CARRIED OUT IN 2013

Projects Supported by University Budget

Theoretical Investigation of Plasmas Spectra by Using Collisional-Radiative Model. Dr. V. Jonauskas. 2008–2013.

Electron-impact collision strength calculations using different R-matrix code versions are performed for the $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4l$ ($l = 0, 1, 2, 3$) configuration levels of W^{45+} ion. The influence of relativistic effects on the collision strength is studied in quasirelativistic and relativistic approximations. Energies and oscillator strengths of inner-shell lines from Fe XIV, Fe XV, and Fe XVI have been investigated. It was showed how the absorption profile of the Fe XIV UTA depends on density, due to the changing populations of levels within the ground configuration.

Main publications:

V. Jonauskas, R. Kisielius, Š. Masys, and A. Kynienė. Analogues of relativistic integrals: their application in R-matrix method for highly charged tungsten ions, *Lith. J. Phys.* **53**, 144–149 (2013).

Investigation of spectroscopic characteristics of heavy and super-heavy chemical elements. Prof. G. Gaigalas. 2009–2014.

The MCHF and CI methods are based on a single orthonormal orbital basis. This usually leads to massive CSF expansions that are difficult to handle, even on large computer systems. The results obtained in the project this year show that it is possible to relax the orthonormality restriction on the orbital basis and break down the originally very large calculations into a series of smaller calculations that can be run in parallel. Various perspectives of the new method are given.

Main publications:

S. Verdebout, P. Rynkun, P. Jönsson, G. Gaigalas, C. Froese Fischer, M. Godefroid, A partitioned correlation function interaction approach for describing electron correlation in atoms. *Journal of Physics B, Atomic Molecular and Optical Physics*, **46**, 085003 (2013).

P. Jönsson, A. Alkauskas, G. Gaigalas, Energies and E1, M1, E2 transition rates for states of the $2s22p^5$ and $2s2p^6$ configurations in fluorine-like ions between Si VI and WLXVI. *Atomic Data and Nuclear Data Tables*, **99**, 431 (2013).

J. Katriel, G. Gaigalas, M. Puchalski, Quantum Defects at the Critical Charge. *Journal of Chemical Physics*, **138**, 224305 (2013).

Investigation of the spectroscopic characteristics of complex atoms and their derivatives. Dr. A. Kupliauskienė. 2012–2017.

Energy levels, electron-impact excitation cross sections and autoionization probabilities of electron-impact 4p-core excited Rb were calculated taking into account relativistic and correlation effects and used for the classification of experimental spectra. The solution of the three-body Schrodinger equation with decaying potentials is shown to exist in the commutator subalgebras. Complex theoretical and experimental studies of the methionine molecule were performed by using electron-impact process for the creation of various fragments.

Main publications:

R. Juršėnas. On the bound states for the three-body Schrodinger equation with decaying potentials. *Few-Body Systems*, **54**:1799-1 (2013).

R. Karazija, S. Kučas. Average characteristics of the configuration interaction in atoms and their applications. *JQSRT*, **129**, 131-144 (2013).

A. V. Snegursky, J. Tamuliene, V. S. Vukstich, L. G. Romanova. Methionine molecule electron-impact-induced fragmentation: mechanisms and chemical structure. In: *Methionine Biosynthesis, Chemical Structure and Toxicity*, Ed. A. Snegursky, New York, Nova Biomedical Press, 2013, p. 113-141.

National Research Projects

European Social Fund under the Global Grant measure “**Establishing and development of atomic data base for astrophysical, technological and laboratory plasma modeling**”. Dr. Habil. P. Bogdanovičius. 2012–2015.

During implementation of the project VP1-3.1-ŠMM-07-K-02-013, the initial version of the atomic database was constructed and data formats were designed. Codes to parse results from database were established. The spectroscopic parameters of 35 atoms and ions were determined and included into database. 15 scientific contributions were presented at national and international conferences, 3 research papers were published. Website informing about the project was created.

Main publications:

R. Karpuškieñė, P. Bogdanovich, R. Kisielius. Significance of M2 and E3 transitions for $4p^5 4d^{N+1}$ - and $4p^6 4d^{N-1} 4f$ -configuration metastable-level lifetimes. *Phys. Rev. A* **88**, 022519(10) (2013).

A. Borovik, A. Kupliauskiene, O.Zatsarinny. Excitation-autoionization cross section of alkali atoms by electron impact. *J. Phys. B: At. Mol. Opt. Phys.*, **46**, 215201 (2013).

G. J. Ferland, R. Kisielius, F. P. Keenan, P. A. M. van Hoof, V. Jonauskas, M. L. Lykins, R. L. Porter, and R. J. R. Williams. Expanded Iron UTA spectra - probing the thermal stability limits in AGN clouds, *The Astrophysical Journal*, **767**, 123 (2013).

European Social Fund under the Global Grant measure “**Investigation of plasma spectra of tungsten ions**”. Dr. V. Jonauskas. 2012–2015.

Energy levels and emission spectra of W^{25+} ion have been studied by performing the large-scale relativistic calculations using a configuration interaction method. Collisional radiative model was used to study lines of W^{23+} ion. The modelled spectra showed low sensitivity on the electron density, which validates the comparison of EBIT and tokamak spectra. Influence of cascade emission to the formation of spectra from plasma created by EBIT in electron trapping mode has been studied. It has been shown that cascade emission can play an important role in the formation of spectra from the EBIT plasma.

Main publications:

V. Jonauskas, Š. Masys, A. Kynienė, G. Gaigalas, Cascade emission in electron beam ion trap plasma, *J. Quant. Spectr. Radiative Transfer*, **127**, 64-69 (2013).

T Pütterich, V. Jonauskas, R. Neu, R. Dux and ASDEX Upgrade Team, The extreme ultraviolet emissions of $W^{23+}(4f^5)$, *AIP Conf. Proc.* **1545**, 132 (2013).

International Research Projects

EU FP7 project: **Contract of Association EURATOM - Lithuania**. Dr. A. Kupliauskienė. 2008–2013.

The energy level spectra and radiative lifetimes were calculated for the $4p^64d^2$, $4p^64d4f$, $4p^54d^3$ configurations of the ion W^{36+} . The first attempt to give a systematic view of average characteristics in the configuration interaction approach was performed. Formation of a narrow group of intense lines in the emission and photoexcitation spectra was explained.

Main publications:

P. Bogdanovich, R. Kisielius. Theoretical energy level spectra and transition data for $4p^64d^2$, $4p^64d4f$, and $4p^54d^3$ configurations of W^{36+} . *Atomic Data Nuclear Data Tables*, **99**, 580-594 (2013).

R. Karazija, S. Kučas, V. Jonauskas, A. Momkauskaitė. Formation of a narrow group of intense lines in the emission and photoexcitation spectra. In: „New Trends in Atomic and Molecular Physics“, Springer Series on Atomic, Optical and Plasma Physics, **76**, 2013, Ed. M. Mohan, Chapter 10, p. 167-188.

VISBY project: **Computational Atomic Structure with Applications to Astronomy and Plasma Physics** (Sweden, Lithuania and Poland) Dr. Habil. G. Gaigalas. 2010–2013.

Based on relativistic wave functions from multiconfiguration Dirac-Hartree-Fock and configuration interaction calculations, E1, M1, E2, M2 transition rates, weighted oscillator strengths, and lifetimes were evaluated for the states of the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations in all oxygen-like ions between F II and Kr XXIX. Valence and core-valence correlation effects were accounted for through single-double multireference expansions to increasing sets of active orbitals.

Main publications:

P. Rynkun, P. Jönsson, G. Gaigalas, C. Froese Fischer. Energies and E1, M1, E2, and M2 transition rates for states of the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations in oxygen-like ions between F II and Kr XXIX. *Astronomy and Astrophysics*, **557**, A136 (8 p.) (2013).

P. Jönsson, M. Godefroid, G. Gaigalas, Jacek Bieron, T. Brage, Accurate Transition Probabilities from Large-Scale Multiconfiguration Calculations – a Tribute to Charlotte Froese Fischer. Book series: AIP Conference Proceedings, **1545**, 266-278 (2013).

P. Jönsson, G. Gaigalas, J. Bieroń, Ch. Froese Fischer, I.P. Grant. New version GRASP2K Relativistic Atomic Structure Package. *Computer Physics Communications*, **184**, 2197-2203 (2013).

NSF (USA) project: **Collaborative Research: Spectral Diagnostics of Heavy Elements at High Redshift** (USA, Lithuania). Dr. R. Kisielius. 2012 – 2014.

The radiative E1 transition parameters and autoionization rates were determined for the ions with a vacancy in inner L shell. Isoelectronic sequences from the Na-like to Zn-like were studied. Data for the ions from $Z=12$ to $Z=30$ were produced and applied in astrophysical plasma modeling code Cloudy.

MAIN R&D&I (RESEARCH, DEVELOPMENT AND INOVATION) PARTNERS

Joint European Torus, Culham (UK)

University of Kentucky, Lexington (USA)

Nature Environment Society, Malmö University, Malmö (Sweden)

Chimie Quantique et Photophysique, Université Libre de Bruxelles (Belgium)

Institute of Electron Physics of Ukraine Academy of Sciences (Uzhgorod, Ukraine)

OTHER SCIENTIFIC ACTIVITIES

Prof. P. Bogdanovičius –

- head of Lithuanian Physics' Olympiad Team.

Prof. G. Gaigalas –

- chairman of the joint committee of doctoral studies between the Institute of Theoretical Physics and Astronomy of Vilnius University and the Lithuanian University of Educational Sciences.

Prof. R. Karazija –

- editorial board member of the *Lithuanian Journal of Physics*;
- member of the Lithuanian Academy of Sciences.

Dr. V. Jonauskas –

- secretary of the Board of the Institute of Theoretical Physics and Astronomy, Vilnius University.

Dr. A. Kynienė –

- president of the Vilnius City Board of the Physics Teachers' Association;
- member of Vilnius City Physics Methodical Board.

Dr. R. Kivilšienė –

- board member of group *History of Physics* (HoP) of the European Physical Society.

Dr. A. Kupliauskienė –

- member of the local organizing committee of the international conference *Structural Change Promoting Gender Equality in Research Organisations*, November 21–22, 2013, Vilnius;
- head of the board of Association “BASNET Forumas”.

Dr. J. Tamulienė –

- management committee member of the Lithuanian Physics Society;
- leader of the Professional Union of Vilnius University.

DEPARTMENT OF THE THEORY OF NUCLEUS

12 A. Goštauto, LT-01108 Vilnius
 Tel. 219 3253, fax 212 5361
 E-mail: egidijus.norvaisas@tfai.vu.lt

Head – Prof. Dr.(HP) *Egidijus Norvaišas*

STAFF

Chief researchers: Dr. Habil. S. Ališauskas (affiliated)

Senior Researchers: Doc. Dr. A. Acus, Dr. A. Juodagalvis, Prof. Dr.(HP) E. Norvaišas.

Researchers: Dr. D. Jurčiukonis, Dr. K. Tamošiūnas, Dr. V. Šimonis (part-time).

Doctoral students: T. Sabonis.

RESEARCH INTERESTS

Development of algebraic techniques for nuclear and particle physics

Investigation of symmetries in nuclear and particle physics

Development of topological soliton model

Investigation of electroweak vector bosons in pp collisions

Investigation of lepton-nucleus interactions in the supernova matter

RESEARCH PROJECTS CARRIED OUT IN 2013

Project Supported by University Budget

Research of Subatomic Systems and Their Dynamics Applying Algebraic and Topology

Methods. Prof. E. Norvaišas. 2011–2015.

The mass spectra of heavy baryons and stability problems in the SU(2), SU(3) topological soliton model were elucidated. Magnetic moments and partial decay rates of M1 radiative transitions have been calculated for all ground state heavy baryons using the modified quark bag model. The neutrino mass spectra in the seesaw extension of the Standard Model neutrino sector were studied under three assumptions: (1) neutrinos are Majorana particles, (2) the number of heavy neutrinos is either one or two, (3) there are two Higgs doublets.

Main publications:

D. Jurčiukonis, E. Norvaišas, On quantization of the SU(2) Skyrmions, Phys. Lett. B, **724**, Issues 4–5, 355 (2013).

D. Jurčiukonis, E. Norvaišas and V. Regelskis, The Spectrum of the Baryon Masses in a Self-consistent SU(3) Quantum Skyrme Model, Physica Scripta, **87**, 025101 (2013).

A. Bernotas, V. Šimonis, Radiative M1 transitions of heavy baryons in the bag model, Phys. Rev. D **87**, 074016 (2013).

National Research Projects

Research Council of Lithuania. **Joint Analysis of Experimental Data and Theory for the Heavy Ion Reactions** (No. PRO-06/2012). Dr. Karolis Tamošiūnas, 2012.11-2013.07

Frontier Ideas project was intended to investigate the possibility to calculate the initial state of heavy ion collision from the raw experimental data using analytic solution of relativistic hydrodynamics on event-by-event basis. Publication in IOP Journal of Physics: Conference Series (JPCS) is with referee.

International Research Projects

Lithuanian Academy of Sciences. **Lithuanian cooperation with CERN**. Dr. A. Juodagalvis, since 2008.

Analysis of the proton-proton collision data recorded with the CERN Compact Muon Solenoid (CMS) detector was in progress. The analysis was focused on the Drell-Yan differential cross section in the electron channel at the proton-proton collision energy of 7 TeV and 8 TeV as well as on the coordination of the Standard Model Physics data and Monte Carlo validation effort. The results of the measurement at 7 TeV were submitted to the Journal of High Energy Physics.

Main publications:

The CMS Collaboration, „Study of the mass and spin-parity of the Higgs boson candidate via its decays to Z boson pairs,“ *Physical Review Letters* **110** (2013) art.no.081803, doi: 10.1103/PhysRevLett.110.081803.

The CMS Collaboration, „Observation of a new boson with mass near 125 GeV in pp collisions at root s=7 and 8 TeV,“ *Journal of High Energy Physics* **6** (2013) art.no.081, doi: 10.1007/JHEP06(2013)081.

The CMS Collaboration, „Observation of long-range, near-side angular correlations in pPb collisions at the LHC,“ *Physics Letters B* **718** (2013) 795-814, doi: 10.1016/j.physletb.2012.11.025.

MAIN R&D&I (RESEARCH, DEVELOPMENT AND INOVATION) PARTNERS

Department of Mathematics, University of York (UK)
Joint Institute for Nuclear Research (Dubna, Russia)

Nuclear Physics Center at Lisbon University (Portugal)
Purdue University, West Lafayette (USA)
European Organization for Nuclear Research CERN (Switzerland)

OTHER SCIENTIFIC ACTIVITIES

Prof. E. Norvaišas –

- Coordinator for Lithuania of COST Action: MP 1006 Fundamental Problems in Quantum Physics. 2011 - 2014

Dr. A. Juodagalvis –

- contact person for the Standard Model Physics PdmV (physics data and Monte Carlo validation) activity at the CERN CMS experiment (in 2012-2013).

DEPARTMENT OF THE THEORY OF PROCESSES AND STRUCTURES

12 A. Goštauto, LT-01108 Vilnius
Tel. 219 3254, fax 212 5361
E-mail: Bronislovas.Kaulakys@tfai.vu.lt

Head - Prof. Dr. Habil. *Bronislovas Kaulakys*

STAFF

Chief researchers: Prof. Dr. Habil. B. Kaulakys, Dr. Habil. G. Juzeliūnas, Dr. (HP) V. Gontis, Prof. Dr. (HP) E. Anisimovas (part-time), Prof. Dr. Habil. A. Matulis (part-time).

Senior researchers: Dr. Habil. V. Gineitytė (part time), Dr. G. Vektaris, Dr. J. Ruseckas, Doc. Dr. D. Šatkovskienė (affiliated).

Researchers: Dr. M. Alaburda, Dr. A. Vektarienė, Dr. A. Mekys (part-time), Dr. V. Kudriašovas (part-time).

Postdoctoral researchers: Dr. R. Juršėnas.

Junior researchers: A. Kononovičius (part-time).

Engineers: R. Kazakevičius (part-time), T. Andrijauskas (part-time).

Doctoral students: T. Andrijauskas, H. R. Hamedi, V. Juknevičius, R. Kazakevičius, A. Kononovičius.

Technicians: G. Žlabys.

RESEARCH INTERESTS

Quantum optics and ultra-cold atoms
Bose-Einstein condensates
Quantum chemistry
Spectroscopy, phase transitions
Condensed molecular structures
Econophysics and physics of finance
Fluctuations and noise, theory of 1/f noise

RESEARCH PROJECTS CARRIED OUT IN 2013

Projects Supported by University Budget

Optical and Kinetic Properties of Cold Atoms and Condensed Molecular Structures.

Habil. Dr. G. Juzeliūnas, 2011–2015.

Transient evolution of the atomic response has been studied in an open four-level atomic medium with applications to lasing with and without population inversion. Electronic transport has been investigated in monolayer and bilayer graphene with single and many short-range defects focusing on the role of edge termination (zigzag versus armchair). The mechanism of thieno[3,2]benzofuran halogenation has been developed and importance of HOMO–HOMO interaction was emphasized using DFT method.

Main publications:

H. R. Hamed, G. Juzeliūnas, A. Raheli, M. Sahrai, High refractive index and lasing without inversion in an open four-level atomic system, *Opt. Comm.* 311, 261–265 (2013).

A. Orlof, J. Ruseckas, and I. V. Zozoulenko, Effect of zigzag and armchair edges on the electronic transport in single-layer and bilayer graphene nanoribbons with defects, *Phys. Rev. B* 88, 125409 (2013).

A. Vektarienė, Insights into the Mechanism of the Benzoannelated Thieno[3,2-b]furan Halogenation. Importance of HOMO–HOMO Interaction, *J. Phys. Chem. A* 117, 8449–8458 (2013).

Theory and Applications of Processes in Complex Systems. Prof. B. Kaulakys. 2011–2015.

A mechanism of intermittency occurring in nonlinear dynamical systems with invariant subspace and zero transverse Lyapunov exponent is analyzed. It is shown that for such systems the power spectral density of the deviation from the invariant subspace can have $1/f$ noise in a wide range of frequencies and non-Gaussian distributions. A Markov jump process with the three-state herding interaction is proposed, providing a background for modeling of return in financial markets.

Main publications:

J. Ruseckas and B. Kaulakys, Intermittency in relation with $1/f$ noise and stochastic differential equations, *Chaos* 23, 023102 (2013).

B. Kaulakys, R. Kazakevičius and J. Ruseckas, Modeling Gaussian and non-Gaussian $1/f$ noise by the linear stochastic differential equations, *IEEE Conferences: Noise and Fluctuations (ICNF)*, 2013 22nd International Conference on, 4 pages, doi:[10.1109/ICNF.2013.6578944](https://doi.org/10.1109/ICNF.2013.6578944).

A. Kononovičius and V. Gontis, Three-state herding model of the financial market, *EPL (Europhys. Lett.)*, 101, 28001 (2013).

National Research Projects

Research Council of Lithuania. **Topological phenomena in cold atom and condensed matter systems** (Project VP1-3.1-ŠMM-07-K-02-046, Global grant). Prof. E. Anisimovas, 2012–2015.

The primary focus of this project was on the manifestation of topological order in the band structures of optical lattices of triangular geometry. In particular, the honeycomb and coupled honeycomb-triangular lattices with a non-uniform synthetic magnetic flux as a means to implement a robust Chern insulator were considered. A large parameter space spanned by the experimentally controllable parameters and obtained phase diagrams identifying the accessible topologically non-trivial regimes was explored.

Main publications:

N. Goldman, E. Anisimovas, F. Gerbier, I.B. Spielman, and G. Juzeliūnas, Measuring topology in a laser-coupled honeycomb lattice: from Chern insulators to topological semi-metals, *New Journal of Physics* 15, 013025 (2013).

Research Council of Lithuania. **Engineering and control of artificial magnetic field and spin-orbit coupling for ultracold atoms** (No. MIP-82/2012). Dr. Habil. G. Juzeliūnas. 2012–2014.

A new technique has been proposed and analyzed for producing two- and three-dimensional Rashba-type spin-orbit couplings for ultracold atoms using atom chips. It is shown how density dependent gauge potentials (DDGP) can be induced in dilute gases of ultracold atoms using light-matter interactions. The DDGP are found to support chiral solitons in a quasi-one-dimensional ultracold gas of interacting Bose atoms, as well as the onset of persistent currents in a ring geometry.

Main publications:

B. M. Anderson, I. B. Spielman, and G. Juzeliūnas, Magnetically Generated Spin-Orbit Coupling for Ultracold Atoms, *Phys. Rev. Lett.* 111, 125301 (2013).

M. J. Edmonds, M. Valiente, G. Juzeliūnas, L. Santos, and P. Öhberg, Simulating an Interacting Gauge Theory with Ultracold Bose Gases, *Phys. Rev. Lett.* 110, **085301 (2013)**.

Research Council of Lithuania. **Coherent manipulation of matter by light and light by matter (TAP-LLT-01/2012)**. Dr. Habil. G. Juzeliūnas. 2012–2014.

Manipulation of slow light with an orbital angular momentum has been studied during its propagation in a cloud of cold atoms affected by four control laser beams in a double tripod configuration of the atomic energy levels. In such a situation the atomic medium is transparent for a pair of probe fields, leading to the creation of two-component (spinor) slow light. Interaction between the probe fields has been explored when two control beams carry optical vortices of opposite helicity.

Main publications:

J. Ruseckas, V. Kudriašov, I. A. Yu, and G. Juzeliūnas, Transfer of orbital angular momentum of light using two-component slow light, *Phys. Rev. A* 87, **053840 (2013)**.

Research Council of Lithuania. **Spin-orbit coupling in ultracold atomic gases** (004/15/MTDS-550000-398). Dr. Habil. G. Juzeliūnas. 2012–2014.

The bound states have been investigated for the spin-orbit coupled ultracold atoms perturbed by a point-interaction. It was shown that, in addition to the bound states obtained by considering weak solutions through the Fourier transform, the ordinary point-interaction representation leads to extra states induced by the spin-orbit coupling. These states are due to the commutation of the original spin-orbit Hamiltonian with a certain self-adjoint extension of the atom-light coupling.

Main publications:

R. Juršėnas and J. Ruseckas, Bound states of the spin-orbit coupled ultracold atom in a one-dimensional short-range potential, *J. Math. Phys.* **54**, 051901 (2013).

International Research Projects

EU FP7 IRSES project: **COLIMA - Coherent Manipulation of Light and Matter via Interferences of Laser-dressed States**. Dr. Habil. G. Juzeliūnas. 2011–2015.

A new scheme for producing a two-component superluminal light has been proposed and analysed. The scheme makes use of two gain doublets and two probe fields. An advantage of the scheme is its flexibility in controlling the two superluminal pulses by changing parameters of the gain doublets. It is shown that if only one probe field is incident, the second field is created and appears at the end of the atom cloud before the main peak of the incident pulse enters it.

MAIN R&D&I (RESEARCH, DEVELOPMENT AND INOVATION) PARTNERS

National Institute of Standards and Technology (USA)

National Tsing Hua University (Taiwan)

Heriot-Watt University (UK)

ICREA and ICFO (Spain)

Leibniz Universität, Hannover (Germany)

OTHER SCIENTIFIC ACTIVITIES

Prof. B. Kaulakys –

- member of the Institute of Physics (UK);
- editorial board member of the Lithuanian Journal of Physics;
- editorial board member of the journal *Nonlinear Analysis. Modelling and Control*;
- vice-president of the Lithuanian Association of Nonlinear Analysts;
- council member of the Lithuanian Scientific Society.

Dr. Habil. G. Juzeliūnas –

- chairman of the 2nd International TLL-COLIMA-FOTONIKA joint workshop on Manipulation of Light by Matter and Matter by Light (Vilnius, September 1-5, 2013);
- member of the Program committee of the 12th international Conference-School on Advanced Materials and Technologies (Palanga, 27–31 August, 2013);
- member of the Institute of Physics (UK).

Dr. (HP) V. Gontis –

- president of the Lithuanian Scientific Society;
- director of the Institute of Lithuanian Scientific Society;
- member of the association Euroscience, <http://www.euroscience.org/>.

PLANETARIUM

12a Konstitucijos pr., LT-09308 Vilnius

Tel. 272 4177, fax 272 4177

E-mail: planet@tfai.vu.lt

Director – Danutė Sperauskienė

STAFF

Lecturers: E. Dačinskaitė, V. Girdzijauskaitė, D. Sperauskienė

Engineer: D. Mešalkin

Booking-clerk: A. Kvaraciejienė

Photographer: G. Janavičius (part-time).

International and National Projects

FP 7 project **Researchers' Night 2013: Researchers on and off work** (Night2013). D. Sperauskienė, 2013.

This project was carried out in Lithuania together with seven other universities and three scientific institutions. The main action took place on the 27th of September and attracted to Planetarium about 600 visitors. Climate changes, secrets of the Universe, wonders of the Hubble space mission were overviewed and discussed with visitors for about 6 hours.

Another big cycle of lectures *Earth and the Universe* comprised 37 meetings with general public. Altogether about 600 lectures were offered and more than 23 000 people attended Planetarium during 2013.

MAIN R&D&I (RESEARCH, DEVELOPMENT AND INOVATION) PARTNERS

International Planetarium Society (Greenville, USA)

The Planetary Society (Pasadena, USA)

Hubble /ESA Information Centre (Munchen, Germany)

Carl Zeiss (Oberkochen, Germany)

Lithuanian Centre of Non-formal Youth Education (Lithuania)