

# Faculty of Physics

## INSTITUTE OF THEORETICAL PHYSICS AND ASTRONOMY

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Director – Dr. Habil. *Gražina Tautvaišienė*

### STAFF

**Distinguished professor:** Habil. Dr. G. Juzeliūnas

**Professors:** Dr. E. Anisimovas (part-time), Habil. Dr. A. Bartkevičius (affiliated), Habil. Dr. R. Karazija (affiliated), Prof. Dr. A. Kučinskas (part-time), Habil. Dr. V. Straižys (Emeritus), Habil. Dr. G. Tautvaišienė (part-time), Prof. Dr. (HP) V. Vansevičius (part-time).

**Research professors:** Dr. K. Černis, Dr. A. Deltuva, Prof. Habil. Dr. G. Gaigalas, Dr. (HP) V. Gontis, Doc. Dr. V. Jonauskas, Dr. H. Kjeldsen (part-time), Prof. Dr. A. Kučinskas (part-time), Dr. J. Ruseckas, Habil. Dr. G. Tautvaišienė (part-time), Habil. Dr. K. Zdanavičius (affiliated).

**Associate professors:** Doc. Dr. T. Gajdosik, Habil. Dr. B. Kaulakys (part-time), Dr. D. Narbutis (part-time), Dr. R. Stonkutė (part-time), Dr. K. Zubovas (part-time), Doc. Dr. D. Šatkovskienė (affiliated).

**Senior researchers:** Doc. Dr. A. Acus, Dr. F. Grundahl (part-time), Dr. R. Janulis (part-time), Dr. A. Juodagalvis, Habil. Dr. V. Gineitytė (affiliated), Dr. D. Jurčiukonis, Dr. R. Karpuškienė, Dr. A. Kazlauskas (affiliated), Dr. R. Kisielius, Dr. A. Kynienė, Dr. S. Kučas, Dr. Š. Masys, Dr. Š. Mikolaitis, Prof. Dr. (HP) E. Norvaišas (affiliated), Dr. E. Pakštienė, Dr. V. Regelskis, Dr. P. Rynkun, Dr. J. Sperauskas, Dr. E. Stonkutė, Dr. J. Tamulienė, Dr. A. Vektarienė, Dr. G. Vektaris, Dr. J. Zdanavičius.

**Researchers:** Dr. T. Andrijauskas (part-time), Dr. K. Brogaard (part-time), Dr. Y. Chorniy, Dr. V. Čepas (part-time), Dr. V. Dobrovolskas, Dr. A. Drazdauskas, Dr. V. Dūdėnas, Dr. C. von Essen (part-time), Dr. R. Juršėnas, Dr. H. R. Hamedī, Dr. R. Kazakevičius, Dr. J. Klevas, Dr. A. Kononovičius, Dr. V. Kudriašov (part-time), Dr. M. Maskoliūnas, Dr. R. Minkevičiūtė, Dr. A. Mekys (part-time), Dr. A. Momkauskaitė, Dr. V. Novičenko, Dr. L. Radžiūtė.

**Research assistants:** E. Kolomiecenas, S. Raudeliūnas (part-time),

**Project-specialists:** M. Ambrosch (part-time), M. Amrozas (part-time), V. Bagdonas (part-time), S. Draukšas (part-time), E. Gvozdiovas (part-time), M. Račiūnas (part-time), C. Viscasillas Vazquez (part-time), G. Žlabys (part-time).

**Doctoral students:** M. Ambrosch, M. Ambrozas, S. Draukšas, E. Kolomiecias, J. Koncevičiūtė, M. Račiūnas, A. Sharma, R. Skorulskienė, R. Urbonavičiūtė, C. Viscasillas Vazquez, G. Žlabys.

**Non-academic staff:** V. Bagdonas (part-time), V. Kakarienė (part-time), B. Kavaliauskienė, S. Lovčikas, R. Mikutavičienė, Ž. Naimovičienė, R. Urbonavičiūtė (part-time).

## RESEARCH AREAS

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

## RESEARCH INTERESTS

Galactic structure and chemodynamical evolution of stellar populations

Chemical composition and mixing phenomena in stellar atmospheres

Convection and non-equilibrium radiative transfer in stellar atmospheres

Stellar asteroseismology

Planet hosting stars and exoplanet transits

Structure and evolution of galaxies

Search and positional observations of comets and asteroids

Theoretical atomic spectroscopy

Algorithms and computer programs for plasma physics, astrophysics and other fields

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

Interactions of atoms and molecules with electrons and radiation

Theoretical investigation of crystalline and electronic structure of perovskite crystals

Algebraic techniques for nuclear and particle physics

Analysis of pp collision data recorded at CERN CMS experiment

Neutrinos in the extended Standard model

Scattering processes in few-body nuclear systems

Quantum optics and ultra-cold atoms

Bose-Einstein condensates

Condensed matter systems

Quantum chemistry

Complexity and statistical physics applications in economics, finance and other social sciences

Fluctuations and noise, theory of 1/f noise

### **DOCTORAL DISSERTATIONS MAINTAINED IN 2020**

J. Bialopetravičius. Analysis of Star Clusters with Convolutional Neural Networks.

### **MAIN CONFERENCES ORGANIZED IN 2020**

Splinter Meeting No. 8 on “Mentoring in the planetary science community” at the virtual Europlanet Science Congress, 2020.10.01, convener Edita Stonkutė.

### **MAIN SCIENTIFIC ACHIEVEMENTS IN 2020**

Emergence of quantum structures was demonstrated in interacting bosonic systems using artificial neural networks.

### **RESEARCH PROJECTS CARRIED OUT IN 2020**

#### **Projects Supported by the University Budget**

**Stellar chemical composition and asteroseismic activity in the Milky Way Galaxy.** Dr. Habil. G. Tautvaišienė. 2016–2020.

We used the NASA TESS space mission data for investigating the Galaxy by carrying out the first asteroseismic ensemble study of red giant stars. We used a sample of 25 stars for which we measured their global asteroseismic observables and estimated their fundamental stellar properties, such as radius, mass, and age. We present simultaneous ground- and space-based observations of primary eclipses of several binary systems in the Southern ecliptic hemisphere in order to verify the reliability of the TESS timestamps. In addition, we used 405 individually measured mid-eclipse times of 26 eclipsing binary stars observed solely by TESS in order to test the existence of a potential drift with a monotonic growth (or decay) affecting the observations of all stars.

#### **Main publications:**

Aguirre, V. S., Stello, D., Stokholm, A., ... Stonkutė, E., ... Kjeldsen, H., ... Detection and Characterization of Oscillating Red Giants: First Results from the TESS Satellite, 2020, *Astrophysical Journal Letters*, 889, L34.

von Essen, C., Lund, M. N., Handberg, R., Sosa, M. S., Gadeberg, J. T., Kjeldsen, H., Vanderspek, R. K., Mortensen, D. S., Mallonn, M., Mammana, L., Morgan, E. H., Villaseñor, J.

N. S., Fausnaugh, M. M., & Ricker, G. R., TESS Data for Asteroseismology: Timing Verification, 2020, *Astronomical Journal*, 160, 34.

**Star formation and dust clouds in the Orion and Perseus arms of the Galaxy.** Prof. V. Straizys. 2016–2020.

Open star clusters Berkeley 86 and Berkeley 87 were investigated using photometry of stars in the Vilnius seven-colour photometric system and the astrometric data from Gaia space observatory of ESA. Photometric spectral classes, luminosities and interstellar extinctions were determined for about 1500 stars. For the stars in clusters the membership probabilities, interstellar reddenings and extinctions, distances and ages were determined. The membership of these clusters to the Cygnus OB1 association was estimated.

**Main publications:**

Straizys V., Boyle R.P., Raudeliūnas S., Zdanavičius J., Janusz R., Macijauskas M., Lazauskaite R., Černis K., Zdanavičius K., Maskoliūnas M., Čepas V., Kazlauskas A., Open cluster IC 1369 and its vicinity: multicolor photometry and Gaia DR2 astrometry, 2020, *Astronomical Journal*, 159, 95

Soam A., Andersson B.-G., Straizys V., Caputo M., Kazlauskas A., Boyle R.P., Janusz R., Zdanavičius J., Acosta-Pulido J.A. Interstellar extinction, polarization, and grain alignment in the Sh 2-185 (IC 59 and IC 63) region, *Astronomical Journal*, in press.

**Hydrodynamical phenomena and radiative transfer in stellar atmospheres.** Prof. Dr. A. Kučinskas. 2016–2020.

We extended our earlier investigation of the interaction between convection and radiative transfer in the atmosphere of a metal-poor subgiant BD+44493. Our extended focus was on several molecular lines, including those of CH and OH. Our findings show that the 3D-1D LTE abundance corrections at the metallicity of BD+44493 may reach up to 1 dex for the abundances of carbon and oxygen determined from molecular lines and thus may influence interpretation of the evolutionary trends of these elements in the Galaxy and beyond. We also determined abundances of zirconium and strontium in atmospheres of RGB stars of the Galactic globular cluster 47 Tuc. In addition, we investigated the effects of convection on the formation of the respective spectral lines with the aid of 3D hydrodynamical model atmospheres.

**Main publications:**

Kolomiecenas, E., A. Kučinskas, A., J. Klevas, H.-G. Ludwig, M. Steffen, P. Bonifacio. Abundances of carbon and oxygen determined from molecular lines in the metal-poor subgiant BD+44493, submitted to “*Astronomy and Astrophysics*”.

Kolomiecenas, E., A. Kučinskas, A., Dobrovolskas, V., Bonifacio, P., Abundances of zirconium and strontium in the RGB stars of Galactic globular cluster 47 Tuc, submitted to “*Astronomy and Astrophysics*”.

**Stochastic Effects in Stellar Systems.** Prof. Dr. (HP) V. Vansevicius. 2019–2023.

We used convolutional neural networks to study star clusters in the galaxy M83 and found an age gradient across the spiral arms which is consistent with the density wave theory. We showed that outflows driven by active galactic nuclei correlate better with their long-term average luminosity rather than the present-day luminosity. We discovered a peculiar red-giant branch of CN enriched stars in the dwarf irregular galaxy Leo A. We determined orbits of 50 binary stars based on their echelle spectra.

**Main publications:**

Bialopetravičius J., Narbutis D. Study of Star Clusters in the M83 Galaxy with a Convolutional Neural Network, 2020, *The Astronomical Journal*, 160, id.264, 11 pp.

Zubovas K., Nardini E., Intermittent AGN episodes drive outflows with a large spread of observable loading factors, 2020, *Monthly Notices of the Royal Astronomical Society*, 498, 3633-3647

**Astrometry and photometry of small Solar-system bodies.** Dr. K. Černis. 2016–2020.

Sixty two new asteroids have been discovered. NEO 2006 VB14 was observed by means of its astrometry and photometry. A new precise orbit of this NEO object was determined. Fourier transform was applied to determine the rotation period of  $P=3.25\text{h}$  for the asteroid 2006 VB14. We published 8180 astrometric positions of 1960 asteroids. Near Earth Objects, TNO, Main Belt asteroids and comets were observed with the 0.35/0.51 m Maksutov telescope (Molėtai Observatory), with the 0.80/1.20 m Schmidt telescope (Baldone Observatory, Latvia), with the 1.8 m Vatican telescope (Mt. Graham, Arizona, U.S.A.). New precise orbits of 37 asteroids discovered at the Baldone observatory were determined. The bright comet C/2020 F3 (NEOWISE) and noctilucent clouds were observed in summer time from the Vilnius station. Four asteroids were named by Jogaila, Valančius, Laugalys, and Druskininkai.

**Main publications:**

Włodarczyk, I., Černis, K., Eglitis, I. Observational data and orbits of the asteroids discovered at the Baldone Observatory in 2015-2018. *Open Astron.* 29, 179 (2020)

Černis, K., Zdanavičius, J. Discovery of seven new asteroids and astrometric observations of 58 asteroids (271 positions) in Moletai Astronomical Observatory (Code 152). *M.P.C.* 118950 (2020 Jan. 9).

Černis, K., Eglitis, I. Discovery of twenty six new asteroids and astrometric observations of 178 asteroids (647 positions) in Baldone Astronomical Observatory (Code 069). *M.P.C.* 118948 (2020 Jan. 9).

### **Multielectron processes in complex atomic systems.** Dr. V. Jonauskas. 2019–2023.

Multiple photoionization cross sections from the K shell were studied for all levels of the Fe<sup>2+</sup> 3d<sup>6</sup> configuration. The ab initio quasirelativistic approach was used to derive transition data for Pd-like tungsten W<sup>28+</sup> ion. Hydrogenated and hydroxylated nanodiamonds were modeled by putting emphasis on the most common paramagnetic impurities - dangling bonds as well as single substitutional nitrogen atoms - and their interaction with water.

#### **Main publications:**

S. Kučas, A. Kynienė, Š. Masys, V. Jonauskas, Multiple photoionization cross sections for Fe<sup>2+</sup> K shell, *Astronomy & Astrophysics* 643, A46 (2020).

R. Karpuškienė, R. Kisielius, Theoretical level energies and transition data for ion W<sup>28+</sup>, *Atomic Data And Nuclear Data Tables* 132, 101309 (2020).

Š. Masys, Ž. Rinkevičius, J. Tamulienė, Computational study on the electronic g-tensors of hydrophilic and hydrophobic nanodiamonds interacting with water, *Journal Of Chemical Physics* 152, 144302 (2020).

### **Correlation and relativistic effects in multivalency atoms and ions.** Prof. G. Gaigalas. 2020–2024.

The new program was created. It performs the transformation of atomic state functions from a *LSJ*-coupled configuration state function (CSF) basis into several other CSF bases such as *jj*, *LK*, *JK*, *JJ*, and many others. The relativistic multiconfiguration Dirac–Hartree–Fock method is used to compute accurate Landé g-factors for states in B II, C I–IV, Al I–II, Si I–IV, P II, S II, Cl III, Ar IV, Ca I, Ti II, Zr III, and Sn II.

#### **Main publications:**

W. Li, P. Rynkun, L. Radžiūtė, G. Gaigalas, B. Atalay, A. Papouliá, K. Wang, H. Hartman, J. Ekman, T. Brage, C. Y. Chen, and P. Jönsson, Multiconfiguration Dirac – Hartree – Fock calculations of Lande g - factors for ions of astrophysical interest: B II, C I–IV, Al I–II, Si I–IV, P II, S II, Cl III, Ar IV, Ca I, Ti II, Zr III, and Sn II, *Astronomy and Astrophysics* 639, A25 (2020).

G. Gaigalas, Coupling: The program for searching optimal coupling scheme in atomic theory, *Computer Physics Communication* 247, 106960 (2020).

B. Smaranika, T. Masaomi, K. Kyohei, D. Kato, and G. Gaigalas, Simulations of Early Kilonovae Emission from Neutron Star Merger, *The Astrophysical Journal*, 901, 29 (2020).

### **Theoretical Study of Light Nuclei and Elementary Particles.** Dr. A. Deltuva. 2016–2020.

Cross section and analyzing powers for the proton-deuteron breakup at 135 and 190 MeV were calculated and compared with the experimental data. Features of Efimov resonances in the three-boson continuum were determined. The influence of a quantum deformation to the spectrum of orthogonal and symplectic spin chains was determined. An algorithm for finding square roots in radicals of an arbitrary multivector in 3D Clifford algebras was found.

### **Main publications:**

A. Deltuva, Energies and widths of Efimov states in the three-boson continuum, Phys. Rev. C 102, 034003 (2020).

A. Gerrard and V. Regelskis, Nested algebraic Bethe ansatz for deformed orthogonal and symplectic spin chains, Nucl. Phys. B 956, 115021 (2020).

A. Dargys and A. Acus, Square root of a multivector in 3D Clifford algebras, Nonlinear Analysis: Modelling and Control 25 (2), (2020), pp. 301–320.

### **Optical, Kinetic, and Topological Properties of Cold Atoms and Condensed Molecular Structures.** Habil. Dr. G. Juzeliūnas, 2018–2021.

Emergence of quantum structures was demonstrated in interacting bosonic systems using artificial neural networks. Superradiant instability driven by Anderson localization was predicted in a hybrid system of the Dicke and Aubry-André (DAA) model for bosons trapped in a one-dimensional (1D) quasiperiodic optical lattice and coupled to a cavity. A set of new benzoquinones was characterized electrochemically and by using quantum chemical analysis.

### **Main publications:**

Giedrius Žlabys, Mantas Račiūnas and Egidijus Anisimovas, Learning quantum structures in compact localized eigenstates, J. Phys. A: Math. Theor. 53, 115302 (2020).

H. Yin, J. Hu, A.-C. Ji, G. Juzeliūnas, X.-J. Liu, Q. Sun, Localization driven superradiant instability, Phys. Rev. Lett. 124, 113601 (2020).

E. Voitechovič, A. Vektarienė, G. Vektaris, R. Jančienė, J. Razumienė, V. Gurevičienė, 1,4-Benzoquinone Derivatives for Enhanced Bioelectrocatalysis by Fructose Dehydrogenase from *Gluconobacter Japonicus*: Towards Promising D-Fructose Biosensor Development, Electroanalysis, 32, 1005 – 1016 (2020).

### **Evolution and Statistics of Complex Systems.** Prof. B. Kaulakys. 2017–2021.

The burst and the inter-burst duration statistical analysis as one more test of long-range memory proposed and implemented with the limit order book data comparing it with other widely used estimators. Signatures of super diffusion in the Lithuanian parliamentary attendance data observed and explained by noisy voter model. We have also generalized the noisy voter model by taking into account supportive interactions. A control algorithm in order to change a sign of coupling strength for the weakly coupled limit cycle oscillators was developed.

### **Main publications:**

V. Gontis, Long-range memory test by the burst and inter-burst duration distribution, J. Stat. Mech. 2020: 093406 (2020).

A. Kononovičius. Noisy voter model for the anomalous diffusion of parliamentary presence. *J. Stat. Mech.* 2020: 063405 (2020).

### **National Research Projects**

Global Grant research project „**Stellar and exoplanet investigations in the context of the TESS and JWST space missions**” (No. 09.3.3-LMT-K-712-01-0103) Dr. habil. G. Tautvaišienė, 2018 – 2022.

We have observed all 302 bright ( $V < 8$  mag) and cooler than F5 spectral class stars in the northern TESS continuous viewing zone with a 1.65m telescope at the Molėtai Astronomical Observatory of Vilnius University and a high-resolution spectrograph. We uniformly determined the main atmospheric parameters, ages, orbital parameters, velocity components, and precise abundances of 24 chemical species and identified stars which may harbour rocky exoplanets. Another study was dedicated to Li, C, and O determination in a sample of 249 stars. We characterised exoplanets WASP-76b, WASP-33b, and high-frequency pulsation modes in young intermediate-mass stars.

#### **Main publications:**

Tautvaišienė, G., Mikolaitis, Š., Drazdauskas, A., Stonkutė, E., Minkevičiūtė, R., Kjeldsen, H., Brogaard, K., von Essen, C., Grundahl, F., Pakštienė, E., Bagdonas, V., & Vázquez, C. V., Chemical Composition of Bright Stars in the Continuous Viewing Zone of the TESS Space Mission, 2020, *Astrophysical Journal Supplement Series*, 248, 19.

Stonkutė, E., Chorniy, Y., Tautvaišienė, G., Drazdauskas, A., Minkevičiūtė, R., Mikolaitis, Š., Kjeldsen, H., von Essen, C., Pakštienė, E., & Bagdonas, V., High-resolution Spectroscopic Study of Dwarf Stars in the Northern Sky: Lithium, Carbon, and Oxygen Abundances, 2020, *Astronomical Journal*, 159, 90.

von Essen, C., Mallonn, M., Hermansen, S., Nixon, M. C., Madhusudhan, N., Kjeldsen, H., & Tautvaišienė, G., HST/STIS transmission spectrum of the ultra-hot Jupiter WASP-76 b confirms the presence of sodium in its atmosphere, 2020, *Astronomy and Astrophysics*, 637, A76.

Global Grant research project “**Quantum engineering in cold atomic gases**” (No. 09.3.3-LMT-K-712-01-0051). Prof. E. Anisimovas, 2018 – 2022.

Off-axis optical vortices were considered using the double-Raman singlet and doublet light-matter schemes. Novel schemes of quantum engineering by means of periodic resonant driving were developed. In particular, we showed that time and space crystalline structures can be combined together and even 6D time-space crystals can be realized in ultracold atomic systems. This opens possibilities for the research of condensed matter physics in dimensions higher than three.

#### **Main publications:**

H. R. Hamed, J. Ruseckas, E. Paspalakis, and G. Juzeliūnas, Off-axis optical vortices using double-Raman singlet and doublet light-matter schemes, *Phys. Rev. A* 101, 063828 (2020).

## International Research Projects

EC Horizon2020 project “**EUROPLANET2024 – Research Infrastructure**” (project No. 871149).  
Dr. Habil. G. Tautvaišienė. 2020 – 2023.

We were working within the work packages dedicated to on-ground observations and early careers training and education. The Europlanet Telescope Network was established and observations have been started. The Early Careers Training and Education Portal was launched, two splinter sessions have been organised during the Europlanet Science Congress as well as two presentations delivered.

### Main publications:

Scherf, M., Tautvaišienė, G., Hueso, R., Heward, A., Telescopes united, *Astronomy & Geophysics*, Volume 61, Issue 4, 2020, p. 4.39

Scherf, M., Snodgrass, C., Hueso, R., Tautvaišienė, G., Podlewska-Gaca, E., Colas, F., Sanchez-Lavega, A., Garate-Lopez, I., Dudziński, G., Bartczak, P., and Kargl, G.: The Europlanet Telescope Network: A global collaboration in support of planetary sciences, *Europlanet Science Congress 2020*, online, 21 September–9 Oct 2020, EPSC2020-313.

Lithuanian-Japanese project **Theoretical Studies of Structure and Properties of Heavy Elements Toward Identification of Gravitational Wave Sources** funded by Research Council of Lithuania (S-LJB-18-1). 2018–2020. Prof. dr. G. Gaigalas.

We performed radiative transfer simulations for blue kilonovae hours after neutron star mergers by performing detailed opacity calculations for the first time. We calculated atomic structures and opacities of highly ionized elements (up to the 10th ionization) with atomic number  $Z=20-56$ . We found out that the bound-bound transitions of heavy elements were the dominant source of the opacities in the early phase ( $t < 1$  day after the merger) and that the ions with a half-closed electron shell provided the highest contributions.

### Main publications:

G. Gaigalas, P. Rynkun, L. Radžiūtė, D. Kato, M. Tanaka, P. Jönsson, Energy level structure and transition data of Er(2+), *The Astrophysical Journal Supplement Series* 248, 13 (2020).

L. Radžiūtė, G. Gaigalas, D. Kato, P. Rynkun, M. Tanaka, Extended calculations of energy levels and transition rates for singly ionized lanthanide elements. I. Pr-Gd, *The Astrophysical Journal Supplement Series* 248, 17 (2020).

M. Tanaka, D. Kato, G. Gaigalas, K. Kyohei, Systematic Opacity Calculations for Kilonovae, *Monthly Notices of the Royal Astronomical Society* 496, 1369-1392 (2020).

Research group project **Optical Control of Ultracold atoms** funded by Research Council of Lithuania (S-MIP-20-36). 2020–2023. Prof. dr. G. Juzeliūnas.

The project started in March 2020. During the first 9 months of the project, the band structure of spinor optical lattices with subwave-length barriers were investigated using the tripod atom-light coupling scheme.

Research Council of Lithuania. **Polish – Lithuanian Black Hole hunt** (S-LL-19-2). Dr. M. Maskoliūnas. 2019 – 2021.

Within the framework of the project, the ground-based photometric follow-up observations “Gaia Alerts” (GA) objects with the telescopes of Molėtai astronomy observatory (MAO) have been carried out. The members of the project arranged the observation program and data analysis of each observation item. The 2020 campaign of MAO observations resulted in more than 400 measurement points, necessary for a drawing of 19 objects light curves.

#### **Main publications:**

Wyrzykowski, Ł.; Mróz, P.; Rybicki, K. A. and 182 more. Full orbital solution for the binary system in the northern Galactic disc microlensing event Gaia16aye, 2020, A&A, vol. 633, 98

Szegedi-Elek, E.; Ábrahám, P.; Wyrzykowski, L. And 59 more. Gaia 18dvy: a new FUor in the Cygnus OB3 association, 2020, ApJ, vol. 899, 130

Lithuanian Academy of Sciences. **Lithuanian cooperation with CERN**. Dr. A. Juodagalvis, since 2008. Project “Physics of subatomic particles in the CERN CMS experiment” (DaFi2019).

Activities at the Compact Muon Solenoid (CMS) experiment focused on the analysis of the Drell-Yan process at 13 TeV using the CMS  $pp$  data of 2016. The background estimation using data-driven methods required deeper studies. Participation in the LHC EW V-jets group started. The study of Grimus-Neufeld model was continued, higher precision of FlexibleSusy code generator pursued. Studies of  $W$  and  $W'$  decays started using the MadMiner analysis framework. Lepton flavor violation decays were studied in a two-Higgs-doublet model with the type-I seesaw mechanism.

#### **Main publications:**

CMS Muon group [from Lithuania: A. Juodagalvis], “Triple-GEM discharge probability studies at CHARM: simulations and experimental results”, JINST 15 (2020) P10013.

CMS Collaboration [from Lithuania: V. Dudenas, A. Juodagalvis, J. Vaitkus], “Measurement of the single top quark and antiquark production cross sections in the  $t$  channel and their ratio in proton-proton collisions at  $\sqrt{s}=13$  TeV”, Phys. Lett. B 800 (2020) 135042.

E. H. Aeikens, P. M. Ferreira, W. Grimus, D. Jurčiukonis, and L. Lavoura, “Radiative seesaw corrections and charged-lepton decays in a model with soft flavor violation”, accepted for publication in JHEP.

International programme **Gaia-ESO Spectroscopic Survey** (ESO project 188.B-3002). Dr. Habil. G. Tautvaišienė. 2012 – 2021.

We investigated universality of the age-chemical-clocks-metallicity relations in the Galactic disc, compared carbon abundances in the Galactic thin and thick discs, designed a new approach to chemically characterizing young open clusters, investigated lithium abundances in metal-rich open clusters of the Solar neighbourhood, characterized a chemical composition of the Li-rich giant in the globular cluster NGC 1261. Seven papers had been published in high impact journals.

### **Main publications:**

Randich, S., Pasquini, L., Franciosini, E., Magrini, L., Jackson, R. J., Jeffries, R. D., d'Orazi, V., Romano, D., Sanna, N., Tautvaišienė, G., Tsantaki, M., Wright, N. J., Gilmore, G., Bensby, T., Bragaglia, A., Pancino, E., Smiljanic, R., Bayo, A., Carraro, G., Gonneau, A., Hourihane, A., Morbidelli, L., & Worley, C. C., The Gaia-ESO Survey: Galactic evolution of lithium at high metallicity, 2020, *Astronomy and Astrophysics*, 640, L1.

Casali, G., Spina, L., Magrini, L., Karakas, A. I., Kobayashi, C., Casey, A. R., Feltzing, S., Van der Swaelmen, M., Tsantaki, M., Jofré, P., Bragaglia, A., Feuillet, D., Bensby, T., Biazzo, K., Gonneau, A., Tautvaišienė, G., Baratella, M., Roccatagliata, V., Pancino, E., Sousa, S., Adibekyan, V., Martell, S., Bayo, A., Jackson, R. J., Jeffries, R. D., Gilmore, G., Randich, S., Alfaro, E., Koposov, S. E., Korn, A. J., Recio-Blanco, A., Smiljanic, R., Franciosini, E., Hourihane, A., Monaco, L., Morbidelli, L., Sacco, G., Worley, C., & Zaggia, S., The Gaia-ESO survey: the non-universality of the age-chemical-clocks-metallicity relations in the Galactic disc, 2020, *Astronomy and Astrophysics*, 639, A127.

Baratella, M., D'Orazi, V., Carraro, G., Desidera, S., Randich, S., Magrini, L., Adibekyan, V., Smiljanic, R., Spina, L., Tsantaki, M., Tautvaišienė, G., Sousa, S. G., Jofré, P., Jiménez-Esteban, F. M., Delgado-Mena, E., Martell, S., Van der Swaelmen, M., Roccatagliata, V., Gilmore, G., Alfaro, E. J., Bayo, A., Bensby, T., Bragaglia, A., Franciosini, E., Gonneau, A., Heiter, U., Hourihane, A., Jeffries, R. D., Koposov, S. E., Morbidelli, L., Prisinzano, L., Sacco, G., Sbordone, L., Worley, C., Zaggia, S., & Lewis, J., The Gaia-ESO Survey: a new approach to chemically characterizing young open clusters. I. Stellar parameters, and iron-peak,  $\alpha$ -, and proton-capture elements, 2020, *Astronomy and Astrophysics*, 634, A34.

International programme **PLATO Science Management**. Prof. dr. A. Kučinskas. 2020 – 2027.

A long-term partnership has been established in late 2020 between the Stellar Atmosphere Physics (SAP) group at ITPA and the European Space Agency's science mission "PLATO" Science Management Work Package 120 "Stellar Science", with prof. dr. A. Kučinskas and dr. J. Klevas becoming the PLATO WP 120 official members. It is foreseen that the SAP group at ITPA will provide the PLATO Science Management consortium with a grid of 3D hydrodynamical model atmospheres of M-type dwarfs which, in cooperation with the PLATO consortium, will be used for the determination of 3D NLTE chemical abundances in the atmospheres of the PLATO target stars.

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

We used 27 days of photometry from the Transiting Exoplanet Survey Satellite to characterize solar-like oscillations in the G8 subgiant of the 94 Aqr triple system. The resulting stellar properties allowed us to probe the evolution of rotation and magnetic activity in the system. The asteroseismic age of the subgiant agrees with a stellar isochrone fit, but the rotation period is much shorter than expected from standard models of angular momentum evolution. The weakened magnetic braking may be needed to reproduce the stellar properties, and evolved subgiants in the hydrogen shell-burning phase can reinvigorate a large-scale dynamo action and briefly sustain magnetic activity cycles before ascending the red giant branch.

### **Main publications:**

Mackebrandt, F., Schuh, S., Silvotti, R., Kim, S.-L., Kilkeny, D., Green, E. M., Lutz, R., Nagel, T., Provencal, J. L., Otani, T., Oswald, T. D., Benatti, S., Lanteri, L., Bonanno, A., Frasca, A., Janulis, R., Pappalardo, M., Molnár, L., Claudi, R., & Østensen, R. H., The EXOTIME project: signals in the O-C diagrams of the rapidly pulsating subdwarfs DW Lyn, V1636 Ori, QQ Vir, and V541 Hya, 2020, *Astronomy & Astrophysics*, 638, A108.

National Science Foundation (USA). **“Fulfilling the Atomic Physics Needs for Spectral Diagnostics of Cosmic Chemical Evolution”**. Dr. R. Kisielius. 2020-2023.

R. Kisielius is a Principal co-investigator of the NSF project based on collaboration of the team from Vilnius University and astronomers from the University of South Carolina (USA). The work concentrates on producing of high-accuracy spectroscopic data needed for the astrophysical research and their accuracy establishment using modern astrophysical modelling codes.

COST Action CA16201 **“Unravelling new physics at the LHC through the precision frontier”** (ParticleFace) (<http://particleface.eu/>). Action Chair: Dr. German Rodrigo (Valencia, Spain) (24 countries). Dr. A. Juodagalvis, Management Committee Member. 2017 – 2021.

A. Juodagalvis and Th. Gajdosik participated in the working groups' and 4th management committee meeting in Krakow, Poland (February 11-13, 2020). The meeting triggered joining the CERN LHC EW V-jets group. Funding for the “Baltic school of High-Energy Physics and Accelerator Technologies 2020” (in August, in Riga, Latvia) was approved, but the event got cancelled. S. Draukšas participated in “PREFIT20: Precision effective field theory school” (March 2-13, DESY, Hamburg). ITPA researchers joined the application of the follow-up COST Action “European network for particle physics at the collider frontier.”

COST Action CA16117 **„Chemical Elements as Tracers of the Evolution of the Cosmos”** (ChETEC) ([http://www.cost.eu/COST\\_Actions/ca/ca11617](http://www.cost.eu/COST_Actions/ca/ca11617)). Action Chair: Dr. Raphael Hirschi, (England) (30 countries). Dr. A. Kučinskas, Managing Committee Member, Member of the project Core Group, Co-lead of the Working Group 3 (Astronomical Observations); dr. V. Dobrovolskas, substitute of the Managing Committee Member. 2017– 2021.

In the framework of this project, a ChETEC Working Group 3 “Astronomical Observations” meeting was planned to take place in Vilnius in spring 2020. Due to COVID-19, the meeting was postponed to spring/summer 2021. V. Dobrovolskas, J. Klevas, A. Kučinskas, R. Skorulskienė attended the ChETEC Period 4 Main Event international conference (2020 September 3-4, 117 participants, remote event). A. Kučinskas presented an invited talk on the current and future spectroscopic studies and 3D/1.5D modeling of radiative transfer that are being carried out under the umbrella of the ChETEC Action.

COST Action CA18104 „**Revealing the Milky Way with Gaia**” (ORIGINS) (<https://www.cost.eu/actions/CA18104>). Action Chair: Nicholas Walton) (28 countries). Dr. Š. Mikolaitis, Managing Committee Member, the leader of the Working Group 5. 2019–2023.

In the framework of this COST action, Carlos Viscasillas Vázquez and Markus Ambrosch attended the international school of CA18104 WG1 “The Milky Way as a Galaxy”, which was organized in Barcelona, Spain on 14-17 January 2020. Carlos Viscasillas Vázquez was awarded a research STSM visit to Arcetri observatory. Canceled because of pandemic. The WG5 workshop “Breaking Barriers: Inspiring the Next Generation” was planned to be co-organised in Santiago, Spain in March 2020. Canceled because of pandemic. The WG5 research summer school “Better Inclusion, Better Science: Building Impact in MW-GAIA” was planned to be organised in Vilnius on 10-12 August 2020. Canceled because of pandemic.

Research Council of Lithuania postdoctoral fellowship **Theoretical multipole interference study for gravitational wave sources** (Nr. 09.3.3-LMT-K-712-19-0080). Dr. L. Radžiūtė, supervisor Prof. Dr. G. Gaigalas, 2020 – 2022.

We have obtained accurate energy levels for the Se II and Te II ions using MCDHF and RCI methods. The accuracy of the results was evaluated comparing energy levels with the data from NIST database and that of other authors. The averaged uncertainty of computed energy levels compared with NIST data is 1.3% and 0.45%, respectively for Se II and Te II ions. Computation of transition properties and evaluation of it is in progress.

Research Council of Lithuania postdoctoral fellowship **Study of the Grimus-Neufeld model** (Nr. 09.3.3-LMT-K-712-19-0013). Dr. V. Dūdėnas, supervisor Assoc. Prof. Dr. Thomas Gajdosik, 2020 – 2022

We have investigated the theoretical constraints for the numerical study of the Grimus-Neufeld model with Flexible-SUSY program. We estimated the upper bound of the seesaw scale, under which the fine-tuning in the scalar sector of the model becomes unacceptable. We also estimated the lower bound of the seesaw scale, under which the Grimus-Lavoura approximation is applicable for neutrino mass calculations.

Research Council of Lithuania postdoctoral fellowship **Spatially inhomogeneous atom-light interaction phenomena** (Project No. 09.3.3-LMT-K-712-19-0031) Dr. Hamid R. Hamedi, supervisor dr. habil. G. Juzeliūnas, 2020 – 2022.

We have proposed a robust localization of the highly-excited Rydberg atoms interacting with doughnut-shaped optical vortices. Compared with the earlier standing-wave (SW)-based localization methods, a vortex beam can provide an ultraprecise two-dimensional localization solely in the zero-intensity center, within a confined excitation region down to the nanometer scale.

**Main publications:**

N. Jia, J. Qian, T. Kirova, G. Juzeliūnas and H. R. Hamedī, Optics Express Vol. 28, Issue 24, pp. 36936-36952 (2020).

Research Council of Lithuania postdoctoral fellowship **Physical modeling of order-book and opinion dynamics** (Nr. 09.3.3-LMT-K-712-02-0026). Dr. A. Kononovičius, supervisor dr. J. Ruseckas, 2017 – 2020.

We have observed signatures of super diffusion in the Lithuanian parliamentary attendance data. We have found that the noisy voter model would be able to explain ballistic diffusion. Though a minor modification, adding randomized observed states conditioned on the latent states, can be applied to also explain super diffusive behavior. We have also generalized the noisy voter model by taking into account supportive interactions. We have conducted thorough analysis of the phase portrait of the generalized model and shown that intensity of support has profound and non-trivial effect.

**Main publications:**

A. Kononovicius. Noisy voter model for the anomalous diffusion of parliamentary presence. Journal of Statistical Mechanics 2020: 063405 (2020).

A. Kononovicius. Supportive interactions in the noisy voter model. Under review.

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

Aarhus University (Denmark)

European Organization for Nuclear Research CERN (Switzerland)

Leibnitz Institute Potsdam, Potsdam (Germany)

Landessternwarte Heidelberg, University of Heidelberg, Heidelberg (Germany)

Max Planck Institute for Astronomy, Heidelberg (Germany)

Observatoire de Paris, CNRS, Université Paris Diderot (France)

Oslo University, Oslo (Norway)

Osservatorio Astronomico di Trieste, Trieste (Italy)

Uppsala University Observatory, Uppsala (Sweden)

Odessa National University, Odessa (Ukraine)

Center for Physical Sciences and Technology (Lithuania)

National Institute of Standards and Technology (USA)

Capital Normal University, Beijing (China)

University of Patras (Greece)

East China Normal University, Shanghai (China)

University of Chicago (USA)

Technical University of Berlin (Germany)

National Institute for Fusion Science (Japan)

National Tsing Hua University, Hsinchu (Taiwan)

Materials Science and Applied Mathematics, Malmö University, Malmö (Sweden)

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

University of Lisbon (Portugal)

University of South Carolina, Columbia (USA)

The Space Telescope Science Institute, Baltimore (USA)

Astronomical Observatory of the University of Warsaw (Poland)

Institute of Physics, Polish Academy of Sciences, Warsaw (Poland)

## **OTHER SCIENTIFIC ACTIVITIES**

### **Dr. A. Deltuva -**

- member of the International Faddeev medal committee.

### **Dr. V. Dobrovolskas -**

- member of the European Astronomical Society (EAS)
- member of the Lithuanian Astronomical Society (LAS)

### **Dr. A. Drazdauskas -**

- member of the International Astronomical Union (IAU).

### **Dr. K. Černis -**

- member of the International Astronomical Union (IAU).

### **Prof. Habil. Dr. G. Gaigalas -**

- council member of CompAS (The International collaboration on Computational Atomic Structure) group (<http://ddwap.mah.se/tsjoek/compas/>);
- editorial board member of the journal *Atoms*.

**Dr. V. Gontis –**

- member of the association of Euroscience, <http://www.euroscience.org/>
- council member of the Lithuanian Scientific Society;
- Academic editor of the journal “Plos One”.

**Dr. A. Juodagalvis –**

- contact person for the CMS outreach and communication in Lithuania, representing the Lithuanian Team at CERN CMS experiment (since 2015);
- Lithuanian representative in CERN Finance Committee (since 2018);
- member of the Council of Experimental nuclear and particle physics center at the Faculty of Physics of Vilnius University (since 2018);
- member of the Board of the Lithuanian Physics Society (since 2018), scientific secretary.

**Dr. R. Juršėnas –**

- member of the American Mathematical Society.

**Distinguished Professor G. Juzeliūnas –**

- True member of the Lithuanian Academy of Sciences;
- Board member of Atomic Molecular Physics and Optical Division (AMOPD) of European Physical Society (EPS);
- Associated member of the National Center for Theoretical Sciences at the National Tsing Hua University, Taiwan;
- Guest Editor of a Topical issue of the European Journal of Physics D:  
<https://epjd.epj.org/component/toc/?task=topic&id=1230>
- Academic editor of the journal “Plos One”;
- Member of Programme Committee of an Annual International Conference-School on Advanced Materials and Technologies (August 2020, Palanga, Lithuania).

**Dr. H. R. Hamedī –**

- Member of the Lithuanian Physics Society
- Member of Physics Society of Iran.

**Prof. B. Kaulakys –**

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

**Prof. R. Karazija –**

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

**Dr. A. Kynienė –**

- President of the Vilnius City Board of the Physics Teachers' Association;
- Member of the Vilnius City Physics Methodical Board;
- Team leader of Particle physics outreach group at the VU Experimental nuclear and particle physics centre;
- Chair of the Assessment of National Physics Maturity Examination Commission;
- Member of the Lithuanian Pupil Physics Olympiad Commission;
- Council member of the Lithuanian Scientific Society.

**Dr. J. Klevas –**

- Member of the International Astronomical Union (IAU);
- Member of the European Astronomical Society (EAS);
- Council member of the Lithuanian Astronomical Society;
- Council member of the Lithuanian Society of Young Researchers.

**Prof. A. Kučinskas –**

- Member of the Board of Directors of the International Journal "Astronomy and Astrophysics";
- Member of the Open Access Working group of the International Journal "Astronomy and Astrophysics";
- Editorial board member of the international journal "Odessa Astronomical Publications";
- National Contact Point of the International Astronomical Union (IAU), IAU member;

- National Representative at the European Astronomical Society (EAS), EAS member;
- President and Council member, Lithuanian Astronomical Society;
- Vice-chair of the Council of the Faculty of Physics, Vilnius University;
- Member of the Study Programme Committee of the Bachelor study programme “Physics” at the Faculty of Physics of Vilnius University;
- Member of the Study Programme Committee of the Master study programme “Theoretical Physics and Astrophysics” at the Faculty of Physics of Vilnius University
- Member of the Central Appellation Commission of the Senate of Vilnius University

**Dr. M. Maskoliūnas -**

- member of the International Astronomical Union (IAU).

**Dr. Š. Mikolaitis -**

- member of the International Astronomical Union (IAU);
- member of the European Astronomical Society.

**Dr. R. Minkevičiūtė -**

- member of the International Astronomical Union (IAU).

**Dr. D. Narbutis -**

- member of the International Astronomical Union (IAU).

**Prof. Dr. (HP) E. Norvaišas -**

- member of Institute of Physics (UK);
- member of the European Physics Society.

**Dr. E. Pakštienė -**

- member of the International Astronomical Union (IAU).

**Dr. L. Radžiūtė**

- member of CompAS (The International collaboration on Computational Atomic Structure) group (<http://ddwap.mah.se/tsjoek/compas/>).

**Dr. P. Rynkun**

- member of CompAS (The International collaboration on Computational Atomic Structure) group (<http://ddwap.mah.se/tsjoek/compas/>).

**Dr. J. Sperauskas -**

- member of the International Astronomical Union (IAU).

**Dr. E. Stonkutė -**

- member of the International Astronomical Union (IAU).
- member of the European Astronomical Society.

**Dr. R. Stonkutė -**

- member of the International Astronomical Union (IAU).

**Prof. V. Straizys -**

- 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;
- member of the European Astronomical Society.

**Assoc. prof. dr. Dalia Šatkovskienė -**

- Member of Administration Board (BoA) of European Platform of Women Scientists (EPWS, <https://epws.org/epws-general-assembly-2017/>);
- President of the regional Baltic States association BASNET Forumas (<https://www.basnetforumas.eu/>).
- Lithuanian Team leader of IUPAP working group on Women in Physics (WP5)
- Member of International Advisory Board (IAB) of EC HORIZON 2020 programme project BALTIC GENDER (<https://www.baltic-gender.eu/>)
- Represents Vilnius University at the European Physicists network GENERA <https://www.genera-network.eu/>

**Dr. J. Tamulienė -**

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

**Dr. Habil. G. Tautvaišienė –**

- Vice-President of [Commission H1 The Local Universe](#) (IAU);
- Organizing Committee Member of [Commission H1 The Local Universe](#) (IAU);
- Member of [Special Nominating Committee](#) (IAU);
- Vice-President of the Lithuanian Physics Society;
- member of the International Astronomical Union (IAU);
- IAU National Outreach Coordinator <https://www.iau.org/public/noc/>;
- founding member of the European Astronomical Society;
- editorial board member of the “Mol” journal <http://mol-en.scg.org.es/editorial-board>
- editor-in-chief of the annual astronomical almanac *Lietuvos dangus* (*Sky of Lithuania*).

**Prof. Dr. V. Vansevičius –**

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

**Dr. J. Zdanavičius –**

- member of the International Astronomical Union (IAU).

**BEST REPORTS DELIVERED AT CONFERENCES ABROAD**

G. Juzeliūnas. Geometric phases and spin-orbit coupling for periodically driven systems, Invited talk at the International Conference “Physics of Quantum Electronics PQE-2020”, Snowbird, USA, 5 – 10 January 2020.

V. Gontis, Spurious versus true long-range memory in social systems, Web Presentation of ECLT Representative Members and Fellows, September 18, 2020, <https://www.youtube.com/watch?v=j4cxkbWXZjw>

G. Tautvaišienė, Overview of the telescope facilities involved in the Europlanet Telescope Network, oral presentation at the Splinter Session “Europlanet Telescope Network” of the Europlanet Science Congress, September 23, 2020.

E. Stonkutė, Europlanet Mentorship Platform, oral presentation at the Splinter Session “Mentoring in the planetary science community” of the Europlanet Science Congress, October 1, 2020.

## **THE MOST IMPORTANT NATIONAL AND INTERNATIONAL AWARDS RECEIVED FOR R&D ACTIVITIES**

Young scientist scholarship “Effect of non-linearity on long-range memory properties of fractional Gaussian noise” (2020; duration: 12 months) awarded by the Lithuanian Academy of Sciences to A. Kononovičius.

## **MOST IMPORTANT CASES OF PARTICIPATION OF RESEARCHERS IN WORKING GROUPS OR COMMISSIONS SET UP BY STATE AUTHORITIES, STATE AND MUNICIPAL INSTITUTIONS, ORGANISATIONS, BUSINESS ENTITIES**

Prof. V. Vansevičius is a member of the Lithuanian Science Council.

Doc. A. Kynienė is the chair of the Assessment of National Physics Maturity Examination Commission.

## **CONSULTATIONS PROVIDED BY THE UNIT TO THE PUBLIC OR ECONOMIC ENTITIES**

Regular consultations for various Police departments concerning the astronomical conditions during the requested time periods when car accidents happened, dr. A. Kazlauskas.

Regular consultations for public concerning the unusual astronomical phenomena and stones found which are suspected to be of extraterrestrial origin, S. Lovčikas, V. Straižys, G. Tautvaišienė.

Regular consultations for schools in elementary particle physics, A. Kynienė, A. Acus, A. Juodagalvis, A. Mekys.

## **MOST IMPORTANT RESEARCH DISSEMINATION ACTIVITIES**

**Annual astronomical almanac** “Lietuvos dangus 2021“, published since 1989 (ISSN 1392-0987), 158 pages in Lithuanian.

In 2020 we have published 41 posts in the **Physics of Risk blog** written in English <http://rf.mokslasplius.lt/>. Majority of the posts contained a brief description of some model from econophysics or sociophysics along with an interactive implementation of the model.

**Science popularization book.** The Lithuanian Edition of the book “Marie Curie - Une femme dans son siècle” (Marija Kiuri. Moteris pralenkusi savo laiką”) written by Curie museum and Marion Augustin was translated and published in 2020 by BASNET Forumas association in collaboration with Vilnius University. The publication of Lithuanian edition was initiated and coordinated by the president of BASNET Forumas Assoc. Prof. Dr. Dalia Šatkovskienė. The book was presented to the public 9 of November 2020. The presentation of the book to the wide public was organized remotely using direct translation by “15 min” TV channel: <https://www.15min.lt/video/knygos-marija-kiuri-moteris-pralenkusi-savo-laika-lietuviskojo-leidimo-pristatymas-visuomenei-190382>

Video **Under One Sky: Astronomy around the World | Lithuania**, the video highlighting the 100 years anniversary of the IAU and providing a brief look at astronomy in Lithuania (created by: Kotryna Reimerytė, Egilė Petrauskytė, Ignas Kančys, Viktorija Zonytė, Šarūnas Mikolaitis, and Gražina Tautvaišienė). <https://www.youtube.com/watch?v=joC3rucGfUw>

Science popularization article by Prof. Gediminas Juzeliūnas at the Webpage of Lithuanian Academy of Sciences “**What are distinctive features of ultracold atomic gases**” (in Lithuanian), <http://www.lma.lt/news/952/38/Kuo-ypatingos-labai-saltos-atomu-dujos>