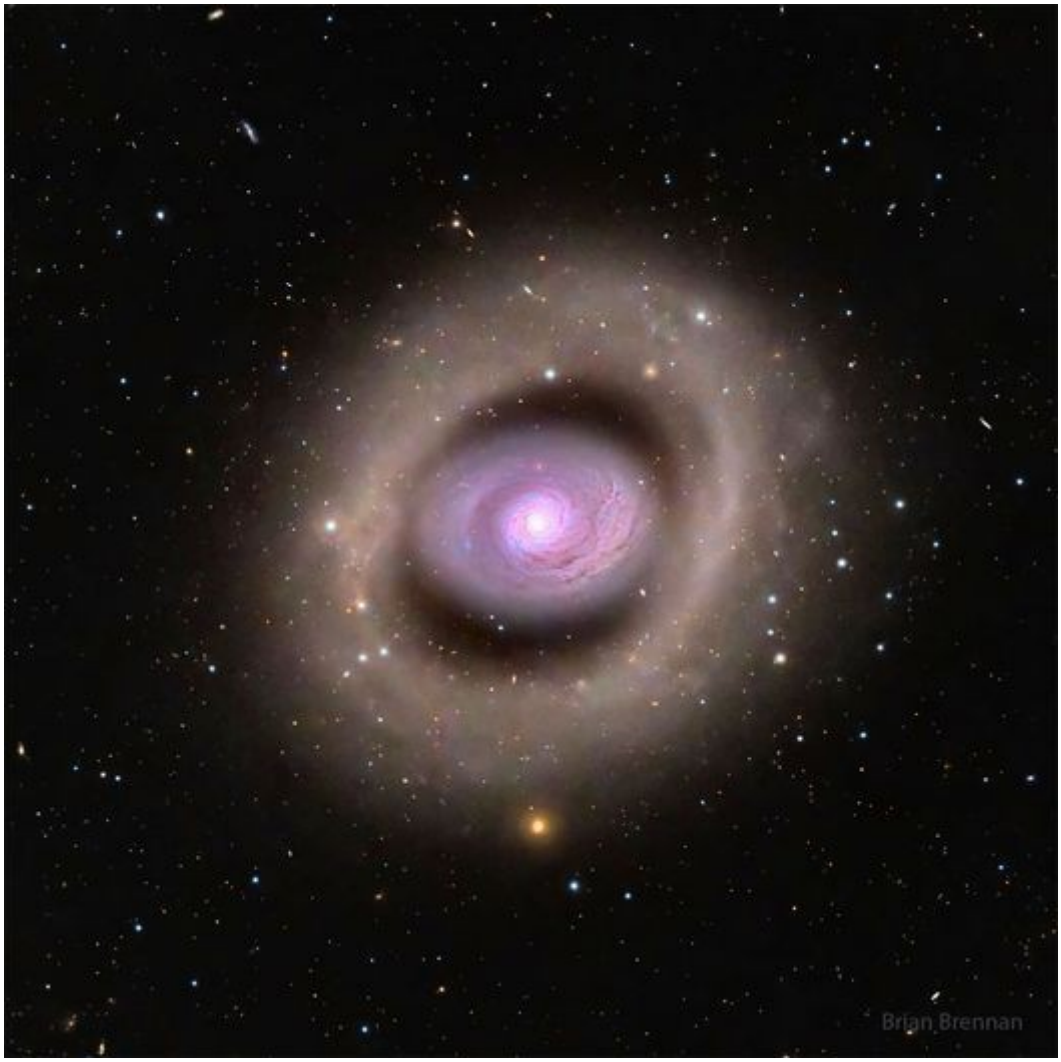
Research Center for Astronomy and Applied Mathematics
of the Academy of Athens

# ANNUAL REPORT 2023



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# Contents

The research scientific staff of KEAEM participated in the following research programs during 2023:

1. **Study of the dynamical evolution of quantum system entanglement and coherence"** (2018-2023). (G. Contopoulos, Ch. Efthymiopoulos, Ath. Tzemos). (Non-funded).

   - Publications in peer-reviewed journals: **2**", **3**", and **4**".
   - Publications in peer-reviewed conference proceedings: "**7**".
   - Talks: **AT-1, AT-2**.

2. **Dissemination of Galactic Dynamics Results"** (15/6/2023-31/12/2024). A program managed by the Research Committee of the Academy of Athens (200/1006), fully funded by the European Astronomical Society (EAS) through the "Wilhelm and Else Heraeus" foundation with a total budget of €40,000. The program aims to organize the conference HERA24: The Nature and the Dynamics of Structures Observed in Galactic Disks," targeting young scientists, scheduled to take place from September 15-20, 2024, at the Academy of Athens. Scientific Supervisor: P. Patsis. Results:

   - The conference organization is in progress: (http://astro.academyofathens.gr/hera24.html)

3. **Numerical investigation of the impact of complex instability on the phase space structure of dynamical systems with emphasis on barred galaxy models"**. (P. Patsis, M. Katsanikas, KEAEM, I. Skokos, H. Moges, University of Cape Town, Cape Town, South Africa, M. Hillebrand, Max Planck Institute for the Physics of Complex Systems, Germany) (2019-2024). The program is funded by the University of Cape Town, supporting visits by Mr. Skokos and Mr. Hillebrand to KEAEM for collaborations within the program.

   - Publications in peer-reviewed journals: One paper has been submitted for publication.
   - Publications in peer-reviewed conference proceedings: **1**", "**2**".
   - Talks: **PP-2**.
   - Exchange visits: Visit of H. Moges to KEAEM (May-June).

4. **"Gas flow in the centers of galaxies"** (2023-). A KEAEM program in collaboration with the Max-Planck-Institut für Extraterrestrische Physik (MPE), Max-Planck-Institut für Astrophysik (MPA), Munich, Germany, and the Laboratoire d'Astrophysique de Marseille (LAM), Aix-Marseille University, Marseille, France (P. Patsis, S. Pastras, MPE, T. Naab, MPA, E. Athanassoula, LAM). The MPE supports travel and accommodation for researchers collaborating on the program.

- Publications in peer-reviewed journals: One paper has been submitted for publication.
- Talks: **PP-2, PP-4**.
- Exchange visits: Visit of P. Patsis to MPA, Munich, for program needs (April 9-30).

5. **"N-body simulations of galactic disks - The relation between observed spiral disk morphologies and the dynamical properties of DM halos"**. (P. Patsis, T. Naab, Max-Planck-Institut für Astrophysik, Germany, P. Grosbol, European Southern Observatory, Munich, Germany). The Max-Planck-Institut für Astrophysik supports visits by Mr. Patsis to Garching and provides computational time at the RZG Computing Center in Garching, Germany, for N-body model numerical simulations.

   - Publications in peer-reviewed journals: One paper is under preparation.
   - Exchange visits: Visit of P. Patsis to MPA, Munich, for program needs (April 9-30). Computational work conducted at the RZG Computing Center.

6. **Morphological features of disk galaxies due to nonlinear phenomena"** (P. Patsis, M. Xilouris, and I. Alikakos, National Observatory of Athens (IAADET)). (Non-funded).

   - Publications in peer-reviewed journals: One paper is in progress.
   - Observing time allocated at the Aristarchos" telescope (2.3 m) on Helmos (September 16-18 and October 13-15).

7. **Star forming sites and global dynamics of galactic disks"** (P. Patsis, P. Papadopoulos (AUTH)). (Non-funded).

   - Publications in peer-reviewed journals:**39**".

8. **"Study of current sheets and high-energy radiation from compact astrophysical objects"** (2023-2026). (I. Dimitropoulos, I. Contopoulos). Program for the doctoral dissertation of Mr. I. Dimitropoulos funded by ELIDEK. Duration: 3 years. Total budget: €31,500.

9. **"500,000 CPU hours on the ARIS HPC"**. Principal Program Investigator: K. Gourgouliatos (University of Patras). Co-Investigator: I. Contopoulos.

10. **The nature of dark energy"** (2011-2018, but publications with research results from the program continue). A program to study the nature of dark energy. It is a collaboration between several universities: S. Vasilakos, M. Plionis (AUTH), J. Sola (University of Barcelona, Spain), S. Capozziello (University of Naples, Italy), A. Lima (University of Sao Paulo, Brazil), and N. Mavromatos (King's College, University of London, UK). Financially supported by the universities of Barcelona, Naples, and Sao Paulo.

- Publications in peer-reviewed journals: **9",10",11",12", 13","14"**.

11. **"ESA / Space Weather Expert Service Network (SWESNET) (2015 - )"**. A program by the European Space Agency (ESA), coordinated by the Royal Belgian Institute of Space Aeronomy, Belgium.

# Publications in 2023

### Special Editions

1. Mr. P.A. Patsis edited the publication of the detailed annual report of the Center for 2022, in a special issue.

2. Mr. M.K. Georgoulis co-edited the special volume titled "Helicities in Geophysics, Astrophysics, and Beyond" (Eds. Kuzanyan, K., Yokoi, N., Georgoulis, M. K. and Stepanov, R.), American Geophysical Union (AGU) Publications, Wiley, December 2023.

### Publications in International Journals with Referees

(Published or accepted for publication in 2023 (39 papers in total))

1. Contopoulos G. and Harsoula M., 2023, "Periodic orbits near a Yang-Mills potential", Phys. Scr. 98, 085203.

2. Tzemos A.C. and Contopoulos G., 2023, "Order, Chaos and Born's Distribution of Bohmian Particles", Particles 6, 923.

3. Tzemos A.C. and Contopoulos G., 2023, "Unstable Points, Ergodicity and Born's Rule in 2d Bohmian Systems", Entropy 25, 1089.

4. Tzemos A.C. and Contopoulos G., 2023, "Chaos and ergodicity in a partially integrable 3d Bohmian system: a comparison with 2d systems", Phys. Scr. 98, 065223.

5. Contopoulos I., Tzemos A.C., Zanias F. and Contopoulos G., 2023, "Interference with Non-Interacting Free Particles and a Special Type of Detectors", Particles 6, 121.

6. Contopoulos I., Kazanas D. and Papadopoulos D. V., 2023, "Gravitational Waves from the Pulsar Magnetosphere", Mon. Not. R. Astron. Soc. (in press).

7. Contopoulos, I., Ntotsikas, D. and Gourgouliatos K. N., 2023, "On the pulsar Y-point»", Mon. Not. R. Astron. Soc., 527L, 127.

8. Ntotsikas D., Gourgouliatos K. N., Lander S. K. and Contopoulos I., 2023, "Twisted Magnetar Magnetospheres", Mon. Not. R. Astron. Soc. (in press).

9. Asimakis, P., Basilakos S., Lymperis A., Petronikolou M. and Saridakis E. N., 2023, "Modified gravity and cosmology with nonminimal direct or derivative coupling between matter and the Einstein tensor", Phys. Rev. D. 107, 084010 .

10. Papanikolaou T., Tzerefos C., Basilakos S., Saridakis E., 2023, "No constraints for f(T) gravity from gravitational waves induced from primordial black hole fluctuations", European Phys. J. C 83, 31.

11. Papanikolaou T., Tzerefos, C., Basilakos S. and Saridakis E., 2023, "No constraints for f(T) gravity from gravitational waves induced from primordial black hole fluctuations'', 2023, Eur. Phys. J. C 83, 58.

12. Papageorgiou A., Plionis M., Basilakos S. and Abdullah H.M., 2023, "The cluster mass function and the 8 tension'', Mon. Not. R. Astron. Soc. (in press).

13. Anagnostopoulos F., Gakis V., Saridakis E. and Basilakos S., 2023, "New models and big bang nucleosynthesis constraints in f(Q) gravity ", Eur. Phys. J. C 83, 58.

14. Saridakis E. et al. (including Basilakos S.), 2023, "Observational constraints on soft dark energy and soft dark matter: Challenging ΛCDM cosmology", Nucl. Phys. 986, 116042.

15. Georgoulis M. K. et al., 2023, "Prediction of Solar Energetic Events Impacting Space Weather Conditions", Adv. Space Res. (in press).

16. Liokati E., Nindos A. and Georgoulis M. K., 2023, "Magnetic Helicity and Free Magnetic Energy as Tools to Probe Eruptions in two Differently Evolving Solar Active Regions", Astron. Astrophys. 672, A3.

17. Liu. Y. et al. (including Georgoulis M.K.), 2023, " Changes of Magnetic Energy and Helicity in Solar Active Regions from Major Flares", Astrophys. J. 942, 27.

18. Ji A. et al. (including Georgoulis M.K.), 2023, "A Systematic Magnetic Polarity Inversion Lines Dataset from SDO/HMI Magnetograms", Astrophys. J. Suppl. Series 265, 28.

19. Poduval B. et al. (including Georgoulis M.K.), 2023, "AI-ready Data in Solar Physics and Space Science: Concerns, Mitigations and Recommendations", Front. Astron. Space Sci. 10, 1203598.

20. Gontikakis C., Antiochos S. and Young P., 2023, "The Transition region of solar flare loops", Astrophys. J. 943, 120.

21. Harsoula M. and Tzemos A.C., “The Building Blocks of the Spiral Arms in Galaxies”, J. Vib. Test. Syst. Dyn. (in press).

22. Legnaro E., Efthymiopoulos C. and Harsoula M., 2023, “Semi-analytical estimates for the chaotic diffusion in the Second Fundamental Model of Resonance. Application to Earth’s navigation satellites”, Phys. D 456, 133946.

23. Katsanikas M. and Wiggins S., 2023, “The Generalization of the Periodic Orbit Dividing Surface for Hamiltonian Systems with Three or more Degrees of Freedom - III”, Int. Journal Bif. Chaos 33, 2350088.

24. Katsanikas M. and Wiggins S., 2023, “The Generalization of the Periodic Orbit Dividing Surface for Hamiltonian Systems with Three or more Degrees of Freedom - IV”, Int. Journal. Bif. Chaos 33, 2330020.

25. Katsanikas M. and Wiggins S., 2023, ”2D Generating surfaces and Dividing surfaces in Hamiltonian systems with three degrees of freedom”, Int. J. Bif. Chaos (in press).

26. Katsanikas M. and Wiggins S., 2023, ”3D Generating surfaces in Hamiltonian systems with three degrees of freedom - I”, Int. J. Bif. Chaos (in press).

27. Katsanikas M. and Wiggins S., 2023, “3D Generating surfaces in Hamiltonian systems with three degrees of freedom - II”, Int. J. Bif. Chaos (in press).

28. Katsanikas M., Hillebrand M., Skokos Ch. and Wiggins S., 2023, “A new type of dynamical matching in an asymmetric Caldera potential energy surface”, Chem. Phys. Lett. 811, 140208.

29. Wiggins S. and Katsanikas M., 2023, “Dynamical Matching in a. three-dimensional Caldera potential-energy surface”, Phys. Rev. E 108, 014206.

30. Hillebrand M., Katsanikas M., Wiggins S. and Skokos Ch., 2023, “Navigating Phase Space Transport with the origin-fate map”, Phys. Rev. E 108, 024211.

31. Zimper S., Ngapasare A., Hillebrand M., Katsanikas M., Wiggins S. and Skokos Ch., 2023, “Performance of chaos diagnostics based on Lagrangian descriptors. Application to the 4D standard map”, Phys. D 453, 133833.

32. Akiyama K. et al. (including Nathanail A.), 2023, “First M87 Event Horizon Telescope Results. IX. Detection of Near-horizon Circular Polarization”, Astrophys. J. Lett. 957 (2), id.L20, 42.

33. Roelofs F. et al. (including Nathanail A.), 2023, “Polarimetric Geometric Modeling for mm-VLBI Observations of Black Holes”, Astrophys. J. Lett. 957 (2), id.L21, 39.

34. Kotaro M. et al. (including Nathanail A.), "Future Prospects for Constraining Black-Hole Spacetime: Horizon-scale Variability of Astrophysical Jet", Mon. Not. R. Astron. Soc. (in press).

35. Torne P. et al. (including Nathanail A.), 2023, "A Search for Pulsars around Sgr A* in the First Event Horizon Telescope Data Set", Astrophys. J. 959 (1), id.14, 27.

36. Mpiskentzis V. et al. (including Nathanail A.), 2023, "Impact of anisotropic ejecta on jet dynamics and afterglow emission in binary neutron-star mergers", Mon. Not. R. Astron. Soc. 527 (3), 9159.

37. Legnaro E. and Efthymiopoulos C., 2023, "A detailed dynamical model for inclination-only dependent lunisolar resonances. Effect on the "eccentricity growth" mechanism", Adv. Space Res. 72, 2460.

38. Sakkas A. et al. (including Tritakis V.), 2023, "A Frequency-Selective Reconfigurable Antenna for Wireless Applications in the S and C Bands", Sensors 23, 8912.

39. Sun Y. et al. (including P. Papadopoulos), 2023, "An improved method to measure 12C/13 and 14N/15N abundance ratios: revisiting CN isotopologues in the Galactic outer disc", Mon. Not. R. Astron. Soc. (in press).

**Publications in conference proceedings and other publications with referees:**

1. Patsis P.A., 2023, "The orbital content of bars", in the proceedings of the conference "Galactic bars: driving and decoding galaxy evolution 3 - 7 July, 2023", held 3-7 July, 2023 in Granada, Spain. Online at http://www.galacticbars2023.com, id.29. DOI 10.5281/zenodo.8127724

2. Patsis P.A., 2023, "Nonlinear Phenomena Shaping the Structure of Spiral Galaxies", in "Chaos, Fractals and Complexity", Springer Proceedings in Complexity, T. Bountis et al. (eds), pp 37-46. Proceedings of the Conference "Dynamical Systems and Complexity", Chania, Crete, 18-26 July 2022.

3. Pandey C. et al. (including Georgoulis M. K.), 2023, "Explainable Deep Learning-based Solar Flare Prediction with post hoc Attention for Operational Forecasting", Discovery Science, (Bifet, A., Lorena, A. C., Ribeiro, R., P., Gama, J. and Abreu, P. H., Editors), LNCS 14276, 567.

4. Ji A. et al. (including Georgoulis M. K.), 2023, "Towards Multi-Instrument Interoperability for Solar Magnetograms in Space Weather Analytics", ICCS (International Conference on Computational Science) (in press).

5. Harsoula M., 2023, "The building blocks of spiral arms in galaxies", in "Chaos, Fractals and Complexity," Springer Proceedings in Complexity, T. Bountis et al. (eds), pp 37-46. Proceedings of the Conference "Dynamical Systems and Complexity", Chania, Crete, 18-26 July 2022.

6. Katsanikas M. and Wiggins S., 2023, "Phase Space Transport and Dynamical Matching in a Caldera-Type Hamiltonian System", in "Chaos, Fractals and Complexity," Springer Proceedings in Complexity, T. Bountis et al. (eds), pp 47-56. Proceedings of the Conference "Dynamical Systems and Complexity", Chania, Crete, 18-26 July 2022.

7. Tzemos A.C., 2023, "Ordered and Chaotic Bohmian Trajectories", in "Chaos, Fractals and Complexity," Springer Proceedings in Complexity, T. Bountis et al. (eds), pp 71-82 Proceedings of the Conference "Dynamical Systems and Complexity", Chania, Crete, 18-26 July 2022.

8. Tzemos A.C. and Contopoulos G., 2023, "Critical points and trajectories of the Bohmian quantum flow", Maple Trans. 3, Article 15546.

**Publications in conference proceedings and other publications without referees:**

1. Contopoulos G., 2023, "Developments of the third integral", Hipparchos 3 (6), 4.

2. Raouafi N. E. et al. (incl. Georgoulis, M. K.), 2023, "Firefly: Enabling a Holistic View of the Sun and its Environment", A White Paper to the Decadal Survey for Solar and Space Physics (Heliophysics) 2024-2033, NASA Technical Report 20220013327.

# Distinctions

1. Mr. **S. Vasilakos** Adjunct Professor (2022-2024) at the European University Cyprus.

2. Mr. **M.K. Georgoulis** was elected as an associate member of the International Academy of Astronautics (IAA) in July 2023.

   He also received an honorary commemorative plaque from the Department of Turkish Studies and Modern Asian Studies of the National and Kapodistrian University of Athens, following his invited participation in a seminar titled "Management of Security Issues through the Use of Satellite Systems in the Greece-Cyprus-Turkey

and Broader Middle East Complex," on July 5, 2023. His presentation was titled "Risks of Performance Degradation or Loss of Satellite Systems Due to Space Weather Outbursts."

3. Article 23 (**Legnaro E., Efthymiopoulos C. and Harsoula M.**) was selected for the "Best Researcher Award" at the "International Research Awards for New Scientific Inventions."

4. Mr. **M. Katsanikas** had a paper (number 24, p. 12) in the journal International Journal of Bifurcation and Chaos, which was classified as "distinguished."

# Participation in Conferences and Talks

## P. Patsis

PP-1. Invited talk at the Max-Planck Institute for Astronomy, Munich, Germany titled "Comparing stellar and gaseous flows in disk galaxies" (28 April).

PP-2. Invited talk at the summer school-conference "Dynamical Systems and Complexity" organized by the Complex Systems and Applications Network (COSA-Net) of the National Center for Scientific Research "Demokritos" with the topic: "Order and Chaos in galactic bars: Utilizing nonlinear dynamics to elucidate galactic morphologies" (18 July). Also chaired the session on 21 July.

PP-3. Member of the Scientific Organizing Committee (SOC) of the conference "Galactic Bars: Driving and Decoding Galaxy Evolution", 3-7 July, 2023 Granada, Spain. Talk titled: "The orbital content of bars" (4 July). Also chaired the session on 3 July.

PP-4. Talk at the conference of the Hellenic Astronomical Society (HEL.AS.S.) titled "The gas inflow in the central kiloparsec of galactic bars" (26-28 June).

## I. Contopoulos

IK-1. Invited talk at the Colloquium, Department of Physics, University of Crete, titled "Quantum Mechanics: reality or an illusion of our detectors?" (23 March).

IK-2. Talk at the 10th Microquasars Workshop, Crete, titled "Generation and Transport of Magnetic Flux in Accretion-Ejection Flows" (22-26 May).

IK-3. Talk at the 16th Greek Astronomy Conference of the Hellenic Astronomical Society, Athens, titled "Novel Features of the Pulsar Magnetosphere" (25-30 June).

IK-4. Invited talk at the Christian Union of Scientists, Athens, titled "Artificial General Intelligence: the new challenge of humanity" (23 September).

IK-5. Invited talk at the conference "Physics Enchants..." of the Union of Greek Physicists, University of Western Attica, titled "Artificial General Intelligence: challenges and risks" (8 December).

IK-6. Invited talk at the Christian Union of Larissa, Larissa, titled "Artificial General Intelligence: challenges and opportunities" (10 December).

IK-7. Invited talk at the Department of Physics, University of Patras, Patras, titled "Machine Learning in the study of Pulsars" (12 December).

## M. Georgoulis

MG-1. Talk at the International Workshop on Machine Learning and Computer Vision in Heliophysics, Sofia, Bulgaria, titled "Benchmark Datasets for Solar Weather Forecasting Applications" (19-21 April).

MG-2. Invited keynote talk at the MIDA Flare Forecasting Workshop, Turin, Italy, titled "The EU/FLARECAST Project: True Progress in Solar Flare Prediction, or a Shot in the Dark?" (22-23 May, online).

MG-3. Invited talk at the 16th Conference of the Hellenic Astronomical Society, Athens, titled "Fundamental Understanding and Forecasting of Solar Energetic Events" (26-28 June).

MG-4. Invited talk at the conference on Security Issues Management using Satellite Systems in the Greece-Cyprus-Turkey and Greater Middle East Complex, War Museum, Athens, titled "Risks of performance degradation or loss of satellite systems due to space weather events" (5 July 2023, online).

MG-5. Invited talk at the International Union of Geology and Geophysics (IUGG) / International Association of Geomagnetism and Aeronomy (IAGA) 2023 Conference, Berlin, Germany, titled

MG-5a "From Understanding to Predicting Solar Eruptions: a New, Potentially Shifting Landscape Ahead".

Additionally, a talk titled

MG-5b "How Quantitative Diagnostics Meaningfully Enhance the Level of Complexity in the Interpretation of Solar Eruptions" (11-20 July).

MG-6. Invited talk at the 2023 Workshop on Machine Learning, Data Mining, and Data Assimilation in Geospace, Johns Hopkins University APL, titled "Existing Benchmark Datasets for Next-Generation Solar Weather Prediction Efforts and Future Mission Planning" (1-24 August, online).

MG-7. Two invited talks at the 19th European Space Weather Week (ESWW2023), Toulouse, France, titled

MG-7a "Prediction of Solar Energetic Events Impacting Space Weather Conditions" and

MG-7b "Solar Flare Prediction: Attempting a Current Snapshot of the State of the Science".

Additionally, two invited panel discussions on thematic meetings, titled

MG-7c "How to best combine Multi-Instrument Observations and Modeling to Realistically Estimate the Intrinsic Properties of CMEs?" and

MG-7d "Present and Future of Hybrid Physics-Data-Driven Approaches in Space Weather Forecasting Applications" (20-24 November).

MG-8. Poster presentation at the 2023 Fall Meeting of the American Geophysical Union, San Francisco, California, USA, titled "ML-Ready Benchmark Datasets for Predicting Solar Flares and Eruptions" (11-15 December).

## K. Gontikakis

KG-1. Poster presentation at the conference of the Hellenic Astronomical Society, Athens, with M.K. Georgoulis and I. Kontogiannis, titled "Study of the evolution of hot plasma emission before flares and CMEs" (25-28 June).

KG-2. Oral presentation at the international conference on Statistical Mechanics, Chania, with S. Antiochos and P.R. Young, titled "Emission measure analysis of the transition region of solar flare structures" (10-14 July).

## M. Katsanikas

MK-1. Invited talk at the summer school-conference "Dynamical Systems and Complexity" organized by the Complex Systems and Applications Network (COSA-Net) of the National Center for Scientific Research "Demokritos" with the topic: "Pitchfork Bifurcations and Dynamical Matching in a Caldera-type Hamiltonian System" (17-26 July).

## A. Nathanail

AN-1. Participation in the 16th conference of the Hellenic Astronomical Society, Athens (June).

AN-2. Talk at the conference ARGOS: Science Priorities for a European Wide-Field Radio Interferometer Hybrid Community Workshop, Crete (24-27 October).

AN-3. Invited Talk at the National Observatory of Athens, (8 November).

AN-4. Invited Talk at the conference Fundamental Physics at the Galactic Centre Workshop, Porto Portugal (December).

### A. Tzemos

AT-1. Invited talk at the summer school-conference "Dynamical Systems and Complexity" organized by the Complex Systems and Applications Network (COSA-Net) of the National Center for Scientific Research "Demokritos" with the title "Introduction to Bohmian Quantum Chaos" (17-26 July).

AT-2. Talk at the Maple Conference 2023, Waterloo Canada, with the title "Approximate Integrals of Motion in Time Periodic Hamiltonian Systems: A Study with Maple'' (26-27 September, online).

## Organisation of Conferences and Meetings

1. PP-1. Mr. P. Patsis is the President of the Scientific and Local Organizing Committee of the conference "HERA24: The Nature and the Dynamics of Structures Observed in Galactic Disks" aimed at young scientists, which will take place from September 15-20, 2024, at the Academy of Athens. The program is funded by the European Astronomical Society (EAS) through the "Wilhelm and Else Heraeus" foundation.

2. SB-1. Mr. Vasilakos was a member of the organizing committee of the international Cosmology conference, "Tensions in Cosmology", in Corfu in September 2023, with the participation of many prominent scientists.

3. Mr. M. Georgoulis was

   - MG-1 Member of the Scientific Organizing Committee, International Workshop on Machine Learning and Computer Vision in Heliophysics, Sofia, Bulgaria, April 19-21.
   - MG-2 Head of the Scientific Organizing Committee, IUGG/IAGA Symposium A17, titled "Interplanetary Shocks, Particle Acceleration and Transport in Solar and Heliospheric Physics", IUGG/IAGA Conference 2023, Berlin, Germany, July 16.

   Mr. Nathanael was

   - AN-1 Member of the organizing committee of the conference of the Hellenic Astronomical Society, Athens, June 2023.

# Seminars

RCAAM, aiming at the continuous effort of informing both researchers and postgraduate students on contemporary research topics in the field of Astronomy-Astrophysics and nonlinear dynamical systems, organizes weekly seminars. Often, researchers from foreign institutions are funded by their institutes to come and speak at RCAAM seminars and interact with our center's researchers. In 2023, 18 seminars were held at the Center, covering topics in Astronomy, Astrophysics, and nonlinear Dynamics. In addition to the researchers and postgraduate students of the Center, the seminars also featured academics, professors, and distinguished scientists from various Universities and Research Centers from Greece and abroad.

Furthermore, in 2023, 30 seminars were held at RCAAM by students from the Physics Departments of the University of Athens and the University of Patras, focusing on high-energy Astrophysics/Magnetohydrodynamics, under the supervision of Professors I. Contopoulos and A. Nathanail.

The following is the list of seminars.

SPEAKER TABLE 2023

| | | |
|---|---|---|
| **Tasos Bountis**<br>University of Patras | Long range interactions enhance stability in 1-D Hamiltonian lattices | 10/1/2023 |
| **Thanasis Tzemos**<br>RCAAM Academy of Athens | Ergodicity and Born's rule in multiqubit Bohmian systems | 31/1/2023 |
| **Merce Romero Gomez**<br>University of Barcelona | Dynamics with Gaia in the Magellanic Clouds | 9/3/2023 |
| **Peter Erwin**<br>Max Planck Institute for Astrophysics | Composite Bulges: A Partial Zoology of Beasts that Live at Centers of Galaxy Disks | 28/3/2023 |
| **Emmanouil Floratos**<br>Academy of Athens | Arnol'd cat map lattices | 4/4/2023 |
| **Mattia Sormani**<br>University of Heidelberg | The Galactic centre: structure, dynamics and star formation | 9/5/2023 |

SPEAKER TABLE 2023

| | | |
|---|---|---|
| **Kostas Dialynas**<br>Space Research and Technology Office<br>Academy of Athens | The science of large scale heliosphere and missions that made it possible | 16/5/2023 |
| **Konstantina Founta**<br>University of Thessaly | Modelling and simulating a combat: Battle of Salamis | 23/5/2023 |
| **Dimitrios Christodoulou**<br>University of Massachusetts | A Compendium of Research Projects from the Past Year | 20/6/2023 |
| **Haris Skokos**<br>University of Cape Town | Numerical approaches for investigating the chaotic behavior of multidimensional Hamiltonian systems | 29/6/2023 |
| **Merak Opher**<br>Boston University | The Heliosphere, a case of a Habitable Astrosphere | 11/7/2023 |
| **Shunsuke Hozumi**<br>Shiga University | The origin of the bar properties generated by the bar instability in flat stellar disks | 24/10/2023 |
| **Martin Bureau**<br>University of Oxford | Probing the Invisible: Weighing Supermassive Black Holes with ALMA | 31/10/2023 |
| **Jairo Méndez Abreu**<br>University de la Laguna | The barred galaxy population in the distant Universe | 7/11/2023 |
| **Sophia Stuber**<br>Max Planck Institute for Astronomy | Molecular Gas Morphologies in Nearby Main Sequence Galaxies from PHANGS | 21/11/2023 |
| **Johan Knapen**<br>Institute of Astrophysics Canary Islands | Uncovering galaxy history through deep imaging and machine learning | 28/11/2023 |
| **George Korkidis**<br>University of Crete | A new probe of Cosmology | 12/12/2023 |
| **Ioannis Contopoulos**<br>RCAAM<br>Academy of Athens | Artificial General Intelligence: Challenges and Opportunities | 19/12/2023 |

SPEAKER TABLE AT ASTROPHYSICS/MAGNETOHYDRODYNAMICS SEMINARS 2023

| | | |
|---|---|---|
| **Elena Antonopoulou** University of Athens | Modeling the Flares of Sagittarius A* via Magnetic Reconnection Phenomena | 12/1/2023 |
| **Vasilis Bisketzis** University of Athens | Magnetic Flux Explosions in MAD Accretion Flows | 20/1/2023 |
| **Iasonas Psomas** University of Athens | Numerical Relativity Simulations for Neutron Star Mergers | 27/1/2023 |
| **Ioannis Dimitropoulos** University of Patras | GRMHD Simulations of Accretion onto Neutron Stars | 3/2/2023 |
| **Elena Antonopoulou** University of Athens | Investigating the Flares of Sagittarius A* in X-rays | 10/2/2023 |
| **Vasilis Bisketzis** University of Athens | A Time-Independent Model for Gaps in Magnetospheres of Rotating Black Holes | 17/2/2023 |
| **Iasonas Psomas** University of Athens | Study of Neutron Star Mergers | 24/2/2023 |
| **Ioannis Dimitropoulos** University of Patras | Accretion onto Black Holes | 3/3/2023 |
| **Argyris Loulis** University of Athens | Energy Extraction Mechanisms from Black Hole Magnetospheres | 10/3/2023 |
| **Elena Antonopoulou** University of Athens | Connecting Polarimetric Observations of Black Holes with Accretion Models via Machine Learning | 17/3/2023 |
| **Vasilis Bisketzis** University of Athens | The Role of Surface Magnetic Fields in Neutron Star Mergers | 24/3/2023 |
| **Iasonas Psomas** University of Athens | Mass Ejection and Nucleosynthesis in Neutron Star Mergers | 31/3/2023 |

SPEAKER TABLE AT ASTROPHYSICS/MAGNETOHYDRODYNAMICS SEMINARS 2023

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|---|---|---|
| **Ioannis Dimitropoulos** University of Patras | Gamma-ray Emission in Pulsars | 7/4/2023 |
| **Argyris Loulis** University of Athens | 3D Simulations of Neutron Stars and their Ejecta | 14/4/2023 |

# Teaching

The researchers of RCAAM taught a series of courses in university departments, seminars for students and researchers, and in schools organized by scientific associations.

- Mr. **Vasilakos** taught, upon assignment, the course of Cosmology in the Departments of Mathematics and Physics at the University of Athens.

# Phds and Masters

At RCAAM, doctoral candidates and graduate students working on their theses for the acquisition of specialization diplomas (Masters), as well as senior university students preparing their bachelor's theses, are employed. Additionally, the researchers of RCAAM participate in committees overseeing dissertations and bachelor's theses, which are mainly conducted outside of RCAAM.

Specifically, in 2023, the members of RCAAM supervised the following doctoral dissertations and master's theses:

- Mr. **I. Contopoulos** is the main supervisor of the doctoral theses
  - Ms. E. Koutsantonio with the title "The Cosmic Battery in Accretion Disks Around Astrophysical Black Holes" (Department of Physics, EKPA, completion of doctoral thesis).
  - Mr. I. Dimitropoulos with the title: "Origin of High-Energy Radiation from Compact Objects (Black Holes, Pulsars)" (Department of Physics, University of Patras).

  Additionally, Mr. **I. Contopoulos** is a member of the three-member committee for the doctoral theses of:
  - Mr. X. Sinis with the title: "Relativistic Instabilities in Astrophysical Jets" (Department of Physics, EKPA).
  - Mr. V. Mpisketzis with the title: "Plasma Dynamics in the Environment of a Rotating Black Hole" (Department of Physics, EKPA).

Finally, he is the supervisor of the master's thesis

  - Mr. D. Dotsikas with the title: "Study of the Magnetospheres of Pulsars" (Department of Physics, University of Patras).

- Mr. **S. Vasilakos** is the main supervisor of the doctoral thesis:

  - Mr. I. Papagiannopoulos, "The Study of Generalized Symmetries in Cosmological Models of Alternative Gravity Theories." (supervisor S. Vasilakos)
  - Ms. P. Tsapi, "Study of the Accelerating Expansion of the Universe Using Planck Data." (supervisor S. Vasilakos)

  Finally, Mr. **S. Vasilakos** is a member of the three-member committee for the doctoral theses of:

  - Mr. G. Gakis at NTUA with the title "Generalized Gravity Theories in the Tangential Bundle".
  - Mr. M. Kapsambelis at EKPA with the title "Generalized Geometric Theories in Gravity and Cosmology".
  - Mr. X. Tserefoy at EKPA with the title "Modified Gravity: Applications in Cosmology, Black Holes, and Gravitational Waves".

- Mr. **K. Gontikakis** is the main supervisor of the doctoral thesis

  - Ms. M. Koleti with the title "Study of the Outflow Regions of Matter from the Solar Atmosphere" (Department of Physics, EKPA). Co-supervisors: N. Vlachakis, Department of Physics EKPA, S. Patsourakos, Department of Physics, University of Ioannina.

  Additionally, he was the supervisor of the bachelor's thesis

  - Mr. Orfeas Stamatakis with the title "Study of the Ultraviolet Emission of Solar Flares with the IRIS Spectrometer," which was completed in April 2023.

- Ms. **M. Harsoula** is a member of the three-member advisory committee for the doctoral theses of:

  - Ms. K. Zouloumi with the title "Spiral Structure of Galaxies and Chaos in N-Body Models of Galactic Disks" (main supervisor X. Efthymiopoulos)
  - Mr. Edoardo Legnaro with the title "Orbital Dynamics and Diffusion in Resonances in the Near-Space Environment" (co-supervisor X. Efthymiopoulos).

- Mr. **M. Katsanikas** was the main supervisor of the thesis

  - Mr. Kostas Margitis for the acquisition of the master's degree in Astrophysics from EKPA with the title "Escape Mechanisms of Exoplanets with P-type Orbits".

  He was also the main supervisor of the bachelor's thesis

  - Mr. Andreas Kontoyiorgos, with the title "Orbital Study of a 2-Dimensional Potential of a Rotating Rod" (Department of Physics, EKPA).

  Additionally, Mr. **M. Katsanikas** taught the course of Dynamical Astronomy in the master's program (MSc) of the Department of Physics at EKPA (academic year 2022-2023, spring semester 2023).

- Mr. **A.X. Tzemos** is the supervisor of the bachelor's thesis

  - Mr. X. Karyofyllis (Department of Physics, EKPA), with the title "Order and Chaos in the de Broglie-Bohm Interpretation of Quantum Mechanics".

# Participation in Committees

The members of RCAAM are active members in many national and international scientific committees for the promotion of researchers and university professors in Greece and abroad. They serve also as referees in the main research astronomical journals.

# Promotion of Astronomy and Public Outreach

The researchers of RCAAM, upon invitation, gave several outreach talks at educational institutions and events for the public. They also wrote popular science articles and contributed to the dissemination of the research results of the Center through their interventions.

- **I. Contopoulos**
- Talk titled "Journey into Space", Monastery of All Saints, Spetses, August 13.
- Discussion titled "Artificial General Intelligence", Monastery of Saint Stephen, Meteora, December 9.
- **S. Vasilakos** In 2023, S. Vasilakos gave over 20 interviews to the printed and electronic press (ERT, MEGA, OPEN, ALPHA, SKAI, Kathimerini, VIMA, etc.).
- **M. Georgoulis**
- Invited talk in the online program "Explorations – Physics" by Spyros Kanouras titled "Life on the Moon", April 24, 2023.

- Invited advisory participation in a meeting between the 1st Gymnasium of Polichni Thessaloniki and a Gymnasium in Croatia related to the ESA competition "Moon Camp Challenge". Mention in a related article in Vima Science, May 28, 2023.

- Participation, upon invitation, in the evening event titled "Culture and Space", organized by the Hellenic Foundation for Culture under the auspices of the Embassy of the Republic of Cyprus in Greece, May 26, 2023. Participation in the discussion as the National Representative in COSPAR.

- Opinion article in the online platform Open Window titled "How we missed a historic opportunity to have a Greek astronaut at the International Space Station", June 1.

- Invited participation in the discussion cycle "Top Scientists: three leading scientists who contributed to space science worldwide", Theatre of the Hellenic-American Union, April 4. Stamatios Krimigis (Academician), Chrysa Kouvelioutou (Professor at George Washington University, USA), and M. Georgoulis. The talk title was "The Sun and Space Weather".

- Invited talk titled "Observing the Sun: from Physical Theory to the Design and Implementation of Space Missions", at the 11th Astronomy Festival of Chios titled "From Zero to Tomorrow", Kambos, Chios, August 20.

- Article in the newspaper "Enimerosi Peloponnisou" titled "Global Distinctions for Greek Solar Physicist Manolis Georgoulis", September 14.

- Interview on the online platform Newsbomb.gr titled "Why the Northern Lights in Greece are Red – When will we see them again, what dangers lie ahead", November 10.

- Opinion article on the online platform Antinews.gr titled "The National Observatory must be preserved intact", December 8.

- **M. Harsoula** Talk in the 6th grade of the 2nd Primary School of Papagou titled "Exploring our Nearby Universe" (November).

- **V. Tritakis** Two talks at the Society of Friends of the People:
  - "Solar Effects on Earth's Climate".
  - "Various Views on Climate Change".