Symmetry
2025
Conference

The 5th International Conference on Symmetry

16–19 May 2025 | Hangzhou, China

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Conference Photo

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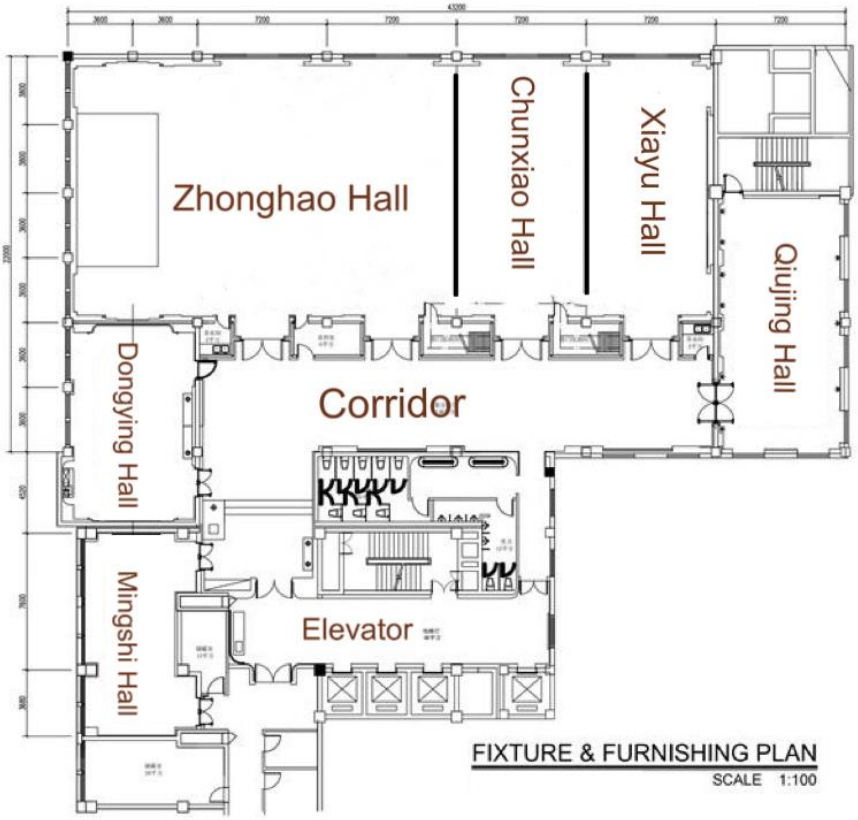
Venue

Address: 76 Qiutao North Road, Shangcheng District, Hangzhou, Zhejiang Province, China

Main Conference Hall
Zhonghao Hall

Meeting Rooms for Sessions
Chunxiao Hall
Xiayu Hall
Qiujing Hall



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Symmetry 2025 — The 5th International Conference on Symmetry

16–19 May 2025 | Hangzhou, China

MDPI Basel • Beijing • Wuhan • Barcelona • Belgrade • Novi Sad • Cluj • Manchester

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Wuhan University of Technology, Wuhan, China

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Budapest University of Technology and Economics, Budapes, Hungary

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Prof. Yi Ling
Prof. Yifu Cai
Prof. Yuning Zhang

Table of Contents

Welcome from the Chairs

Dear Colleagues,

We are thrilled to announce that "**Symmetry 2025 — The 5th International Conference on Symmetry**" will be held from **16 to 19 May 2025** in **Hangzhou, China**. This marks an exciting new chapter for our conference series as we bring this esteemed event to Asia for the first time.

Building upon the success of our previous conferences in Spain, we are eager to explore the rich tapestry of symmetry in the beautiful and historic city of Hangzhou. Known for its scenic West Lake and harmonious blend of nature and urban development, Hangzhou offers an inspiring backdrop for our discussions on symmetry and its applications across various scientific disciplines.

As in previous years, our aim is to foster interdisciplinary dialogue and collaboration among scholars, engineers, students, and professionals working in symmetry-related fields. We welcome contributions from computer science, engineering, mathematics, physics, chemistry, symmetry applications, and beyond.

We invite you to join us in Hangzhou for what promises to be an enriching exchange of ideas and knowledge. Together, let us continue to unravel the mysteries of symmetry and its profound impact on our understanding of the natural world.

Kind regards,

Prof. Changzheng Qu
Prof. Jihuan He
Prof. Sergei D. Odintsov

Prof. Changzheng Qu
Ningbo University, Ningbo, China

Prof. Jihuan He
Soochow University, Soochow, China

Prof. Sergei D. Odintsov
Institute of Space Sciences (IEEC-CSIC), Barcelona, Spain

symmetry

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- Journal Rank: JCR - Q2 (Multidisciplinary Sciences) / CiteScore - Q1 (General Mathematics)
- **Rapid Publication:** manuscripts are peer-reviewed and a first decision is provided to authors approximately 17.3 days after submission; acceptance to publication is undertaken in 3.7 days (median values for papers published in this journal in the second half of 2024).
- **Recognition of Reviewers:** reviewers who provide timely, thorough peer-review reports receive vouchers entitling them to a discount on the APC of their next publication in any MDPI journal, in appreciation of the work done.
- **Testimonials:** See what our editors and authors say about Symmetry.

Impact Factor: 2.2 (2023); 5-Year Impact Factor: 2.3 (2023)

Plenary Speakers

Presentation Title: Symmetry and group action

Prof. Jiping Zhang
Peking University, Beijing, China

Professor Jiping Zhang is a distinguished Chair Professor at Peking University and academician of the Chinese Academy of Sciences. Professor Zhang is the Director of The Sino-Russian Mathematics Center and Associate Editors-in-Chief of Encyclopedia of China (Mathematics). As a mathematician he has made outstanding contributions in algebra including representation theory and finite group theory. Professor Zhang was awarded the National Natural Science Prize and Chern Mathematics Prize. He was an Alexander Von Humboldt reseach fellow. He served as the deputy president of Chinese Mathematical Society and members of CDE and CDC-GSC of International Mathematical Union. Professor Zhang was the dean of the School of Mathematics at Peking University initiating and leading the PKU programme to have cultivated many top talents including the welkonwn “ Golden Generation of Mathematics” .

Presentation Title: A QCD phase diagram by a holographic model

Prof. Ronggen Cai
Ningbo University, Ningbo, China

Professor Rong-Gen Cai, a distinguished Chinese physicist and academician of the Chinese Academy of Sciences, serves as the President of Ningbo University. Specializing in gravitational theory and cosmology, Prof. Cai has made significant contributions to his field. His expertise is widely recognized, as evidenced by his key positions in various physics societies and leadership of major research projects. Prof. Cai's academic journey began with a Ph.D. from Fudan University, followed by postdoctoral research across China, South Korea, and Japan. His outstanding work has earned him prestigious accolades, including the National Natural Science Award and the Thomson Reuters Highly Cited Researcher Award.

Presentation Title: The unified universe history from modified gravity

Prof. Sergei D. Odintsov
Institute of Space Sciences (IEEC-CSIC), Barcelona, Spain

Prof. Sergei Odintsov is an ICREA Research Professor at ICE (CSIC-IEEC). He is the author of about 730 articles cited over 65000 times, and two of his manuscripts were cited more than 3000 times. Prof. Odintsov is Member of the Royal Norwegian Academy and SANS(Serbia), member of the European Physics Society, and the Italian Society for General Relativity and Gravitation. He was awarded the Amaldi Gold Medal: European Prize for Grav. Physics 2014. Prof. Odintsov is an Editorial Board Member of seven journals. His h-index=125 (Google S.), h=114 (inspirehep). According to research.com he is ranked 532 among the Top 1000 Scientists in Physics in the world (2023). Top Cited Clarivate Analytics Researcher in 2014–2018, 2023.

Keynote Speakers

Prof. Antonino Marciano

Fudan University, Shanghai, China

Prof. Chunbiao Li

Nanjing University of Information Science & Technology, Nanjing, China

Prof. Haitang Yang

Sichuan University, Chengdu, China

Prof. Hong Lv

Tianjin University, Tianjin, China

Prof. Jianting Ning

Wuhan university, Wuhan, China

Prof. Jianxin Lu

University of Science and Technology of China, Hefei, China

Prof. Jie Yang

Shanghai Jiaotong University, Shanghai, China

Prof. Jihuan He

Soochow University, Soochow, China

Prof. Józef Drabowicz

University of Czestochowa, Czestochowa, Poland

Assist. Prof. József Schindler

Budapest University of Technology and Economics, Budapes, Hungary

Dr. Longxing Su

Dongguan University of Technology, Dongguan, China

Prof. Stephen Anco

Brock University, St. Catharines, Canada

Assoc. Prof. Shaobo He

Xiangtan University, Xiangtan, China

Prof. Senyue Lou

Ningbo University, Ningbo, China

Prof. Shangdong Yang

Lanzhou University, Lanzhou, China

Prof. Yajun Yin

Tsinghua University, Beijing, China

Prof. Yang Zhang

University of Manitoba, Winnipeg, Canada

Prof. Yanxi Liu

Penn State University, State College, USA

Prof. Yimin Wei

Fudan University, Shanghai, China

Invited Speakers

Dr. Anna Tokareva
University of Chinese Academy of Sciences, Beijing, China

Assist. Prof. Chengcheng Han
Sun Yat-sen University, Guangzhou, China

Prof. Giovanni Modanese
Free University of Bozen-Bolzano, Bolzano, Italy

Dr. Jingcao Cai
Anhui Polytechnic University, Wuhu, China

Prof. Jipeng Cheng
China University of Mining and Technology, Xuzhou, China

Dr. Junling Wang
Beijing Institute of Technology, Beijing, China

Dr. Nick Houston
Beijing University of Technology, Beijing, China

Prof. Samad Noeiaghdam
Henan Academy of Sciences, Zhengzhou, China

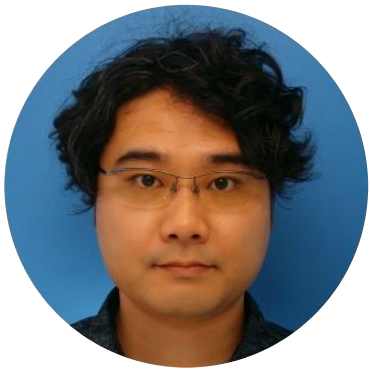
Prof. Samantha Jenkins
Hunan Normal University, Changsha, China

Prof. Shaowen Wei

Lanzhou University, Lanzhou, China

Prof. Song He

Ningbo University, Ningbo, China



Assoc. Prof. Taishi Katsuragawa

Central China Normal University, Wuhan, China

Prof. Tao Zhu

Zhejiang University of Technology, Hangzhou, China

Assoc. Prof. Waichon Lio

Beihang University China, Beijing, China

Dr. Weiyang Ding

Fudan University, Shanghai, China

Prof. Wenbin Lin

University of South China, Hengyang, China

Prof. Yeling Zhou

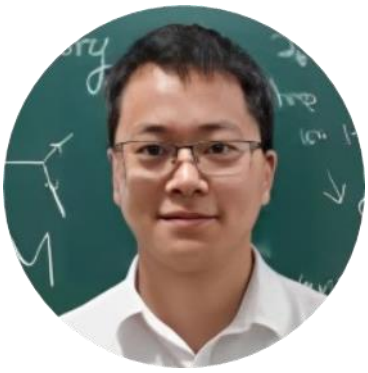
University of Chinese Academy of Sciences, Beijing, China

Prof. Yongchao Zhang

Southeast University, Nanjing, China

Prof. Yuanbin Zhang
Zhejiang Normal University, Jinhua, China

Prof. Yunlong Zhang
National Astronomical Observatories(CAS), Beijing, China



Assoc. Prof. Zhijin Li
Southeast University, Nanjing, China

Symmetry 2025 Program

Day 1 (16 May, Friday)			
15:00~17:00 Registration			
Day 2 (17 May, Saturday)			
8:00~9:00 Registration			
9:00	**Networking**		
	Zhonghao Hall		
9:30	**Opening Ceremony**		
9:45	**Plenary talk 1**		
10:25	Tea break		
10:50	**Plenary talk 2**		
11:30	**Plenary talk 3**		
12:10	Lunch		
	Qiujing Hall	**Chunxiao Hall**	**Xiayu Hall**
13:30/14:00	**Physics 1**	**Chemistry 1**	**Engineering 1**
15:30	Tea break		
16:00	**Physics 2**	**Chemistry 2**	**Engineering 2**
17:30	**Poster Session**		
18:30	**Banquet Dinner**		
Day 3 (18 May, Sunday)			
8:00~8:30 Registration			
	Qiujing Hall	**Chunxiao Hall**	**Xiayu Hall**
9:00	**Physics 3**	**Mathematics 1**	**Engineering 3**
10:30	Tea break		
11:00	**Physics 4**	**Mathematics 2**	**Computer Science 1**
12:30	Lunch		
13:30/14:00	**Physics 5**	**Mathematics 3**	**Computer Science 2**
15:30	Tea break		
16:00	**Physics 6**	**Mathematics 4**	**Computer Science 3**
17:30	Closing Remarks and Award Ceremony		
18:00	**Buffet Dinner**		
Day 4 (19 May, Monday)			
Dismiss and Free Activities			

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Symmetry 2025 Detailed Program

Opening Ceremony and Plenary Talks

Day 2 (17 May, Saturday) 9:30 - 12:10 | Zhonghao Hall

Time	Program	
9:30	Opening Ceremony	
9:45	**Plenary talk 1**	**Symmetry and group action** *Prof. Dr. Jiping Zhang* *Peking University, Beijing, China*
10:25	Tea break	
10:50	**Plenary talk 2**	**A QCD phase diagram by a holographic model** *Prof. Dr. Ronggen Cai* *Ningbo University, Ningbo, China*
11:30	**Plenary talk 3**	**The unified universe history from modified gravity** *Prof. Dr. Sergei D. Odintsov* *Institute of Space Sciences (IEEC-CSIC), Barcelona, Spain*

Day 2 (17 May, Saturday) 13:30 - 17:30 | Qiujing Hall

Physics Session 1 Session chair: Prof. Shin'ichi Nojiri		
13:30	Keynote	**Testing parity violations in the gravitational sector: birefringence in fermion-attenuated gravitational wave power spectrum** *Antonino Marciano (Fudan University, Shanghai, China)*
14:00	Invited	**Holographic Correlators of Boundary/Crosscap CFTs in Two Dimensions** *Song He (Ningbo University, Ningbo, China)*
14:20	Invited	**Grand Unified Theories: testability in particle physics and cosmology** *Ye-Ling Zhou (University of Chinese Academy of Sciences, Beijing, China)*
14:40	Oral	**New axion contribution to the two-photon decays of neutral pions** *Zhen-Yan Lu*
14:55	Oral	**Gross and subatomic matter/antimatter asymmetry: examination of scientific method from theory to experimental results** *Mark Pickrell*
15:10	Oral	**Asymptotically flat hairy black holes with (A)symmetric vacua** *Xiaoyan Chew*
15:25	Oral	**Construction of regular black holes: effective dynamics and quantum gravity implications** *Hongguang Liu*

Physics Session 2 Session chair: Prof. Haitang Yang		
16:00	Invited	**Exploring parity and Lorentz symmetry violations in gravity with astrophysical observations** *Tao Zhu (Zhejiang University of Technology, Hangzhou, China)*
16:20	Oral	**Symmetry constraint on Berry phase in crystalline solid** *Jing Zhang*
16:35	Oral	**A treatment to gravitational perturbations and Lorentz-violating effects with Lagrangian analysis** *Chao Zhang*
16:50	Oral	**Finitely supertranslated Schwarzschild black hole and its perturbations** *Shaoqi Hou*
17:05	Oral	**The Recent Progress of DarkSHINE R&D** *Rui Yuan*
17:20	Oral	**Exploring Modular Flavor Symmetries Across Various Modular Group Realizations** *Carlos Moises Arriaga Osante*

Day 2 (17 May, Saturday) 13:30 - 17:30 | Chunxiao Hall

Chemistry Session 1 Session chair: Prof. György Keglevic		
13:30	Invited	**A Geometric Berry Phase Angle Induced in Im-3m H3S at 200 GPa by Ultra-fast Laser Pulses** *Samantha Jenkins (Hunan Normal University, Changsha, China)*
13:50	Keynote	**Transition-Metal Catalyzed Desymmetrization to Access Different Organophosphorus** *Shangdong Yang (Lanzhou University, Lanzhou, China)*
14:20	Keynote	**Optical Resolution: the Behaviour of Related Structures and the Role of Solvents.** *Jozsef Schindler (Budapest University of Technology and Economics, Budapes, Hungary)*
14:50	Keynote	**Molecular engineering self-assembled monolayers for perovskite solar cells** *Weihua Tang (Xiamen University, Xiamen, China)*
15:20	Oral	**Chemical Equitable Partitions: A new Perspective on Molecular and Crystal Lattice Symmetries, and Its Implications for the Study of Structure–Property Relationships** *Vasilios Raptis*

Chemistry Session 2 Session chair: Prof. Weihua Tang		
16:00	Keynote	**α-Hydroxyphosphonates, α-Hydroxyphosphine Oxides and their Derivatives** *György Keglevich (Budapest University of Technology and Economics, Budapes, Hungary)*
16:30	Keynote	**Selected Optically Active Organic Compounds Containing Stereo- and/or Nonsterogenic Heteroatoms: Historical Aspects and Recent Results** *Józef Drabowicz (University of Czestochowa, Czestochowa, Poland)*
17:00	Invited	**Anion pillared metal-organic frameworks for gas separation** *Yuanbin Zhang (Zhejiang Normal University, Jinhua, China)*
17:20	Oral	**Chiral Perovskites and Their Chirality-Induced Spin Selectivity** *Shuo Sun*

Day 2 (17 May, Saturday) 14:00 - 17:30 | Xiayu Hall

Engineering Science Session 1 Session chair: Prof. Chong Wang		
14:00	Keynote	**Modeling of the Discrete Memristor and Its Applications: An Anticipation** *Shaobo He (Xiangtan University, Xiangtan, China)*
14:30	Keynote	**Photoresponse and synapse characteristics of Ga2O3 based devices** *Longxing Su (Dongguan University of Technology, Dongguan, China)*
15:00	Oral	**Application of Symmetry and Fractional-order Mechanics of Bone in Physical Fractal Space** *Zhimo Jian*
15:15	Oral	**Physical Fractal and Fractal Operators Abstracted from Arterial Blood Flow** *Tianyi Zhou*

Engineering Science Session 2 Session chair: Prof. Deming Lei		
16:00	Keynote	**Distribution regulation of chaos based on offset boosting** *Chunbiao Li (Nanjing University of Information Science & Technology, Nanjing, China)*
16:30	Invited	**AI-Driven Sustainable Manufacturing: Innovations in Resource Recovery and Recycling** *Jie Li (Donghua University, Shanghai, China)*
16:50	Invited	**Introduction to Uncertainty Theory** *Waichon Lio (Beihang University China, Beijing, China)*
17:10	Oral	**The Key optoelectronic measurement technology for space gravitational wave detection** *Tao Yu*
17:25	Oral	**The Continued Fraction Structure in Physical Fractal Theory** *Ruiheng Jiang*

Day 3 (18 May, Sunday) 9:00 - 12:30 | Qiujing Hall

Physics Session 3 Session chair: Prof. Shaowen Wei		
9:00	Invited	**Cosmological Non-Gaussianity and Neutrino Seesaw** *Chengcheng Han (Sun Yat-Sen University, Guangzhou, China)*
9:20	Invited	**Unitarity and causality constraints on effective field theories** *Anna Tokareva (University of Chinese Academy of Sciences, Beijing, China)*
9:40	Invited	**The post-Newtonian metric of a self-gravitating and collapsing thin spherical shell** *Wenbin Lin (University of South China, Hengyang, China)*
10:00	Invited	**Black Hole singularity resolution in infinite derivative gravity theories** *Alexey Koshelev (ShanghaiTech university, Shanghai, China)*
10:20	Oral	**Can the evolution of our universe be treated as an initial value problem?** *Martin Tamm*
10:35	Oral	**Polarization modes of gravitational waves in general Einstein-vector theory** *Xiao-Bin Lai*

Physics Session 4 Session chair: Prof. Shin'ichi Nojiri		
11:00	Keynote	**Progress on the open string pair production in Type II superstrings** *Jianxin Lu (University of Science and Technology of China, Hefei, China)*
11:30	Invited	**Dark photon constraints from the APEX cavity haloscope experiment** *Nick Houston (Beijing University of Technology, Beijing, China)*
11:50	Invited	**Compact Star Physics in F(R) Gravity** *Taishi Katsuragawa (Central China Normal University, Wuhan, China)*
12:10	Oral	**Quasinormal Ringing of de Sitter Braneworlds** *Hai-Long Jia*

Day 3 (18 May, Sunday) 13:30 - 17:30 | Qiujing Hall

Physics Session 5 Session chair: Prof. Song He		
13:30	Invited	**Laboratory Constraints on Neutrinophilic Mediators Without Infrared Divergences** *Yongchao Zhang (Southeast University, Nanjing, China)*
13:50	Invited	**Chiral Gravitational Wave Background: Generation and Detection** *Yun-Long Zhang (National Astronomical Observatories, CAS, Beijing, China)*
14:10	Invited	**Black Hole Thermodynamics and Phase Transitions** *Shaowen Wei (Lanzhou University, Lanzhou, China)*
14:30	Oral	**Sixfold Discrete Symmetry of Fermion Fields as Explanation for Dark Matter** *Avraham Nofech*
14:45	Oral	**Recent Dark "Matter/Photon/Higgs" search results from ATLAS** *Ngoc Khanh VU*

Physics Session 6 Session chair: Prof. Shaowen Wei		
16:00	Keynote	**Geometric Origins of Yang-Mills In Flat Spacetime from Heterotic String** *Hong Lv (Tianjin University, Tianjin, China)*
16:30	Keynote	**The correspondence of generalised entropic cosmology theory with $F(T)$ and $F(Q)$ modified gravity and gravitational waves** *Shin'ichi Nojiri (Nagoya University, Nagoya, Japan)*
17:00	Invited	**Next-to-leading order corrections to the conserved current three-point correlators in the large N expansion** *Zhijin Li (Southeast University, Nanjing, China)*
17:20	Oral	**Symmetry in Kottler–Møller and Rindler Coordinates with Coupled Parameters** *Nikolai Akintsov*

Day 3 (18 May, Sunday) 9:00 - 12:30 | Chunxiao Hall

Mathematics Session 1 Session chair: Prof. Changzheng Qu		
9:00	Keynote	**Babylonian Algorithms and Ancient Chinese Algorithms and Their Modern Applications** *Jihuan He (Soochow University, Soochow, China)*
9:30	Invited	**KP theory and infinite dimensional Lie algebras** *Jipeng Cheng (China University of Mining and Technology, Xuzhou, China)*
9:50	Invited	**A Novel Model of Supply and Demand of Energy for Solar Farms in China** *Samad Noeiaghdam (Henan Academy of Sciences, Zhengzhou, China)*
10:10	Oral	**Conjecture O and the Gamma Conjectures: A Unified Framework in Quantum Cohomology and Geometric Applications** *Xiaobin Li*
10:25	Oral	**Symmetry and exact solutions of the (2+1)-dimensional generalized Burgers–Fisher equation** *Yanting Ren*

Mathematics Session 2 Session chair: Prof. Qingwen Wang		
11:00	Keynote	**Coseparable Nonnegative Tensor Factorization With T-CUR Decomposition** *Yimin Wei (Fudan University, Shanghai, China)*
11:30	Invited	**Dual-Valued Functions of Dual Matrices with Applications in Causal Emergence** *Weiyang Ding (Fudan University, Shanghai, China)*
11:50	Oral	**A Shear Flow Model for Compressible Micropolar Real Fluids with Heat Conduction and Symmetry-Driven Reduction** *Ivan Dražić*
12:05	Oral	**Mathematical elements in trees, forests, and nature** *Iwao Uehara*

Day 3 (18 May, Sunday) 14:00 - 17:30 | Chunxiao Hall

Mathematics Session 3 Session chairs: Prof. Shoufeng Shen and Prof. Ying Shi		
14:00	Keynote	**Nonlocal symmetries of integrable systems** *Senyue Lou(Ningbo University, Ningbo, China)*
14:30	Invited	**Recent advances in Aharonov-Bohm extended electrodynamics** *Giovanni Modanese (Free University of Bozen-Bolzano, Bolzano, Italy)*
14:50	Oral	**The 3D Flow of a Compressible Micropolar Real Gas with Spherical Symmetry: The Global Existence of the Solution** *Angela Bašić-Šiško*
15:05	Oral	**Algebraic Nexus of Fibonacci Forms and Two-Simplex Topology in Multicellular Morphogenesis** *Elizabeth Lamb*
15:20	Oral	**Generalized bigraded Toda hierarchy** *Jinbiao Wang*

Mathematics Session 4 Session chairs: Prof. Qingwen Wang, Prof. Shoufeng Shen, Prof. Ying Shi		
16:00	Keynote	**Exact solutions of nonlinear PDEs by symmetry multi-reduction** *Stephen Anco (Brock University, St. Catharines, Canada)*
16:30	Keynote	**Reduced biquaternion tensors and their applications** *Yang Zhang (University of Manitoba, Winnipeg, Canada)*
17:00	Oral	**Equivariant formality of homogeneous spaces** *Chi-Kwong Fok*
17:15	Oral	**Fifth-order nonlinear evolution equations of soliton type: old and new results** *Sandra Carillo*
17:30	Oral	**Response control and bifurcation analysis of a generalized and fractional Rayleigh-Duffing oscillator under recycling noises** *Yajie Li*

Day 3 (18 May, Sunday) 9:00 - 12:30 | Xiayu Hall

Engineering Science Session 3 Session chairs: Prof. Chong Wang and Prof. Deming Lei		
9:00	Keynote	**Fractal operators with fractional orders in fractal spaces abstracted form biological systems** *YajunYin (Tsinghua University, Beijing, China)*
9:30	Invited	**A shuffled frog leaping algorithm with Q learning for distributed hybrid flow shop scheduling problem with missing operations** *Jingcao Cai (Anhui Polytechnic University, Wuhu, China)*
9:50	Oral	**Novel non-probabilistic uncertainty-based fault diagnosis method considering sample distribution** *Qiang Xin*
10:05	Oral	**A study on symmetric truncated icosahedral tensegrity** *Jingyao Zhang*

Computer Science Session 1 Session chairs: Prof. Kuo-Hui Yeh and Prof. Hu Xiong		
11:00	Keynote	**A Survey of Expressive Attribute-Based Encryption Scheme With Provable Security** *Hu Xiong (University of Electronic Science and Technology of China, Chengdu, China)*
11:30	Keynote	**RESEARCHES ON THE DEFENSES AND OUT-OF-DISTRIBUTION DETECTION IN TRUSTWORTHY DEEP LEARNING** *Jie Yang (Shanghai Jiaotong University, Shanghai, China)*
12:00	Oral	**ADTSA: an Adaptive Dual-subpopulation based Tree Seed Algorithm for Local Optima Avoidance and Fast Convergence** *Hao Li*
12:15	Oral	**AMTSA: Adaptive and Migration-enhanced Tree Seed Algorithm for Complex Optimization Problems** *Chenxi Li*

Day 3 (18 May, Sunday) 14:00 - 17:30 | Xiayu Hall

Computer Science Session 2 Session chairs: Prof. Kuo-Hui Yeh and Prof. Hu Xiong		
14:00	Keynote	**ZEROS FOR DATA SCIENCE** *Yanxi Liu (Penn State University, State College, USA)*
14:30	Invited	**Symmetry Features in Space Target Radar Detection and Imaging** *Junling Wang (Beijing Institute of Technology, Beijing, China)*
14:50	Oral	**Review on Fractal Analysis in Tsunami Modeling by symmetric analysis: A New Perspective for Predicting Tsunami Behavior** *Yan Wang*
15:05	Oral	**KMBCA: A K-Means clustering-based Besiege and Conquer Algorithm with adaptive and multi-strategy enhancements** *Aobo Zhang*

Computer Science Session 3 Session chair: Prof. Kuo-Hui Yeh		
16:00	Keynote	**Provably Secure Searchable Symmetric Encryptions: Definition, Construction, Attacks and Defenses** *Jianting Ning (Wuhan Unversity, Wuhan, China)*
16:30	Keynote	**Security Risk Assessment for Industrial Automation and Control Systems** *Kuo-Hui Yeh (National Yang Ming Chiao Tung University, Taiwan, China)*
17:00	Oral	**Learn From Human Eyes: Zero-Shot Recurring Pattern Detection on a Multi-Perception Benchmark** *Shimian Zhang*

Session 1. Physics

sciforum-111420: Chiral Gravitational Wave Background: Generation and Detection

Yun-Long Zhang

National Astronomical Observatories, CAS

Circularly polarized gravitational wave backgrounds are predicted in many well-motivated models of inflation and phase transitions involving spontaneous parity violations. We consider an axion-like mechanism coupled with the Nieh–Yan term. This interaction leads to the direct and efficient production of gravitational waves during the radiation-dominated era, originating from the tachyonic instability of the gravitational perturbations with the Nieh–Yan term. We calculate the energy spectral density of the chiral gravitational wave background and the comoving energy density of axion-like fields. Based on the numerical results, we explore the parameter space of the axion masses and decay constants for detectable gravitational wave signals, either in pulsar timing arrays or space-based gravitational wave detections. We further investigate the detection of such parity-violating signals using a network of two space-borne triangular detectors. We derive the general analytical formula for the overlap reduction functions of networks composed of two triangular detectors by exploiting the system's symmetrical properties under the long-wave approximation. Based on these results, we further assess the detectability of a parity-violating background using alternative LISA–Taiji network configurations. We find that the sensitivity to the parity-violating component can be significantly enhanced at low frequencies by adjusting the orientation of Taiji's constellation plane. This sensitivity gain is approximately an order of magnitude around the millihertz band, making the peak sensitivity comparable to that of the total intensity. This provides a promising opportunity to constrain various parity-violating theories in the millihertz band using upcoming space-borne detectors.

sciforum-117619: Quasinormal Ringing of de Sitter Braneworlds

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Compared with the Poincaré braneworld, the de Sitter (dS) braneworld aligns more closely with the present universe characterized by a small but finite cosmological constant. To explore the quasinormal ringing properties within the dS brane scenario, we investigate the gravitational perturbations in both thin and thick dS brane configurations. Analysis of the perturbation equations reveals that the effective potential along the extra dimension exhibits the shape of Pöschl–Teller potential, asymptotically approaching a constant value (mass gap) at infinity. In particular, this mass gap can be reduced. And analytical calculations further indicate that the gravitational perturbations, apart from the zero mode, possess a series of discrete, purely imaginary quasinormal modes in the late stages. This result implies that these perturbations decay without oscillation over time. The analytical findings also demonstrate that the brane structure primarily determines the distribution of the quasinormal spectrum while preserving the purely imaginary nature of the quasinormal frequencies. Subsequently, we further simulate the gravitational wave signal by numerically evolving the perturbation equations, which yield late-stage results consistent with the analytical predictions. Interestingly, these quasinormal modes carry information about the cosmological constant on the brane, which provides a potential new pathway for the study of cosmology in the dS brane scenario.

sciforum-117658: A treatment to gravitational perturbations and Lorentz-violating effects with Lagrangian analysis

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The gravitational waves (GWs) and the physics behind them have drawn a lot of attention over the past decade ever since the first direct detection of GWs in 2015. This confirmed one of the most crucial predictions of general relativity (GR). As a key source (especially when considering third-generation detectors) for revealing whether a theory of gravity is consistent with observations and reflecting certain inherent features of it, the quasi-normal mode (QNM) problem of black holes (BHs), e.g., those emitted during the so-called ringdown stage, has been playing an important role in related areas. Such a problem is strongly related to gravitational perturbations. A key difficulty in tackling it arises from the sophisticated mathematical structure of the Lagrangian of a certain theory, e.g., Lorentz-violating (LV) gravity, which focuses on testing bizarre observable phenomena outside the range of GR's predictions (e.g., the so-called universal horizon) and showing the dawn of constructing a quantum theory of gravity. Under the framework of the novel treatment to be introduced (with pedagogical examples), we shall analyze LV gravity by performing gravitational perturbations on it with an efficient method and proceed to analyze the results of the corresponding QNM problem. Some of the stability analysis will also be carried out in this procedure.

sciforum-117649: Can the evolution of our universe be treated as an initial value problem?

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Ever since the days of Isaac Newton, an almost universal method for solving problems in physics has been to identify the forces involved, write down the equations of motion, and then solve these with respect to certain initial conditions.

But can we be sure that this is the right way to treat cosmology? The method is not symmetric with respect to time: even if the equations of motion are essentially time-symmetric, the treatment of the boundary conditions (in the past and in the future) is not. Thus, taking this standard method as our starting point, we automatically build time asymmetry into our model.

Today, we now know that the initial value approach, in order to explain observations, seems to demand new components, like dark energy. And so far, there has been no independent support for the existence of such energy.

I suggest that a time-symmetric approach, based on the Principle of Least Action, where the past and the future play symmetric and equally important roles, could be an alternative that does not need any dark energy. This possibility is based on the observation that the Principle of Least Action is essentially equivalent to the initial value approach locally but not globally.

To illustrate this idea, I use a (non-standard) version of the Principle of Least Action. The resulting model provides an explanation for accelerating expansion without any dark energy, but it cannot be viewed as an initial value problem in the usual way.

It is not claimed that the simple model presented here is any final answer. Rather, the claim is that as long as we do not know what dark energy is, we must keep the door open for other possibilities, including the one where there is no such thing as dark energy.

sciforum-118044: Cosmological Non-Gaussianity and Neutrino Seesaw

Hong-Jian He

Tsinghua University

The neutrino mass generation via conventional seesaw mechanism is realized at high scales around O(10^{14})GeV and probing new physics of the seesaw scale poses a great challenge. A striking fact is that the neutrino seesaw scale is typically around the cosmological inflation scale. In this talk, I discuss a framework incorporating inflation and neutrino seesaw in which the inflaton primarily decays into right-handed neutrinos after inflation. This decay process is governed by the inflaton interaction with the right-handed neutrinos that respects the shift symmetry. Under the neutrino seesaw mechanism, fluctuations of the Higgs field can modulate the inflaton decays, contributing to the curvature perturbation. We investigate the induced non-Gaussian signatures and demonstrate that such signatures provides an important means to probe the high-scale neutrino seesaw mechanism.

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sciforum-117829: Finitely supertranslated Schwarzschild black hole and its perturbations

Shaoqi Hou

Wuhan University

A finitely supertranslated Schwarzschild black hole possesses nontrivial super-Lorentz charges compared to the standard one. This may impact the quasinormal modes of the black hole. Since Einstein's equations are generally covariant, the quasinormal modes of a supertranslated black hole can be obtained by supertranslating the familiar results for a standard black hole. It turns out that the supertranslated quasinormal modes can be obtained by simply shifting the retarded time of the standard modes by an angle-dependent function parameterizing the supertranslation. Therefore, the supertranslated quasinormal modes oscillate at the same frequencies and decay at the same rates as the corresponding standard ones. The supertranslated metric is time translation invariant but does not explicitly respect spherical symmetries, although it is implicitly rotationally symmetric.

So, the supertranslated perturbations can still be written as linear combinations of the eigenfunctions of the generalized angular momentum operators for the underlying rotational symmetry. With a suitably defined asymptotic parity transformation, any perturbation can be decomposed into even and odd parity parts. Then, one may conclude that the isospectrality still holds. To detect such supertranslated quasinormal modes, one has to place multiple gravitational wave interferometers around the supertranslated black hole and measure the differences in the time shifts between interferometers. Gravitational lensing may also be helpful in the same regard.

sciforum-117787: Grand Unified Theories: testability in particle physics and cosmology

Ye-Ling Zhou

Hangzhou Institute for Advanced Study, University of Chinese Academy of Sciences

Four fundamental forces that describe interactions between matter have been found in nature. They are electromagnetic force, weak force, strong force and gravity. For a long time, physicists have been trying to unify these forces in the same theoretical framework. Given that the quantisation of gravity has not yet been achieved, one idea is to unify the first three forces that describe the interactions between elementary particles, which is the Grand Unified Theory (GUT) of particle physics. A well-known phenomenological prediction of GUTs is proton decay, which sets a strong constraint to GUTs due to its null observation. On the other hand, masses and mixing of quarks and leptons are correlated since all fermions are arranged in the same representation of SO(10). As the era of neutrino precision measurement is coming, experimental data in the fermion sector will become more and more important in the future study of GUTs. On the cosmological side, the breaking of SO(10) to the Standard Model gauge groups generates cosmic strings, which radiates gravitational waves via string oscillation. In this talk, I will first introduce the research background and theoretical framework of the theory. Combining the latest experimental progress from particle physics and cosmology, I will focus on the phenomenological progress related to GUTs.

sciforum-121749: Next-to-leading order corrections to the conserved current three-point correlators in the large N expansion

Zhijin Li

Southeast University, Physics Department

The three-point correlators of the conserved currents, including the stress tensor and global symmetry currents, have broad applications in several directions in physics, including the continuous phase transition, early time cosmology and quantum gravity through AdS/CFT correspondence. In this talk, I will explain the perturbative computations to the conserved current three-point correlators to the subleading order in the large N expansion. The perturbative loop computations of these three-point correlators are technically chanllenging -- it needs to compute the three-loop integrals with three external momenta, which are hard to evaulate analytically. I will introduce a novel method by employing the strong constraints from the conformal symmetry. More specifically, due to the conformal symmetry, the three-point correlators of the conserved currents can be almostly solved up to few free parameters. We take special limits of one of the three external momenta, then the three-loop integrals with three external momenta can be reduced to two-loop integrals with two external momenta, which can be computed analytically. This significantly simplifies the loop integrals, while the key information on the free paramters in the three-point correlators can be extracted from the reduced loop integrals. This work provides a insightful example to show how the constraints from the conformal symmetry can help to improve the classical perturbative methods. I will apply this method to compute the subleading order corrections to the conserved current three-point correlators in both O(N) vector and Gross-Neveu models. This method can be applied for general conformal field theories. I will breifly explain the applications of this method in gauge theories and inflation theories.

sciforum-117621: Polarization modes of gravitational waves in general Einstein-vector theory

Xiao-Bin Lai *, Yu-Qi Dong, Yu-Qiang Liu and Yu-Xiao Liu

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We study the polarization modes of gravitational waves in general Einstein-vector theory with an arbitrary constant background vector field under a Minkowski background. We compare these polarization modes with those of other vector--tensor theories and constrain the parameter spaces based on the gravitational-wave event GW170817 with its electromagnetic counterpart GRB170817A and observations of pulsar timing arrays. The presence of the background vector field leads to the anisotropy of space and a rich variety of gravitational wave contents. Our results reveal that the polarization modes of gravitational waves depend on the parameter spaces. There are at least two, and at most five, independent polarization modes in one parameter space. In different parameter spaces, some mixture modes are allowed, including tensor--vector, tensor--scalar, tensor--vector--scalar, vector--scalar, and scalar--scalar mixture modes, as well as five independent modes (excluding P_l): P_+, $P_{\times}$, P_x, P_y, and P_b. In all regions of the parameter spaces, there are always two tensor modes, which can be either independent of or mixed with other modes. The independent P_b mode consistently exhibits the same speed as light. If the speed of tensorial gravitational waves strictly equals that of light, only the P_+, $P_{\times}$, and P_b modes are permitted. Furthermore, through comparisons with some vector--tensor theories, and based on the observations of gravitational waves, the P_b mode is expected to be allowed.

sciforum-112318: Re-evaluation of ΛCHP Hubble Parameters for Decoding VAUE Universe Acceleration

Hassan UL Rizwan

Riphah International University, Islamabad, Pakistan

The cosmological parameters BCP and DCP are accelerating more rapidly than we expected. This has accelerated our understanding of its functions in covariance with expansion parameters [1]. The Hubble tension is a long-familiar question in the exploration of cosmological parameters [2][3]. The measurement of the Hubble constant *(H_0)* unveils a disparity in how quickly the BCP and DCP are accelerating [4]. Different methods of measuring parameters yield various results, highlighting the fact that numerous questions in this domain remain unanswered [5][6]. This gap brings to light questions regarding the cosmological parameters currently known (e.g., CDM**)** [*7*][8] and suggests the necessity of incorporating new parameters, e.g., the DPP method, to gain an understanding of the accelerated universe. This theory integrates a relationship into the Hubble equation, where both BCP and DCP are accelerated cosmological Hubble parameters**.** This integration pertains to how cosmological Hubble parameters evolve across the past, present, and future dimensions. We propose that both BCP and DCP are influenced by stochastic variables in a diametrical domain characterized by contrasting magnitudes of matter. The conjunctive mass term, volume term, and CHP in this theory provide a new perspective on BCP, specifically DCP and Hubble tension. This theory discusses how the re-evaluation of our current understanding of BCP and DCP is necessary to integrate this acceleration of universe expansion changes. This adjustment could help us understand one of the biggest mysteries in modern cosmology.

sciforum-116325: $f(Q,L_m)$ gravity: a new modified theory of gravity

Pradyumn Kumar Sahoo

Birla Institute of Technology & Science-Pilani, Hyderabad Campus

In the present talk, I will extend the concept of $f(Q)$ symmetric teleparallel gravity by introducing arbitrary coupling between the non-metricity Q and matter Lagrangian L_m in the Lagrangian density f of the theory, which, thus, leads to the $f\left(Q,L_m\right)$ theory. This generalization encompasses Coincident General Relativity (CGR) and the Symmetric Teleparallel Equivalent to GR (STEGR). Using metric formalism, we derive the field equation of the theory, which generalizes the field equations of $f(Q)$ gravity. From the study of the covariant divergence of the field equations, it follows that the presence of geometry–matter coupling leads to the non-conservation of the matter energy–momentum tensor. The cosmological implications of the theory are investigated in the case of a flat, homogeneous, and isotropic Friedmann–Lemaitre–Robertson–Walker geometry. As the first step in this direction, we obtain the modified Friedmann equations for $f(Q,L_m)$ gravity in a general form. Specific cosmological models are investigated for several choices of $f(Q,L_m)$, including $f(Q,L_m)=-\alpha Q + 2L_m + \beta$ and $f(Q,L_m)=-\alpha Q + (2L_m)^2 + \beta$, respectively. Comparative analyses with the standard Λ CDM paradigm are carried out, and the observational implications of the models are investigated in detail.

sciforum-116611: Advanced Modeling of Curie Temperature and Density in Pure and Ti-Doped $LiNbO_3$

mohamed MED beriniz

Sultan Moulay Slimane University of Beni Mellal, ENSA of Khouribga, Laboratory of science and technology for the engineer LASTI Laboratory

Lithium niobate ($LiNbO_3$), both in its pure form and titanium (Ti)-doped variants, is widely used in electro-optical and ferroelectric applications due to its excellent nonlinear optical, piezoelectric, and photorefractive properties. In this study, we employ advanced vacancy models and an extended theoretical approach (Th2) that incorporates electrostatic interactions between first- and second-neighbor ions to improve the accuracy of structural and thermal property predictions. Our model provides enhanced precision compared to conventional approaches (Th1), particularly for non-stoichiometric and doped compositions.

A comparative analysis of the Curie temperature and density as a function of the Ti doping concentration was conducted, with results validated against experimental data. The study revealed that Ti doping significantly influences the structural and thermal stability of LiNbO3, altering key parameters such as phase transition temperature, lattice structure, and unit cell density. The proposed model effectively captures substitution mechanisms and the role of vacancies in doped LiNbO3, providing a more comprehensive understanding of its ferroelectric behavior and transition dynamics.

These findings offer valuable insights for optimizing LiNbO3-based materials in electro-optical modulators, waveguides, nonlinear optics, and high-precision sensors. Our approach highlights the significance of incorporating second-neighbor interactions in theoretical modeling, paving the way for improved material design in advanced technological applications.

sciforum-122287: Asymptotically flat hairy black holes with (A)symmetric vacua

Xiao Yan Chew

Jiangsu University of Science and Technology

I will present herein recent advancements in the study of scalarization in hairy black holes within the framework of Einstein gravity. Specifically, I will focus on the Einstein–Klein–Gordon theory, where the Einstein gravity is minimally coupled to scalar fields governed by non-positive definite scalar potentials, which exhibit both symmetric and asymmetric vacua. These potentials lead to the scalarization of asymptotically flat and spherically symmetric hairy black holes, a phenomenon in which the black hole develops scalar hair, which is a deviation from the vacuum solutions of general relativity. These scalarized black holes can bifurcate from the standard electrovacuum black holes, where the scalar field becomes nontrivial and modifies the black hole's structure.

By solving the field equations numerically, derived from the Einstein–Klein–Gordon theory, I will also highlight some key results from my recent research (2210.01313, 2307.13972, 2401.09039, 2405.04921, and 2405.06407) that shed light on these interesting phenomena. In particular, I will discuss how the specific profiles of the scalar potentials influence various properties of the resulting hairy black holes, such as their Hawking temperature, and stability under linear perturbations. This presentation aims to provide a deeper understanding of the conditions under which scalarization occurs and its implications for the study of black hole physics.

sciforum-121568: Black Hole Thermodynamics and Phase Transitions

Shao-Wen Wei

School of Physical Science and Technology, Lanzhou University

Black hole thermodynamics has garnered widespread attention, offering us a novel understanding of these objects characterized by extremely strong gravity. By combining fundamental disciplines such as gravitational theory, quantum mechanics, and statistical physics, studies in this area not only facilitate a reexamination of these basic theories but also have significant implications for the establishment of quantum gravity. In this talk, we will provide a comprehensive overview of recent advancements in the field of black hole thermodynamics. We will focus particularly on phase transitions analogous to those observed in van der Waals fluids, especially the gas-liquid phase transition. These phase transitions provide a unique perspective which we can examine the thermodynamic behavior of black holes and uncover their underlying microscopic properties. By studying these phenomena, we aim to reveal the hidden structure and dynamics of black holes, shedding light on their nature. Moreover, we will employ topological methods to explore the universal characteristics of black hole systems. By analyzing their topological properties, we can classify black holes into different topological classes, revealing the inherent similarities and differences among various black hole configurations. This topological approach not only enriches our understanding of black holes but also provides a powerful tool for uncovering the fundamental principles that govern their behavior. Through these combined efforts, we hope to advance our knowledge of black holes.

sciforum-117647: Compact Star Physics in F(R) Gravity

Taishi Katsuragawa

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Compact objects are an interdisciplinary research topic in high-energy physics, and their study has become a central issue in modified gravity theories. A compact object is in hydrostatic equilibrium between the repulsive force of internal matter and the attractive force of gravity, governed by the Tolman-Oppenheimer-Volkoff (TOV) equation. By solving the TOV equation for a given equation of state (EOS), we can predict the mass-radius (M-R) relation of compact objects, while observations provide a way to test the EOS. Thus, compact objects and their observations have attracted significant attention in both nuclear physics and astrophysics.

In modified gravity theories, the TOV equation is altered, leading to different M-R relations. Observations of compact objects, therefore, offer a crucial test of gravitational theories in strong-field and non-perturbative regimes. Understanding the interplay among nuclear physics, astrophysics, and gravitational theory is essential, as compact objects serve as key phenomenological probes of modified gravity. The M-R relations of compact objects have been extensively studied in various modified gravity theories.

This talk will examine both the internal and external structure of compact objects in F(R) gravity. We will explore novel physical predictions arising from the additional fundamental scalar field in F(R) gravity. Furthermore, we will discuss the importance of observables beyond the M-R relation in testing gravitational theories and consider the impact of the scalar field on neutron star cooling.

sciforum-108756: Complete realization of a moderate principle of relativity for particle dynamics in translational reference frames

C.Y. Chen

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This paper presents a new development in revealing the nature of the inertial force, a concept that has long stimulated discussion in the history of physics. On this basis, its implications are systematically introduced for the improvement of particle dynamics. Firstly, all the theorems in the framework of classical mechanics can be form-invariant generalized to any translational frame of reference, provided that the physical meaning of the force term of the particle in the original formulation is replaced from the total forces to the forces being relatively accounted for. Secondly, in analytical mechanics, since in general the conservative force corresponding to the potential energy is typically a part of the forces acting on the particle, it is enough to ensure that the reference origin is chosen at a position where the vector sum of the conservative forces corresponding to the potential energy is always zero. However, in the case of a general translational reference frame, a correction term for the potential energy due to the forces acting on the reference object must be included in the expression of the Lagrangian and Hamiltonian quantities. Thirdly, the symmetric new equation is applied to the system of particles. The generalized center-of-mass motion theorem and the generalized fixed-axis rotation theorem in the translational reference frame are developed. Finally, for instance, the multi-body dynamics is discussed. In principle, the detour that is introduced by the center-of-mass reference frame can be directly omitted and crossed. To illustrate this, the planetary perturbation equation is demonstrated to be derived in a single step by applying the symmetric new equation of Newtonian dynamics. Besides, the introduction of the symmetric new equation has led to further improvements and refinements in the planetary perturbation equation.

sciforum-117766: Constraints on high density equation of state from compact objects observations

Shupeng Wang and Lu Zhenyan

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Recently, it has been shown that the inclusion of a new term in the thermodynamic potential density, as required by the thermodynamic consistency criterion, can effectively resolve the thermodynamic inconsistency problems of the conventional perturbative quantum chromodynamics (pQCD) model. This additional term is determined by satisfying the fundamental differential equations of thermodynamics. It plays a crucial role in resolving inconsistencies at comparatively low densities and becomes negligible at extremely high densities, acting as a chemical potential-dependent bag constant. This term introduces a novel feature into the model, which helps ensure the internal consistency of the theoretical framework. Within this model, our analysis incorporates an additional constraint derived from the NICER observations of the mass and radius of the isolated pulsar PSR J0030+0451.

In other words, our results indicate that the measured tidal deformability for event GW170817 places an upper bound on the maximum mass of ud quark stars, but which does not rule out the possibility of the existence of quark stars composed of ud quark matter, with a mass of about two times the solar mass. Furthermore, we find that for the enhanced perturbative QCD model with reasonable parameters, the properties of ud quark stars are consistent with the observations of PSR J0740+6620, PSR J0030+0451, and GW170817 simultaneously. The symmetry energy of the quark matter is also calculated and discussed.

sciforum-123182: Construction of regular black holes: effective dynamics and quantum gravity implications

Hongguang Liu

Westlake University

In General Relativity, gravitational dust collapse dynamics are intrinsically connected to cosmological evolution described within the Lemaitre–Tolmann–Bondi (LTB) coordinate framework. By embedding LTB models into spherically symmetric spacetime structures in both effective dynamics and modified gravity theories, we propose a novel reconstruction algorithm that systematically translates the given metrics—whether formulated in Schwarzschild-like coordinates or cosmological frameworks—into corresponding effective models. This method allows thesimultaneous derivation of two key components: the 1+1-dimensional field-theoretic description governing system dynamics and their associated covariant Lagrangians within four-dimensional extended mimetic gravity. The reconstruction framework is particularly powerful for constructing Lagrangian formulations of extended mimetic gravity, applicable to black holes with regular centers (e.g., Bardeen and Hayward metrics) as well as loop quantum gravity (LQG)-inspired bouncing cosmological scenarios. Furthermore, it establishes a pathway to generalize regular black hole solutions to broader inhomogeneous dust collapse models. Within this formalism, we can explore novel perspectives on physical properties such as weak solution existence for these generalized systems. Notably, for certain classes of regular black holes modeled here, we formulate a Birkhoff-like theorem within LTB coordinates. Additionally, our analysis reveals that the uniqueness of effective spherically symmetric vacuum solutions in Schwarzschild-like coordinates may not hold universally—this dependence arises from how regularization characteristics (encoded via polymerization functions) influence model behavior.

sciforum-118986: Dark photon constraints from Axion and dark Photon EXperiment program cavity haloscope experiment

Nick Houston

Beijing University of Technology

The dark photon is a promising candidate for dark matter, which comprises most of the matter in our visible universe. Via kinetic mixing with the Standard Model, it can also be resonantly converted to photons in an electromagnetic cavity, offering novel experimental possibilities for the discovery and study of dark matter. We report the results of a pathfinder dark photon dark matter cavity search experiment performed at Hunan Normal University and the Institute of Physics, Chinese Academy of Sciences, representing the first stage of the APEX (Axion and dark Photon EXperiment) program. Finding no statistically significant excess, we place an upper limit on the kinetic mixing parameter |χ| 3.7 × 10−13 around mA ≃ 29.5 μeV at a 90% confidence level. This result exceeds other constraints on dark photon dark matter in this frequency range by roughly one order of magnitude.

sciforum-116938: Estimating the Effective Permittivity and Effective Thermal Conductivity of Materials with Rotationally Symmetric Inclusions

Jesus Nain Camacho Hernandez * and Guido Link

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An effective medium is a mixture of inclusions embedded in a host medium whose macroscopic properties can be approximated as those of a homogeneous material. Mixing relations are widely used to estimate the properties of effective media, i.e., their thermal conductivity and permittivity, by considering their microscopic structure. These mixture relations are based on Effective Medium Approximation and commonly assume inclusions to have idealized geometrical shapes, such as spheres or ellipsoids. While this assumption is often suitable, it becomes less accurate for inclusions that deviate significantly from those idealized geometries. This work introduces a set of rotationally symmetric geometrical elements—cones, half-spheres, toruses, biconcave disks, and cylinders—to extend the geometrical shapes for modelling inclusions. These geometrical elements may better represent certain real-world inclusions, leading to improved estimations of their effective properties. A key advantage of rotationally symmetric objects is that their orientation aligns with their axis of rotation, unlike other shapes that require more parameters for defining their orientation.

In this study, anisotropic models were constructed for numerical calculations, using rotationally symmetric elements to determine their effective permittivity and effective thermal conductivity, both given as second-order tensors. The results of their effective properties were incorporated into a topological mixing relation to determine a morphology-based correlation parameter specific to each geometrical inclusion. A comparative analysis was performed between the numerical simulation, state-of-the-art mixing relations, and the topological mixing relation across various random anisotropic models. The findings demonstrate that the topological relation offers more accurate estimations of effective properties, highlighting that the newly considered elements produce distinct results compared to spheres or ellipsoids. This, in turn, may improve the design and analysis of composite materials with diverse inclusion morphologies.

sciforum-123190: Exploring Modular Flavor Symmetries Across Various Modular Group Realizations

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The efforts of recent years to provide a theoretical explanation for the flavor problem in the Standard Model have led several authors to consider an additional symmetry in the theory, which corresponds to a finite modular group, commonly referred to as a flavor group. In the context of a SUSY or a SUGRA scenario, the super-fields of the theory transform under the action of the flavor group, while the Yukawa couplings are modular forms that depend on a scalar field. Upon closely examining the mathematics behind finite modular groups, it turns out that they are not always associated with a single space of modular forms. This mathematical detail introduces a theoretical subtlety in the construction of flavor models with modular symmetries, which ultimately leads to different phenomenological scenarios. There exist several modular groups exhibiting this characteristic that have not been used in the current literature to construct any flavor model, despite containing irreducible 3-dimensional representations (triplets) that could be assigned to each flavor because their group orders are very large, which makes their calculations computationally challenging. In this talk, the most recent advances in this direction will be presented along with some particular modular group examples with high group orders.

sciforum-118863: Exploring parity and Lorentz symmetry violations in gravity with astrophysical observations

Tao Zhu

Zhejiang University of Technology

Symmetry is a central topic in modern fundamental physics, playing a pivotal role in both quantum theories and general relativity. It was well established early in the 1950s that one of the discrete symmetries, parity, is broken in the weak interaction, revealing that our nature is parity-violating. In the context of gravitational interactions, Lorentz and parity symmetries serve as cornerstone principles of general relativity. However, many quantum theories of gravity, such as string theory, loop quantum gravity, and Hořava-Lifshitz gravity, predict potential violations of these symmetries. Furthermore, a wide range of modified gravity theories introduce explicit breaking of Lorentz and parity symmetries in the gravitational sector. Testing the fundamental symmetries of gravity through experiments and observations is therefore of critical importance. While the Lorentz and parity symmetries has been tested to spectacular accuracices in particle experiments for the standard model of particle physics, the constraints on both symmetries in the gravitational sector are far less refined. In this talk, I will focus on the violation of parity symmetry in gravity. I will provide a brief review of several parity-violating gravitational theories and discuss their potential implications for solar system tests, binary pulsars, and other astrophysical observations. Additionally, I will present our recent work on probing both parity and Lorentz symmetry violations in gravity using gravitational wave observations from the LVK collaboration as well as prospects with future gravitational wave detectors.

sciforum-118802: Full electrical manipulation of perpendicular magnetization in [111]-orientated Pt/Co heterostructure enabled by anisotropic epitaxial strain

Haiming Xu

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The effective manipulation of perpendicular magnetization through spin–orbit torque (SOT) holds great promise for advancing high-density, low-power, high-endurance nonvolatile magnetic memory and spin-logic devices. However, achieving deterministic field-free switching of perpendicular magnetization driven by SOT remains a challenge for most conventional materials with high symmetry, thereby limiting the practical applications of SOT-based spintronic devices. This study elucidates the achievement of a full electrical manipulation of the perpendicular magnetization in epitaxial [111]-orientated Pt/Co heterostructure with a face-centered cubic structure. A large anisotropic epitaxial strain induces a symmetry transition from the ideal C_{3v} to C_{1v}, attributed to the mismatch between the [11] and [1 0] directions at the Pt/Co interface, as clearly evidenced by atomic-scale imaging combined with geometrical phase analysis. First-principle calculations further reveal that this anisotropic epitaxial strain also generates a noteworthy in-plane magnetization component along the [11] direction, further breaking the magnetic symmetry. Notably, the epitaxial [111]-orientated Pt/Co heterostructure demonstrates sustained high-temperature performance, reaching up to 393 K, highlighting the robustness imparted by the strain-induced in-plane symmetry breaking within the epitaxial system. This exceptional high-temperature stability implies broad applicability for this approach, particularly in industrial-grade magnetic random-access memory. Furthermore, we have successfully demonstrated the capability to achieve all-electric control over a comprehensive set of eight Boolean logic operations within a single SOT device. This research presents a direct and potent method for harnessing epitaxial strain to break in-plane symmetry not only geometrically but also magnetically, thereby paving the way for diverse wafer-scale applications in next-generation spintronic memory devices and programmable spin-logic systems.

sciforum-122245: Geometric Origins of Yang-Mills In Flat Spacetime from Heterotic String

Hong Lv

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Gauge symmetry and diffeomorphism are two cornerstone local symmetries in fundamental physics. Interpreting the more abstract gauge symmetry as having a more intuitive geometric origin in higher dimensions was pioneered by Kaluza and Klein. However, imposing a geometric origin of non-abelian Yang-Mills gauge symmetry typically leads to gauged supergravities with AdS vacua, which is desirable in the AdS/CFT correspondence, but less valuable in particle phenomenology or cosmology.

In this talk, we propose a new duality between the bosonic string with an anomalous term and the heterotic string in ten dimensions. This duality allows us to map the Mink(4)xS(3)xS(3) vacuum of the bosonic string to the Mink(4) x R xT(1,1) vacuum. Intriguingly, the heterotic vacuum preserves 1/4 of the supersymmetry, even though it has the bosonic string origin. We exploit this duality for a new consistent Kaluza-Klein reduction of heterotic string on warped R x T(1,1) space. We obtain four-dimensional N=1 Einstein-Yang-Mills-scalar supergravities with Minkowski vacuum, where the SU(2)xSU(2) Yang-Mills originates from the isometry group of T(1,1) space.

sciforum-118127: Gross and subatomic matter/antimatter asymmetry: examination of scientific method from theory to experimental results

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One of the major mysteries of modern physics is the apparent matter/antimatter asymmetry in the Universe. In light of the recognized subatomic asymmetry between matter and antimatter, for which Cronin and Fitch received the Nobel Prize, it has recently been hypothesized that there exists a fundamental matter/antimatter symmetry in the Universe that flows directly from subatomic matter/antimatter asymmetry. An explanation of this hypothesis, and experimental results indicating the accuracy of this hypothesis, has recently been published in the presenter's article, "Composite matter/antimatter hadron structure indicated experimentally at the Texas Petawatt Laser Facility", Phys. Ess. 37(4):270 (Dec 2024). A model of a symmetric matter/antimatter hadron structure, and the resulting cosmology, are considered.

The hadron model advanced here has significant implications for flavor symmetry within hadrons, proton--proton chain reactions in stars, Dark Energy, the Cosmological Constant, Dark Matter, and beta decay.

One interesting aspect of this matter/antimatter hadron model is the role that mathematical symmetry modeling (and symmetry-breaking dynamics) has played in our understanding of the nature of matter and antimatter. Most fundamentally, the nature of scientific methods—particularly the development of scientific hypotheses from mathematical modeling—is considered. The work of Han and Nambu in early mathematical modeling (with particular emphasis on integer-charged structures within nuclei) in the 1960s is considered.

sciforum-122984: Harnessing Machine Learning for Quantum Shape Transitions: A LightGBM Approach to Nuclear Collectivity

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Nuclear shape transitions are fundamental to understanding the structural evolution and symmetry properties of atomic nuclei, especially in the rare-earth region where collective behaviors emerge prominently. In this study, we propose a novel, model-independent structural signature, $dR_{4/2} \times BE(0^+ \rightarrow 2^+)$, which combines excitation energy ratios and electromagnetic transition probabilities to sensitively probe shape-phase transitions in even-even nuclei ranging from Ce to Hf (Z = 58–72, N = 84–102). To address experimental data limitations in certain isotopes, we complement this physics-based approach with a machine learning framework based on the Light Gradient Boosting Machine (LightGBM) algorithm. Using refined Grodzins-type parameters as input features, the model is trained to predict the evolution of nuclear collectivity across isotopic chains. This approach builds upon our previously validated methodology, recently accepted at a leading IEEE platform, reinforcing its robustness and relevance to nuclear physics research. Our study is the first to develop a unified, data-driven strategy that effectively models shape evolution and collective dynamics in the A~150 mass region, even where experimental data are lacking or sparse. The model successfully captures known systematics and anomalies, predicts unmeasured properties in ten nuclei, and accurately delineates transitional behavior near N≈90 in Gd–Er and symmetry saturation around N≈100 in Yb–Hf. The convergence of the proposed structural parameter toward unity reveals strong correlations with U(5) to SU(3) shape-phase transitions, consistent with the Interacting Boson Approximation (IBA) framework. By bridging physical observables with machine learning predictions, this study presents a powerful and interpretable framework for exploring nuclear symmetry and guiding both experimental designs and theoretical advancements in nuclear structure research.

sciforum-119359: Holographic Correlators of Boundary/Crosscap CFTs in Two Dimensions

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This work explores holographic correlators within the frameworks of two-dimensional Boundary Conformal Field Theory (BCFT) and Crosscap Conformal Field Theory (XCFT). Utilizing the AdS/CFT correspondence, we compute stress tensor correlators in BCFT, considering both tensionless and tensionful end-of-the-world (EOW) brane scenarios. We derive recurrence relations for two-point and three-point correlators and examine the impact of non-zero brane tension on correlators. Extending these results, we investigate the holographic duals of XCFTs, presenting explicit scalar and stress tensor correlator computations on projective geometries such as RP2. Additionally, we analyze stress tensor correlators at a finite cutoff, uncovering deformations of one-point and two-point functions induced by the cutoff. Our findings provide novel insights into the holographic structures of BCFT and XCFT while laying the groundwork for future research into higher-dimensional extensions.

sciforum-121871: Laboratory Constraints on Neutrinophilic Mediators Without Infrared Divergences

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Some (light) particles ϕ can couple to the neutrinos ν and charged leptons ℓ in the standard model (SM), and thus be relevant to neutrino self-interactions, heavy neutrinos, and dark (matter) particles etc. Such particles will induce exotic decays of some SM particles, such as the exotic decays $\pi, K \to \ell + \nu + \phi$, $\tau \to \pi + \nu + \phi$ and $Z \to \nu + \bar{\nu} + \phi$. However, these decays suffer from infrared divergences in the limit of the vanishing mediator mass, i.e., $m_\phi \to 0$. We show that the infrared divergences can be cancelled out by including the 1-loop contributions of the mediator to the standard 2-body decays, by virtue of the Kinoshita–Lee–Nauenberg theorem. We then update the existing laboratory constraints on neutrinophilic scalar mediators, thereby extending the limits far beyond the decaying parent particle mass and excluding a wider range of parameter space. These corrections will also changes significantly the current experimental limits, e.g. those from PIENU and NA62. These new “physical” limits derived here have significant implications for the future detection prospects of non-standard neutrino (self-)interactions. The requirement of absence of infrared divergences will also have far-reaching implications for the rich phenomenologies of heavy neutrinos and dark matter particles.

sciforum-123043: Large gauge transformation in cosmological perturbation theory

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Cosmological perturbation theory plays an important role in linking models of the early universe with observed density fluctuations. Various pathologies can seemingly occur when considering quantum loop corrections, but many of these can be resolved by understanding a symmetry called Large gauge transformation. This symmetry is a symmetry for global transformations derived from the symmetry for general coordinate transformations that inevitably exists in the framework of relativistic theories. One of the problems solved by this symmetry is the problem of infrared divergence. By requesting that the state of the universe preserves this symmetry, it can be shown that the IR divergence appearing in the loop calculations cancels out completely. It also allows us to guarantee that the theoretical predictions of cosmologically observed fluctuations are robust predictions, independent of what has happened on smaller scales. This has received much attention in recent years due to the upsurge in research on primordial black hole formation scenarios. Furthermore, the equation between correlation functions, called the consistency relation in cosmological perturbations, can also be understood naturally from the standpoint of respecting the Large gauge transformation. It can be said that this principle has been unconsciously respected as a result of actual honest calculations. On the other hand, in exotic scenarios, pathologies can occur because this symmetry is not respected.

sciforum-117020: Multifractal Dimension Spectrum Analysis for Nuclear Density Distribution

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The study of the intricate distribution of nucleons in atomic nuclei, resulting from complex nucleon correlations, is essential for deepening our understanding of nuclear physics. We introduce a simple and novel method using multifractal spectral dimensions to study the non-uniformity and irregularity of nucleon distribution in different types of atomic nuclei. This approach quantifies the spatial complexity and heterogeneity of nucleon arrangements, providing a powerful tool to explore the underlying nuclear forces and interactions. By analyzing the multifractal spectral dimensions, we can capture subtle variations in nuclear morphology, such as the diffuse neutron halo in exotic nuclei and the localized clustering in α-structured systems. We perform a thorough analysis of ^{16}O, ^{40}Ca, and ^{208}Pb, covering both stable configurations and unconventional arrangements, including neutron halo structures and tetrahedral α-clustering. Our results reveal distinct patterns corresponding to different nucleon distribution structures, demonstrating the remarkable sensitivity of multifractal spectral dimensions to nucleon density distributions. The simplicity and robustness of this approach make it a valuable tool for improving nuclear modeling and predicting nuclear behavior. By bridging the gap between theoretical models and experimental observations, our method offers a new perspective for exploring the rich diversity of nuclear systems and their emergent properties. This work not only deepens our understanding of nuclear phenomena but also opens new avenues for studying the complex structural characteristics of atomic nuclei, with potential applications in nuclear astrophysics, reactor physics, and the study of exotic nuclei.

sciforum-117670: New axion contribution to two-photon decays of neutral pions

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The presence of axions introduces new diagrams at one-loop order to the two-photon decays of the neutral pion through axion–pion mixing. In this work, we calculate this correction, missing in all current calculations, in the framework of SU(2) chiral perturbation theory. We show that the correction is proportional to the axion–photon coupling and the square of axion mass, which in turn is strongly suppressed by the axion decay constant for the classical space window but may not be negligible for the QCD axion in the MeV or even larger mass range. On the other hand, in combination with the experimental measurement of the decay width of $\pi^0\rightarrow\gamma\gamma$ process, this result rules out the standard QCD axion as an explanation for the possible discrepancy between the chiral perturbation theory prediction and the experimental data. Our result provides insight into the behavior of the neutral pion in the presence of an axion field background. We mention that, similar to the heavy QCD axion, ALPs can also couple to the neutral pion and have masses in the MeV range or beyond. In this sense, the discussion can also be extended to ALPs, although ALPs are not proposed to solve the strong CP problem and their masses are independent of the corresponding decay constant. We hope that this will stimulate work towards a more controlled determination of the coupling constants of CHPT and experimental searches for the axion, including the standard and heavy QCD axions and ALPs, as well as future research on the dynamics of the QCD axion and ALPs and their implications for cosmology, such as in a warm and dense medium.

sciforum-119243: Progress on the open string pair production in Type II superstrings

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In this talk, we will report on the progress of the open string pair production, like the Schwinger pair production in QED, for D-branes carrying their respective worldvolume electric fields in Type II string theories. We find that one isolated D-brane cannot give rise to the pair production. We need at least two D-branes, for example, two D3 branes, placed in parallel at a separation, with one taken as the visible brane, mimicking our own (1 + 3) world, and the other one taken as the hidden one. The open string pair production is due to the virtual open string/anti-open string connecting the two D3 branes, thus along the direction transverse to the visible brane. In other words, the produced pair is along the extra dimensions. We explain the physics behind the pair production enhancement when a particular magnetic flux is also applied. In addition, we will discuss the relation between the stringy computed pair production rate and the relevant QED one and show that the two agree with each other when the so-called weak field limit is taken. This has important implications in that the detection of the usual QED Schwinger pair production provides not only a test of the QED vacuum picture, but also potentially hints at the existence of extra dimensions, along with that of dark matter, not in the form of particles (the hidden brane with respect to the visible one), given that as long as the pair production is concerned, this system can be viewed as a simplified version of the intersecting D-brane construction of the particle physics standard model.

sciforum-118843: QCD topology and axion properties in an isotropic hot and dense medium

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We study the QCD topology and axion properties at finite temperature and chemical potential in the framework of the two-flavor Nambu–Jona-Lasinio model. We find that the behaviors of the two lowest cumulants of the QCD topological charge distribution and axion properties are highly sensitive to the critical behavior of the chiral phase tran sition. In particular, the topological susceptibility and the axion mass follow the response of the chiral condensate to temperature and chemical potential, showing that both quantities decrease monotonically with the increment of temperature and/or chemical potential. However, it is important to note that the normalized fourth cumulant behaves differently depending on the temperature. At low temperatures, it is a non-monotonic function of the chemical potential, while at high temperatures, it monotonically decreases. Additionally, its value invariably approaches the asymptotic value of b_2^{inst} = –1/12, predicted by the dilute instanton gas model. We also observe that with the increase in chemical potential at relatively low temperatures, the axion self-coupling constant exhibits a sharp peak around the critical point, which can even be more than twice its vacuum value. After that, the self-coupling drops sharply to a much lower value than its vacuum value, eventually approaching zero in the high chemical potential limit. The finding that the axion self-coupling constant is significantly enhanced in high-density environments near the chiral phase transition could lead to the creation or enhancement of an axion Bose–Einstein condensatein compact astrophysical objects.

sciforum-121524: Recent Dark "Matter/Photon/Higgs" search results from ATLAS

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A first dedicated search was performed for dark matter particles produced in association with a resonantly produced pair of b-quarks with m(bb) 150 GeV, using 140 $fb^{-1}$of proton–proton collisions recorded by the ATLAS detector at a center-of-mass energy of 13 TeV. This signature is expected in extensions of the Standard Model predicting the production of dark matter particles, particularly those containing dark Higgs bosons. This search uses a novel experimental method to extend the experimental reach to lower bb-pair invariant masses, considers a wider range of dark Higgs boson interpretations, and excludes new regions of parameter space for this model.

Science Bulletin 2024,69(19):3005-3035

Results from a wide range of searches targeting different experimental signatures with and without missing transverse momentum (?$_?^{????}$) are used to constrain a Two-Higgs-Doublet Model (2HDM) with an additional pseudo-scalar mediating the interaction between ordinary and dark matter (2HDM+a). Constraints are derived for several common as well as new benchmark scenarios within the 2HDM+a, leading to the best results of this type of collider search in the world.

JHEP 08 (2024) 153

A combination of searches for Higgs boson decaying into a visible photon and a massless dark photon (H→γγ?) is presented using 139 fb^{-1} of proton–proton collision data at a centre-of-mass energy of √s = 13 TeV recorded by the ATLAS detector at the Large Hadron Collider. The observed (expected) 95% confidence level upper limit on the Standard Model Higgs boson decay branching ratio is determined to be Br(H→γγ$_?$) 1.3% (1.5%). The search is also sensitive to higher-mass Higgs bosons decaying into the same final state. The observed (expected) 95% CL limit on the cross-section time branching ratio ranges from 16 fb (26 fb) for ?$_?$ = 400 GeV to 1.0 fb (1.5 fb) for ?$_?$ = 3 TeV. Results are also interpreted in the context of a minimal simplified model.

sciforum-116887: Sixfold Discrete Symmetry of Fermion Fields as an Explanation for Dark Matter

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Abstract: We address the question "what is dark matter?" The method uses the Pauli algebra formof the Dirac equation, equivalent to the standard one but allowing the use of the multiplicative structure of algebra. In this form, discrete symmetries of fermion fields are the same as the automorphisms of the Pauli group. We construct the prototype Dirac equation using Clifford algebra and then use its six representations by complex two-by-two matrices to construct the six symmetric versions, indexed by permutations of three letters. The solutions of symmetric equations form the six sectors of fermion fields. It is shown that the sectors are genuinely distinct, by proving that any fermion field belonging to two different sectors must have zero mass. Also shown is the lack of electromagnetic interaction between one sector and another, since each sector has its own matrix coupling the fermion field to the electromagnetic field. The key tool used is mass inversion symmetry, introduced in [1]. The sixfold symmetry predicts the ratio of dark to ordinary matter to be 5:1, which is close to the observed ratio of 5.2:1. However, this symmetry is constructed only for interactions between fermion fields and the electromagnetic field, not yet taking into account the weak and strong interactions. So this article is an indication that maybe the complete answer can be found if sixfold symmetry extends to these interactions.

sciforum-118107: Symmetry constraint on Berry phase in crystalline solid

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Topological quantum chemistry has seen sucessful application in classification of topology of connected band in crystalline solid. This is based on the hypothesis that connected band with real space description based on Wannier functions centred on the crystallographic orbits of Wyckoff position. This naturally leads to investigation based on band representations or EBRs, which are the Fourier transform of these Wannier functions with respect to the coordinates of the orbits of the Wyckoff positions. However, there are know issues. The first concerns the hypothesis of triviality of connected bands represented by Wannier functions induced BRs. It is known that band associated with Wannier functions centred on orbits of Wyckoff position 4b of crystal with space group F222 has non-zero Berry phase. The second is that the determination of topology of band connectivity, established from decomposition of EBR and compatibility relation, requires explicit evaluation of Berry phase or Wilson matrix. The question arises if possible configurations of band connectivity of EBR can be established from symmetry without involving dynamics of a system. It is clearly desirable to have a symmetry based technique to establish all possible configuration of band connectivities from EBR that exclude those identified from compatibility relations but not represented by EBR. The third concerns disconnected band represented by EBR centred on Wyckoff positions with multiplicity and whether the disconnected components are trivial or non-trivial. Alternative question is if there is invariant subspaces for such EBR. The last is that if there is a symmetry based selection rule on Berry phase or other Wilson matrix based topological invariants given a connected bands and space group, which supersede the hypothesis and address the contra-indication. Projection operator techniques are developed to establish band connectivity that corresponds to EBRs. Selection rule is developed based on general matrix elements theorem.

sciforum-109870: Symmetry in Kottler–Møller and Rindler Coordinates with Coupled Parameters

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This report investigates symmetry properties in Kottler–Møller and Rindler coordinate systems, focusing on their application to light-like, space-like, and time-like trajectories with coupled parameters. These coordinate systems are essential for describing accelerated and uniformly moving reference frames in relativistic contexts. Kottler–Møller coordinates are used to model hyperbolic motion under constant acceleration, while Rindler coordinates describe uniformly accelerated observers and event horizons. The analysis explores how symmetry is maintained or broken in these systems under varying trajectory types, providing insights into spacetime structure.

The theoretical background of Kottler–Møller and Rindler coordinates is reviewed, emphasizing their relevance in general relativity and quantum field theory in curved spacetime. These coordinates are critical for understanding observer-dependent horizons and accelerated motion. A challenge arises in applying these systems to different types of trajectories, especially in preserving symmetry for light-like, space-like, and time-like paths. This challenge is addressed by examining the symmetries and invariants within each coordinate system, focusing on the effects of coupled parameters.

Algebraic methods are employed to identify the invariants under symmetry transformations for each trajectory type and to analyze the consistency of these transformations across different frames. Special attention is given to the singularities that occur in light-like and space-like cases. The results show that Rindler coordinates impose unique constraints on coupled parameters for light-like trajectories due to the presence of event horizons. In contrast, Kottler–Møller coordinates exhibit robust symmetry across all trajectory types when specific parameters are coupled.

In conclusion, coupled parameters play a key role in controlling symmetry properties within these coordinate systems. The findings suggest that understanding symmetry in Kottler–Møller and Rindler coordinates provides valuable insights into accelerated motion and the role of horizons. This work contributes to the broader field of relativistic physics, where the interaction between accelerated frames and spacetime geometry has significant implications.

sciforum-119362: Testing parity violations in the gravitational sector: birefringence in fermion-attenuated gravitational wave power spectrum

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Within the framework of Chern-Simons gravity, a theory that dynamically violates parity, we analyze the power spectrum of gravitational waves in light of the damping effect due to the free streaming of relativistic neutrinos and dark fermions. The power spectrum is expressed in terms of right- and left-handed polarizations, and the evolution of the gravitational waves is studied numerically. Birefringence is explicitly shown in the power spectrum, though the difference in the amplitudes is small. Specific features of peaks and dips appear in the gravitational waves power spectrum, mirroring chiral gravitational waves mediated parametric resonance during reheating. Our result represents a useful tool to test Chern-Simons gravity and enables to constrain mechanisms of inflation and reheating related to this theory. We predict a falsifiable pattern of observable peaks and dips in the chiral independent gravitational waves power spectrum, eventually observable in next space-borne gravitational interferometers, including LISA, Taiji and Tianqin.

sciforum-118853: The correspondence of generalised entropic cosmology theory with $F(T)$ and $F(Q)$ modified gravity and gravitational waves

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This talk is based on the collaboration with Sergei D. Odintsov, arXiv:2502.15272 [gr-qc]. We investigate the correspondence between modified gravity theories and general entropic cosmology theory. Such a theory is proposed by an analogy with Jacobson's work, where the Einstein equation was derived from the Bekenstein–Hawking entropy. We compare FLRW equations obtained in entropic gravity with those in modified gravity theories. Some correspondence was found between $F(T)$ and $F(Q)$ gravity and general entropic gravity. We regard the $F(T)$ and $F(Q)$ gravity theories as effective local theories corresponding to the entropic gravity theories, and we investigate the gravitational waves. The obtained equation of the gravitational wave is identical to that in Einstein's concept of gravity, except that the gravitational coupling is modified by the functional forms of $F(T)$ and $F(Q)$. It is interesting that, in the case of the Tsallis entropic cosmology, gravitational coupling becomes small or large, which may suppress or enhance the emission of the gravitational wave.

sciforum-117973: The post-Newtonian metric of a self-gravitating and collapsing thin spherical shell

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Birkhoff's theorem asserts that the spacetime geometry of any spherically symmetric system must be static and is uniquely described by the Schwarzschild metric, which is time-independent and does not account for any dynamic features. However, in this work, we investigate the metric of a self-gravitating, collapsing, infinitely thin spherical shell in the weak-field and slow-motion limits, revealing a contradiction to Birkhoff's theorem within the framework of the post-Newtonian (PN) approximation theory. Our calculations show that, in the PN approximation, the time-dependent metric describing such a system does not conform to the static Schwarzschild solution. This is because, in this dynamic scenario, the matter distribution evolves over time, affecting the spacetime geometry in a way that is not captured by the Schwarzschild metric. To ensure the accuracy of our approach, we not only demonstrate that the PN metric satisfies the Einstein field equations to the appropriate order but also derive the leading-order components of the energy-momentum tensor for the thin spherical shell. The primary aim of this work is to highlight an important subtlety in solving the Einstein field equations: coordinate transformations can change the form of the matter energy-momentum tensor, leading to a solution that no longer corresponds to the original physical setup, thus affecting the interpretation of the resulting metric.

sciforum-121504: The Recent Progress of DarkSHINE R&D

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Sci. China-Phys. Mech. Astron., 66(1): 211062 (2023)
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PoS ICHEP2024 (2025) 728 [DOI:10.22323/1.476.0728]
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DOI:10.1016/j.nuclphysbps.2024.06.019 [CLHCP2023 proceeding]
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DOI:10.1016/j.nuclphysbps.2024.06.014 [CLHCP2023 proceeding]
DOI:10.1016/j.nuclphysbps.2024.07.003 [CLHCP2023 proceeding]

DarkSHINE is a fixed-target experimental initiative which aims to search for light Dark Matter and mediators at SHINE (Shanghai high repetition rate XFEL and extreme light facility being the first hard X-ray FEL in China), which is under construction with targeted completion in 2025/2026. DarkSHINE aims to search for a new mediator, Dark Photons, bridging together the Dark sector and ordinary matter. In this work and presentation, we present the idea of this new project and first prospective study in the search for Dark Photons decaying into light Dark Matter as well as the very recent progress made in technical R&D. It also provides the opportunity to incorporate a broader scope of BSM search ideas such as ALP/Anomalous Muonium/LLP, etc., and electron/photon/neutrino-nuclear interaction product measurements, utilizing a fixed-target experiment of this type. Also, in the future, the DarkSHINE experiment has great potential to be upgraded into the positron beam mode and search for Dark Photons via more production channels through s/t-channel annihilations. Last but not least, DarkSHINE will likely provide cross-reference experimental data together with future LDMX experiments, the continued NA64 experiment, etc., and become part of the global efforts for accelerator-based Dark Matter searches.

sciforum-122384: The Six-fold Discrete Symmetry of Fermion Fields as an Explanation for Dark Matter

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Using the version of the Dirac equation formulated in the Pauli algebra of two-by-two complex matrices, we show the existence of its six symmetric versions, the solutions of which are referred to as the six sectors of fermion fields. There is proof that the Pauli algebra version is fully equivalent to the standard version. There is also proof that the six sectors are distinct, showing that if a fermion field belongs to two sectors at once, then its mass is necessarily zero. The proof uses the mass inversion symmetry introduced in an earlier article. This symmetry, denoted M, is mathematically similar to the charge conjugation of symmetry C.

Also shown is the lack of electromagnetic interactions between different sectors since each of the six equations has its own matrix coupling the fermion field to the electromagnetic field. This explains why matter belonging to sectors other than ours is invisible to us.

Altogether, this predicts a ratio of dark matter to ordinary matter of 5:1, which is close to the observed ratio of 5.2:1. There is the possibility that there is no discrepancy at all between the prediction and the observations if some ordinary matter belonging to our sector is not visible, such as being in a black hole without visible accretion.

It is shown that the group of discrete symmetries of fermion fields is isomorphic to the group of automorphisms of the first Pauli group (G1).

Since the six-fold symmetry is only proven for electromagnetic interactions, there is a need to check if it extends to the whole electroweak sector. This and the hypothetical extension of the symmetry to strong interactions should be atopic of further research.

sciforum-118556: The unified universe history from modified gravity

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Current science lacks universality. Each discipline includes dozens of sub-disciplines. Often, researchers working within the same discipline but with different sub-disciplines do not even understand each other's research terminology. This is true for physics, biology, chemistry, etc. We search for some fundamental principles that may help to create a universal approach to the understanding of the fundamental laws governing our universe. Symmetry may be one of such principles. The current talk on theoretical cosmology gives a brief overview of the universe's history from inflation to radiation/matter dominance and, finally, the dark energy era via modified gravity. A number of alternative gravities that pretend to describe the universe's evolution are reviewed. Such theories enjoy general covariance, and they are often ghost-free ones. Special attention is paid to so-called F(R) gravity and Einstein–Gauss–Bonnet gravity. This universal general approach opens a new view to the universe's evolution as a whole, not just specific descrptions of eras, which are now standard in cosmology. The specific details of our studies can be found in reviews:

S.~Nojiri, S.~D.~Odintsov and V.~K.~Oikonomou, Modified Gravity Theories on a Nutshell: Inflation, Bounce and Late-time Evolution," Phys. Rept. \textbf{692} (2017), 1-104;

J.~de Haro, S.~Nojiri, S.~D.~Odintsov, V.~K.~Oikonomou and S.~Pan, Finite-time cosmological singularities and the possible fate of the Universe," Phys. Rept. \textbf{1034} (2023), 1-114

sciforum-118085: Unitarity and causality constraints on effective field theories

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Implications of general properties of quantum field theory, such as causality, unitarity, and locality include constraints on the couplings of the effective field theory (EFT) coefficients. These constraints follow from the connections between the infrared (IR) and ultraviolet (UV) theory imposed by dispersion relations for four-particle amplitudes which formally allow us to express EFT couplings through the moments of positive-definite functions (imaginary parts of partial wave amplitudes). Previous studies of these positivity bounds were mainly focused on the weakly coupled EFTs, limiting the analysis to tree-level amplitudes of the IR theory. In this work, we extend the scope of positivity bounds including one-loop amplitudes, which is essential especially for the loops of massless particles. Examining a single scalar theory we confirm that the presence of massless loops cannot be reduced only to the running of EFT couplings because loops also modify the crossing symmetry relations (null constraints). Our results demonstrate that while for small coupling constants, the one-loop bounds are in good agreement with the tree-level results, the allowed EFT parameter ranges can be significantly modified if a weak coupling assumption is not additionally imposed. In particular, we found that an upper bound on dimension-8 coupling becomes significantly stronger, and the dimension-12 coupling can be slightly negative which was thought to be forbidden by tree-level positivity bounds.

sciforum-118178: When symmetries break! — The implications of symmetry breaking in fundamental physics

Andrew Fowlie

Xi'an Jiaotong Liverpool University, Suzhou, China

We discuss the significance of symmetry and symmetry breaking in fundamental physics. Using the symmetries of the Standard Model of particle physics as an example, we start by reviewing the role of symmetry in our current laws of nature, including discrete symmetries and continuous space-time, global and gauge symmetries. We introduce the concept of spontaneously symmetry breaking and explain how the ground state of a theory can break a symmetry, paying particular attention to the Higgs mechanism of the Standard Model. We briefly note other ways in which symmetries may be broken, such as explicitly or by quantum effects. We explain why some symmetries, such as the electroweak symmetry, must be broken and, using electroweak symmetry and supersymmetry as examples, discuss why only spontaneously breaking a symmetry preserves desirable aspects of that symmetry. Lastly, we discuss the observational consequences of symmetry breaking in our cosmological history. We show that symmetries can break during a first-order phase transition. We discuss an important observational consequence of a such a transition — gravitational waves. These are ripples in space-time caused by the violent release of latent heat and could be detected using special laser interferometers. Lastly, we explain the connection between symmetry breaking and the dominance of matter over anti-matter.

Session 2. Mathematics

sciforum-117155: Recent advances in Aharonov–Bohm extended electrodynamics

Giovanni Modanese [1,*] and Fernando Minotti [2]

[1] University of Bolzano
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The extended theory of electrodynamics, which was first proposed by Ohmura in 1956 and then by Aharonov and Bohm in 1963, has been considerably developed in recent years, concerning both its (simple!) formal structure and its possible applications. The main features of this extended theory are that (1) local conservation of charge is not required in a matter system as a condition for making possible its coupling to the e.m. field; (2) gauge invariance is reduced; and (3) there is an additional e.m. degree of freedom represented by a scalar field S. The field S satisfies a D'Alembert equation in which the source is the "extra-current" I, which quantifies the violation of local conservation, namely $I=\partial_t\rho+\nabla\cdot\mathbf{J}$. An additional feature is that the expressions for the e.m. energy–momentum tensor and the Lorenz force are partially modified. For example, the power exerted by the e.m. field on a probe contains, besides the usual terms, a term proportional to I_pV, where V is the electric potential and I_p is the extra-current in the probe. All this can have interesting phenomenological consequences for the e.m. interactions of quantum systems at the semi-classical level, in cases in which local charge conservation is partially violated for various reasons. Of special interest, in this respect, are systems with macroscopic quantum effects, molecular junctions, tunnel junctions.

sciforum-119801: Algebraic Nexus of Fibonacci Forms and Two-Simplex Topology in Multicellular Morphogenesis

Elizabeth Lamb

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sciforum-118010: Generalized bigraded Toda hierarchy

Yue Liu, Xingjie Yan, Jinbiao Wang * and Jipeng Cheng

School of Mathematics, China University of Mining and Technology, Xuzhou, 100083, China

The bigraded Toda hierarchy is a special reduction of Toda hierarchy under a constraint, and this constraint has a generalization with respect to the eigenfunction of Toda hierarchy, which is the analogue of the famous constrained KP hierarchy. We refer to this as the generalized bigraded Toda hierarchy (GBTH). This hierarchy begins with the constrained KP hierarchy and boson-fermion correspondence, which establishes an isomorphism between fermionic and bosonic Fock spaces. It is known that different bosonizations of the fermionic KP hierarchy will give rise to different kinds of integrable hierarchies. Using two typical bosonizations, KP and Toda, one can derive the fermionic hierarchy of constrained KP hierarchy by applying the inverse of bosonization of KP to its bilinear equations. From this fermionic form, bilinear equations of GBTH can be derived by using another bosonization. One can also find that the tau functions of GBTH satisfy the modified Toda hierarchy. Next, based upon the bilinear equations, the wave functions, dressing operators, Lax equations and constraint of GBTH can be obtained with a method similar to Toda hierarchy. Conversely, we also derive bilinear equations of GBTH from the corresponding Lax structure, thereby proving the equivalence between the bilinear equations and the Lax structure.

sciforum-123188: Trisection of the angle

Constantinos Challoumis

National and Kapodistrian University of Athens

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sciforum-117907: A Novel Model of Supply and Demand of Energy for Solar Farms in China

Samad Noeiaghdam

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The efficient management of solar energy systems is critical for maximizing energy production and ensuring grid stability. This study presents a comprehensive analysis of a nonlinear system of ordinary differential equations (ODEs) that models the dynamics of energy supply, demand, and storage in a solar cell farm. The model incorporates key factors such as solar irradiance, temperature, battery storage, and maintenance costs, providing a robust framework for understanding the complex interactions within solar energy systems. Using the Adomian Decomposition Method (ADM), we solve the system of ODEs and analyze the stability of the equilibrium points by computing the eigenvalues of the Jacobian matrix. Real-world data from China is used to parameterize the model, ensuring practical relevance. The study evaluates the convergence of the approximate solutions and computes the residual errors for different levels of approximation, demonstrating the accuracy and reliability of the ADM. The results show that the system exhibits unstable equilibrium points under normal conditions, highlighting the need for control mechanisms to ensure stability. Numerical simulations reveal that the ADM provides highly accurate solutions, with residual errors decreasing significantly as the number of iterations increases. This work contributes to the growing body of knowledge on solar energy systems by providing a theoretical framework for analyzing the dynamics of solar farms and offering practical insights for optimizing energy production and storage. The findings have important implications for energy policymakers, engineers, and researchers working on renewable energy systems.

sciforum-118117: A Shear Flow Model for Compressible Micropolar Real Fluids with Heat Conduction and Symmetry-Driven Reduction

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sciforum-123103: Advancing Tensor Theories

Pierros Ntelis

Aix-Marseille University

I will present herein an in-depth exploration of the foundational principles of tensor and category theories, advancing these fields through the introduction of novel concepts backed by rigorous constructive proofs. A central focus will be the generalization of tensor theory via the innovative concept of a generalized tensor index. This versatile framework unifies diverse tensor indices into a cohesive structure, extending beyond traditional notions of vectors and dual vectors. I will delve into the transformation properties of these generalized tensors, demonstrating how they expand the expressive power of tensor calculus. To enrich this framework, I will employ fractional derivatives to offer a geometrical interpretation, unveiling fresh insights into the structural properties of these tensors and their potential to capture complex phenomena, such as fractional geometry, in an economical and elegant manner.

Furthermore, I will establish a profound linkage between tensor and category theories, weaving together sets, tensors, categories, and functors, augmented by extensions like partial differentiation and integration. This synthesis gives rise to original mathematical constructs—setorial tensors, categorial tensors, and functorial tensors—each opening uncharted pathways in mathematical analysis. Setorial tensors, for instance, introduce tensors with set-based elements, while categorial and functorial tensors integrate categories and functors as tensor components, fostering a novel interplay between these disciplines. These contributions build upon and extend prior research, significantly enhancing tensor, category, set theories, logic, topology, symmetry, algebraic geometry, foundations, and philosophy.

The implications of this work are far-reaching, with potential applications spanning physics, topology, and beyond. For example, the connection between generalized tensors and fractional derivatives may find use in quantum mechanics or differential geometry, while the fusion of tensor and category theories could inspire new approaches in theoretical physics and computational frameworks. This study will illuminate these advancements, offering a forward-looking perspective on their transformative potential across mathematics and science.

sciforum-118056: Babylonian algorithm

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Xi 'an University of Architecture and Technology, Soochow University

This paper presents a novel and efficient solution method based on an improved Babylonian algorithm for analyzing the dynamic behavior of strongly nonlinear vibration systems. This research focuses on typical high-order nonlinear oscillator equations, innovatively combining ancient computational principles with modern engineering challenges. By introducing dynamic adaptive weighting factors and frequency correction terms, the iterative process of the 3800-year-old Babylonian algorithm has been fundamentally optimized. These improvements enable the automatic adjustment of approximation accuracy and stability control during the iteration process. Compared with traditional methods, the convergence speed is increased by 30% to 50%, while the error relative to the exact solution remains within 1%. The modified algorithm demonstrates outstanding adaptability to complex nonlinear phenomena such as amplitude–frequency dependency changes and bifurcation behaviors caused by high-order nonlinear terms, which usually pose challenges to traditional methods like the Homotopy Perturbation Method (HPM) and Variational Iteration Method (VIM). Numerical verification within the parameter range (a, b) shows a high degree of consistency with the analytical solution, especially in capturing the transient response during the energy conversion process. Practical applications in micro-electromechanical systems (MEMSs) demonstrate that the algorithm's computational efficiency is 40% faster than mainstream algorithms in nonlinear resonance analysis, effectively solving key issues including nonlinear stiffness compensation and dynamic stability prediction. This research not only reactivates ancient mathematical wisdom through modern computational mechanics but also establishes a new paradigm for solving high-dimensional nonlinear problems in smart materials and energy harvesting devices. The open-source implementation framework of the algorithm further enhances its potential in industrial applications requiring real-time nonlinear system optimization.

sciforum-123625: Babylonian Algorithms and Ancient Chinese Algorithms and Their Modern Applications

Ji-Huan He

Yango University

This paper delves into Babylonian and ancient Chinese algorithms, exploring their principles, connections, and modern applications, while also introducing the variational iteration algorithm. The Babylonian square - root algorithm yields highly accurate approximate solutions by iteration, based on inequality - based mean - value computations. He Chengtian's inequality from ancient China is closely related to the Babylonian algorithms, and there is an inherent connection between He Chengtian's mean and the Ying Buzu Shu. Both share similarities in practical problem-solving approaches and algorithmic foundations.

These ancient algorithms are widely used in contemporary scenarios. He Chengtian's inequality is used in areas such as musical scale reconstruction and solving nonlinear vibration equations. The Ying Buzu Shu can solve problems such as nonlinear vibration equations. Babylonian algorithms are used in MEMS systems and nonlinear vibration studies. The variational iteration method effectively solves a wide range of equations and has shown remarkable results in various fields, including fuzzy differential equations, optimal control, finance, q-difference equations, swarm intelligence, differential-difference equations, and electrochemistry.

Despite their origins in different civilizations, ancient algorithms embody parallel mathematical reasoning and logic. They provide valuable insights for modern mathematics and scientific research. Modern methods, such as the variational iteration algorithm, build on these ancient concepts and drive continuous progress in related disciplines.

sciforum-119351: Bianchi Type V Anisotropic Cosmological model with a Dynamic Cosmological Constant Λ(t) along with Quadratic Deceleration Parameter in f (R, T) Gravity

Jenia Fardousi Koly [1], Md. Nirab Hossain [2,*], Rashedul Islam Seum [3] and Dr. Md Showkat Ali [4]

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[4] Vice Chancellor (VC), Begum Rokeya University, Rangpur Professor, Department of Applied Mathematics, University of Dhaka

Introduction

This study investigates a Bianchi Type V anisotropic cosmological model in the *f(R, T)* gravity framework, incorporating a time-dependent cosmological constant Λ(t) and a quadratic deceleration parameter. This work aims to explore how modifications to general relativity, particularly the introduction of *f(R, T)* gravity, can explain the observed accelerated expansion of the universe. The presence of anisotropy in the large-scale structure of the cosmos and the dynamical evolution of the deceleration parameter makes this model a compelling alternative to the standard ΛCDM paradigm.

Methods

The field equations are derived using the modified Hilbert-Einstein action for *f(R, T)* gravity, with a time-dependent deceleration parameter. Solutions are obtained under an anisotropic metric, with constraints ensuring physical viability. Key cosmological parameters, including the Hubble parameter, scale factor, and energy density, are analyzed using analytical and numerical techniques. Stability conditions and energy constraints are examined.

Results

The findings indicate that the anisotropy parameter remains constant throughout cosmic evolution, implying a stable anisotropic expansion. The equation of state parameter exhibits a transition from a quintessence-like phase to a phantom-dominated scenario, suggesting the potential occurrence of a Big Rip singularity. The Om(z) diagnostic test confirms that the universe undergoes a transition from a decelerated phase to an accelerated expansion, consistent with late-time cosmic observations. Graphical analysis of cosmological parameters further supports the model's predictions and highlights deviations from the standard ΛCDM model.

Conclusions

The study demonstrates that incorporating a time-dependent cosmological constant in gravity provides an effective theoretical framework for explaining the universe's accelerated expansion and transition phases. The proposed model successfully describes cosmic evolution while maintaining physical consistency. These results contribute to ongoing efforts in modifying general relativity to better align with observational data and offer insights into the nature of dark energy and cosmic anisotropy.

sciforum-122989: Combinatorial comparison of trace monoids via their dependence graph symmetries

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Traces are equivalence classes of strings in an alphabet Σ, where some letters commute—modeling actions that can run in parallel—and others do not and must run sequentially. These are described with the dependence graph (Σ , D) and its complementary independence graph (Σ , I). Two basic performance measures of a trace, t, are its sequential and parallel execution times, known as length |t| and height h(t), respectively. Traces of height one correspond to cliques of (Σ , I). Every trace has a particular unique representation as a product of cliques known as the Cartier–Foata normal form (CFNM).

The trace monoid M=M(Σ,D) is described by the bivariate generating series F(D)= F(x,y)=∑_(t∈M)⁣ 〚x^h(t) y^(|t|) 〛. In Ref. [1], we show that F(D) is rational and can be easily computed using the symmetries of the dependence graph via the notion of equitable partition, also known as feasible coloration in Ref. [2].

We now investigate under which conditions on their dependence graphs two trace monoids M(Σ , D_1) and M(Σ , D_2) are combinatorially equivalent, i.e., F(D_1)= F(D_2). We search amongst fractionally isomorphic graphs (graphs that have the same equitable partition; see Ref. [3] for more details) with the same independence polynomial. This is an ongoing research project; to our knowledge, it seems difficult to find such a pair of non-isomorphic graphs. The same question is also meaningful for the seemingly easier problem of comparing the corresponding height-generating series H(x)=F(x,1).

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sciforum-118002: Conjecture O and the Gamma Conjectures: A Unified Framework in Quantum Cohomology and Geometric Applications

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Conjecture O and the Gamma Conjectures, introduced by Galkin, Golyshev, and Iritani (GGI), stand as pivotal open problems in the quantum cohomology of Fano manifolds, bridging algebraic geometry, mathematical physics, and representation theory. These conjectures aim to decode the structural essence of quantum multiplication by uncovering profound connections between the spectral properties of quantum cohomology operators and the underlying geometry of Fano varieties. **Conjecture O** specifically investigates the spectral simplicity and eigenvalue distribution of the operator associated with the first Chern class c_1 in quantum cohomology rings, positing that its eigenvalues govern the convergence and asymptotic behavior of quantum products. In parallel, the **Gamma Conjectures** propose a dual perspective: they assert that solutions to the quantum differential equations—central to the Gromov–Witten theory—are encoded via residues of the Gamma class, a characteristic class derived from the Gamma function, thereby forging an explicit link between quantum cohomology data and topological field theories (TQFTs).

This survey synthesizes the evolution, mathematical formalism, and ground-breaking results surrounding these conjectures. A landmark achievement lies in the verification of **Gamma Conjecture I** for Del Pezzo surfaces, where the compatibility of Gamma classes with mirror symmetry constructions has been rigorously established, offering a blueprint for higher-dimensional Fano manifolds. Simultaneously, extensions of **Conjecture O** to flag manifolds (e.g., homogeneous spaces G/P) have unveiled its broader algebraic geometric relevance, particularly in contexts involving equivariant quantum cohomology and Schubert calculus. The interplay between these conjectures is further enriched by interdisciplinary tools, such as quantum D-modules (encoding differential equations for Gromov–Witten invariants).

sciforum-111132: Convergence Of A Total Asymptomatically Quasi-Non-Expansive Mapping Using Zamfirescu Operator In A Banach Space

Felix Damilola Ajibade * and Daniel Bakare

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This study explores the convergence behaviour of total asymptotically quasinonexpansive (TAQN) mappings when applied to a Zamfirescu operator within the context of Banach spaces. Through a combination of theoretical analysis and numerical experiments, the research utilizes two specific examples to demonstrate the convergence properties of the proposed schemes. The findings highlight the robust convergence characteristics of sequences generated by the Zamfirescu operator on TAQN mappings. In particular, the study reveals that the Ishikawa iterative schemes consistently converge to a fixed point more quickly than traditional methods such as the Mann and Noor schemes. This is especially evident in the early stages of the iterative process, where the Ishikawa scheme outperforms the others in terms of speed and efficiency. Comparative analysis of different schemes further demonstrates that the Zamfirescu operator offers competitive convergence rates, with notable advantages in terms of efficiency. These results underscore the Zamfirescu operator's potential as an effective tool for addressing fixed-point problems, particularly in the fields of numerical simulations, optimization, and other computational applications. This study's contributions enhance the understanding of fixed-point theory within Banach spaces and provide a robust foundation for future research into the optimization and practical implementation of Zamfirescu operators. The results offer valuable insights that could drive further advancements in computational methodologies and applications.

sciforum-117760: Coseparable Nonnegative Tensor Factorization With T-CUR Decomposition

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It is well known that the nonnegative matrix factorization (NMF) is an important unsupervised learning method to extract meaningful features from data. To address the NMF problem within a polynomial time framework, researchers have introduced a separability assumption, which has recently evolved into the concept of coseparability. This advancement offers a more efficient core representation for the original data. However, in the real world applications, the data is more naturally represented as a multidimensional array, such as images or videos. The NMF's application to high-dimensional data involves vectorization, which risks losing essential multidimensional correlations. To retain these inherent correlations in the data, we turn to tensors (or called multidimensional arrays) and leverage the tensor t-product. This approach extends the coseparable NMF to the tensor setting, creating what we term coseparable nonnegative tensor factorization (NTF). In this talk, we will provide an alternating index selection method to select the coseparable core. Furthermore, we validate the t-CUR sampling theory and integrate it with the tensor discrete empirical interpolation method to introduce an alternative, randomized index selection process. These methods have been tested on both synthetic and facial analysis datasets. The results demonstrate the efficiency of coseparable NTF when compared to coseparable NMF.

sciforum-118063: Dual-Valued Functions of Dual Matrices with Applications in Causal Emergence

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Dual continuation, an innovative insight into extending the real-valued functions of real matrices to the dual-valued functions of dual matrices with a foundation of the G\^ateaux derivative, is proposed in this talk. Theoretically, the general forms of dual-valued vector and matrix norms, which remain properties in the real field, are provided in this talk. In particular, we mainly focus on the dual-valued vector p-norm and the unitarily invariant dual-valued Ky Fan p-k-norm in this talk. The equivalence between the dual-valued Ky Fan p-k-norm and the dual-valued vector p-norm of the first k singular values of the dual matrix is then demonstrated. Practically, we define in this talk the dual transitional probability matrix (DTPM for short), as well as its dual-valued effective information (${\rm{EI_d}}$). Additionally, we elucidate the correlation between the dual-valued effective information ${\rm{EI_d}}$, the dual-valued Schatten p-norm, and the dynamical reversibility of a dual transitional probability matrix. Through numerical experiments on a dumbbell Markov chain, our findings indicate that the value of k, corresponding to the maximum value of the infinitesimal part of the dual-valued Ky Fan p-k-norm by adjusting p in the interval $[1,2)$, characterizes the optimal classification number of the system for the occurrence of the causal emergence.

sciforum-120058: Equivariant formality of homogeneous spaces

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Equivariant formality, a notion in equivariant topology introduced by Goresky-Kottwitz-Macpherson, is a desirable property of spaces with group actions. Broad classes of spaces of especial interest are well-known to be equivariantly formal, e.g., compact symplectic manifolds equipped with Hamiltonian compact Lie group actions and projective varieties equipped with linear algebraic torus actions, of which flag varieties are examples. Less is known about homogeneous spaces G/K (where G and K are compact Lie groups) equipped with the left translation action by K, which is not necessarily of maximal rank. Using the K-theoretic version of equivariant formality we developed in previous work which involves analysis of vector bundles over G/K, we find two characterizations of equivariant formality of homogeneous spaces. The first one equates equivariant formality with a "smoothness" condition of the restriction map of the representation ring of G to that of K. In the second characterization, we introduce the notion of K-theoretic volume forms and prove that equivariant formality amounts to the non-degeneracy of the volume form of G/K defined in terms of K-theoretic indices. Our results unveil the K-theoretic nature of the symmetry of homogeneous spaces and provide a new perspective of their equivariant formality which had been studied in cohomological terms.

sciforum-116982: Fifth-order nonlinear evolution equations of soliton type: old and new results

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Nonlinear evolution equations of soliton type are considered. In particular, attention is focused on equations of the fifth order.

Specifically, the Kawamoto equation, the Caudrey–Dodd–Gibbon–Sawada–Kotera (CDGSK) equation, and the Kaup–Kupershmidt (KK) equation are investigated: they are connected via Bäcklund transformations into a wide net of links which we term a *Bäcklund Chart.* The links obtained previously by Rogers and Carillo are revisited, and new results are obtained.

These equations exhibit a very interesting symmetrical structure so that full hierarchies are present. Indeed, they all admit a hereditary recursion operator. Hence, each one of the mentioned equations represents the base member of a corresponding hierarchy of equations. These hierarchies are constructed via the recursive application of the respective recursion operators. The symmetry properties of such equations are investigated, and in addition, the connections among them are shown, aiming to generalise them to the non-commutative setting. Finally, we conduct a comparison between the net of links, derived via Bäcklund transformations, among the fifth-order nonlinear evolution equations and an analog net of links connecting third-order Korteweg–de Vries (KdV) and modified Korteweg–de Vries (mKdV) equations. Other third-order nonlinear evolution equations are also provided. Hence, the analogies and discrepancies between the connections established in the case of fifth-order equations with respect to those established in the case of third-order equations are analysed. This study aims to open the way for the construction of corresponding non-Abelian equations of the fifth order.

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sciforum-109563: Further on Binary Fuzzy Codes and Their Properties

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Binary fuzzy codes are an extension of binary codes. This paper further explores binary fuzzy codes and determines their arithmetic properties. Additionally, we add properties of the Hamming distance of fuzzy codes and uncover the Euclidean distance of fuzzy codes. From our exploration of fuzzy distances, Hamming distance is affected by the parameter weight of error patterns (e) and probability(p) of the channel in which the channel sends the received word incorrectly. Whereas Euclidean distance is determined by three parameters e, p, and the length (n) of the codeword. We also determine the dimension of fuzzy codes equivalent to binary fuzzy vector spaces. Generating a code and exploring its properties is crucial for using codes in the decoding/encoding process in a communication system with noisy channels. Finally, we determine the decoding algorithm for fuzzy codes using the minimum distance decoding technique. In particular, the study of fuzzy subsets and their fuzzy distance is applied to distance-based similarity measures for multi-criteria decision-making in linguistic communication. The use of minimum distance decoding using Hamming distance makes our computation than Euclidean distance. However, if two or more codewords have the same minimum distance with the received word, using Euclidean distance increases the probability of the receiver decoding the sent word correctly.

sciforum-117741: He's Frequency Formulation for free vibration of a Tapered beam

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Physical systems often demonstrate nonlinear behavior that remains unresolved in many practical scenarios. A tapered beam is a structural element that exhibits a variable cross-sectional profile along its length. The beam may either expand or contract in width and/or depth, resulting in a gradually changing cross-section. It is necessary to examine the nonlinear oscillatory dynamic behaviour of these elements at large amplitudes, as they are commonly used in load-bearing applications such as bridge construction, aeronautical engineering, automobile manufacturing, and other load-bearing applications.

He's frequency formulation was initially inspired by an ancient Chinese algorithm. He's frequency formulation represents an exceptionally potent analytical instrument within the domain of vibration theory. This formulation not only presents a profound method of analysis but also offers significant promise for advancing our comprehension and practical applications in this intricate field. The formulation provides an efficient and highly efficacious means of determining the complex frequency-amplitude relationship of nonlinear oscillators. This relationship is of crucial importance for understanding the behavior and characteristics of a broad spectrum of systems, ranging from mechanical vibrations to electrical circuits and beyond.

In this study, He's Frequency Formulation is employed to investigate the free vibration characteristics of a tapered beam, addressing its nonlinear dynamic model. By seeking periodic motion solutions to the governing equation, the explicit relationship between frequency and is amplitude analytically derived. Such insights hold significant value for researchers and engineers engaged in structural analysis and design optimization, offering a computationally efficient alternative for nonlinear vibration analysis.

sciforum-117901: KP theory and infinite-dimensional Lie algebras

Jipeng Cheng

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The KP theory, formulated by the Kyoto School, holds a pivotal position in mathematical physics and the realm of integrable systems. Central to KP theory is the concept of the tau function, which typically satisfies the Hirota bilinear equations. From Sato's perspective, the KP tau function can be regarded as a point within the infinite-dimensional Grassmannian, with the corresponding bilinear equations being interpretable as the Plücker relation. The KP theory is replete with rich algebraic structures. For instance, the infinite-dimensional Lie algebra $\mathfrak{gl}(\infty)$ is related to the KP integrable hierarchy in KP theory through the use of fermionic and bosonic highest-weight representations. The KP tau function is considered as the group orbit of the highest-weight vector, with the group associated with the Lie algebra $\mathfrak{gl}(\infty)$, and this is determined by the Hirota bilinear relations. In this presentation, we aim to review these typical algebraic constructions for the KP hierarchy. Subsequently, we will explore the algebraic constructions of extensions of and reductions in the KP hierarchy. KP extensions generally take the form of multi-component generalizations, corresponding to different representations of Lie algebras. In contrast, KP reductions are often constructed using various sub-algebra structures of the Lie algebra $\mathfrak{gl}(\infty)$. In addition to these reviews, we will also present some novel results during the lecture.

sciforum-116203: Mathematical elements in trees, forests, and nature

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When we look at nature, we sometimes feel that it is "beautiful." But why do we feel that nature is beautiful?

One of the reasons is mathematics. There are many different mathematical laws and mechanisms hidden in the natural world. The mathematics inherent in nature is the backbone of the beauty of nature, the production and stagecraft, and stimulates our vision and sensibilities. It can also be said that we humans have discovered mathematics in nature.

Needless to say, mathematics is indispensable when working in natural sciences, including various fields of agriculture. Regardless of your strengths or weaknesses, there is an inseparable bond between agriculture and mathematics/numbers, such as cultivation area, harvest volume, management profits, compound interest calculations, and statistical calculations in laboratory training. I am one of the students at the bottom of forest science and forestry studies, and when I look at forests, I can see that mathematics is literally present in all of the universe.

In forest and forestry research, it is common to draw approximate curves and calculate correlation coefficients from survey data. In the graduation and master's theses of forestry students, inductive methods are generally used to derive and present approximate formulas and risk rates as a conclusion to the research data. However, even with the same inductive method, deductive methods can be considered to find hidden laws and patterns in forest phenomena and events and utilizedin forest operations and management. Just as the world of forests is wide and rich, the world of mathematics is also wide and rich. It is expected that a new phase of research can be developed in forest science and forestry by gaining a deeper understanding of the appeal of each field of study.

sciforum-121742: More details on two solutions with ordered sequences for binomial confidence intervals

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While many continuous distributions are known, the list of discrete ones (usually derived from counting) is relatively short. This list becomes even shorter when dealing with dichotomous observables: binomial, hypergeometric, negative binomial, and uniform. Binomial distribution is important for medical studies, since a finite sample from a population included in a medical study with a yes/no outcome resembles a series of independent Bernoulli trials. The problem of calculating the confidence interval (with a conventional risk of 5% or otherwise) has been found to be one of combinatorics, with several algorithms disputing the exact calculation, each according to a formal definition of its precision. Two previously proposed algorithms are provided here through four case studies, with sample sizes of 30, 45, 100, and 900. In these cases, at a 5% significance level, ordered sequences defining the confidence bounds were generated for two formal definitions. Images of the error's alternation are provided and discussed. Both algorithms propose symmetric solutions in terms of both confidence intervals and actual coverage probabilities. The confidence intervals are not symmetric with respect to the observed variable, but are mirrored symmetric relative to the middle of the observed variable domain. When comparing the solutions proposed by the algorithms, with increasing sample size, the ratio of identical confidence levels increases and the difference between actual and imposed coverage is reduced.

sciforum-121246: Nonlocal symmetries of integrable systems

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In additional to local symmetries, there are infinitely many nonlocal symmetries for integrable systems. The nonlocal symmetries may be potential symmetries, residual symmetries, square eigen-function symmetries, infinitesimal Darboux transformations and Backlund transformations and Mobious invariance. Some types of nonlocal symmetries may be localized to find related group invariant solutions (including the interaction solutions among different types of nonlinear waves) and finite Darboux transformations and/or Levi transformations. In(1+1)-dimensions, the local symmetries correspond to the positive integrable hierarchies while the nonlocal symmetries are related to the negative integrable hierarchies. Usually, there are more negative hierarchies than positive hierarchies. For instance, there is no even order positive Korteweg-de Vries (KdV) hierarchy while both the even order and the odd order KdV hierarchies do exist. In (2+1)-dimensions, the nonlocal potential symmetries are responsible for the positive integrable hierarchy while the square eigen-function related nonlocal symmetries are responsible for the negative hierarchies. Nonlocal symmetries can be used to nonlinearize linear Lax pairs to find new nonlinear integrable hierarchies via applying the nonlinearization approach, introducing self-consistent sources, and using fermionic and anyonic nonlocal symmetries to find super-integrable systems, ren-integrable systems, super-symmetric and ren-symmetric integrable systems. Using different space-times, the nonlocal symmetries and local symmetries may be related by duality transformations. Finally, the physical meanings of infinitely many symmetries are found to be linked with the existence of multiple wave solutions.

sciforum-117958: On solutions of a kind of quaternion tensor equation

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Tensors are higher--dimensional generalizations of vectors and matrices, and have been widely studied in recent years because of their practical application in many fields, including signal processing, quantum entanglement, computer vision, numerical analysis, data mining, graph analysis, neuroscience, psychometrics, and so on.

Various aspects of the results for real (complex) tensors have been widely investigated. For example, Sun et al. [L.Z. Sun, B.D. Zheng, C.J. Bu, Y.M. Wei, Moore--Penrose inverse of tensors via Einstein product, Linear and Multilinear Algebra. 64(4)(2016)686--698.] defined the Moore--Penrose inverse of tensors with the Einstein product, and obtained the explicit formulas of the Moore--Penrose inverse of some block tensors. Liang et al. [M.L. Liang, B. Zheng, Further results on Moore--Penrose inverses of tensors with application to tensor nearness problems, Comput Math Appl. 2019, 77(5):1282-1293. M.L. Liang, B. Zheng, R.J. Zhao, Tensor inversion and its application to the tensor equations with Einstein product, Linear and Multilinear Algebra, 67(4)(2018)1--28.] proposed the full rank decomposition of tensors by introducing a new kind of tensor rank, which gave a novel representation of the Moore--Penrose inverse and considered the tensor nearness problem associated with a tensor equation. They obtained several necessary and sufficient conditions for the invertibility of a tensor and proposed some approaches for calculating the inverse.

In this paper, by using the complex representation of quaternion tensors, and the Moore--Penrose generalized inverse, we derive the expressions of the least squares solution with the least norm, the least squares pure imaginary solution with the least norm, and the least squares real solution with the least norm for a kind of quaternion tensor equation, respectively. We firstly derive the formulas about complex tensors. Then we use the results to derive the explicit expression for the solutions, respectively.

sciforum-118082: On weakly cyclic Schouten symmetric manifolds

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This paper introduces a novel class of non-flat Riemannian manifolds known as weakly cyclic Schouten symmetric manifolds, denoted as $(WCSS)_n$. These manifolds are characterized by specific symmetries in their Schouten tensor, which play a crucial role in differential geometry and the study of curvature properties. This paper establishes a sufficient condition under which $(WCSS)_n$ can be classified as quasi-Einstein manifolds. Quasi-Einstein manifolds are important generalizations of Einstein manifolds and have applications in mathematical physics, particularly in general relativity and geometric analyses. Furthermore, this paper explores the structure of conformally flat $(WCSS)_n$ manifolds, examining how their curvature properties interact with conformal transformations. This study then proceeds to investigate Einstein $(WCSS)_n$ manifolds for dimensions $n > 2$, establishing the fundamental relationships that govern their geometric structure. Finally, this paper delves into the conditions under which a $(WCSS)_n$ manifold exhibits semi-symmetric and Weyl semi-symmetric properties for $n > 2$. These properties are significant in understanding the geometric behavior of manifolds under various curvature conditions. The results obtained in this study contribute to the broader field of Riemannian geometry by providing deeper insights into the interplay between Schouten symmetry and fundamental curvature structures. We hope that the contributions to this work yield impactful knowledge for readers.

sciforum-122408: Reduced biquaternion tensors and their applications

Yang Zhang

University of Manitoba

Reduced biquaternion algebra is four-dimensional commutative algebra over the real number field and contains zero divisors. Third-order tensors over reduced biquaternions have important applications in many areas, such as computer version and physics.

For color video processing tasks, we explore a quaternion tensor model beyond the traditional quaternion, called the third-order reduced biquaternion tensor model. This model not only maintains the correlation between the RGB channels but is also not affected by the curse of dimensionality. To address the challenges posed by reduced biquaternions that contain zero divisors and the lack of Euclidean geometric properties, we define the operations such as the conjugate transpose and Ht-product based on the unique characteristics of reduced biquaternion tensors. Utilizing the orthogonal basis method, we prove the existence of Ht-SVD and then develop a computational algorithm.

Moreover, we extend the Moore–Penrose inverse to the third-order reduced biquaternion tensors. Our Ht-SVD allows us to derive the explicit form of this MP inverse efficiently. Furthermore, we applythe general solution/the least-squares solutions/minimal norm least-squares solution to the classic reduced biquaternion tensor equation via our MP inverses. Finally, we propose two novel fast algorithms for color video compression and deblurring. The experimental results indicate that our methods have the best performances compared to other methods, especially in CPU time.

sciforum-117777: Response control and bifurcation analysis of a generalized and fractional Rayleigh–Duffing oscillator under recycling noise

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This study examines the stochastic bifurcation phenomenon in a fractional and tristable Rayleig–Duffing oscillator driven by recycling noise excitations. First, using the harmonic balance method and minimizing the mean square error, an approximate integer-order equivalent system is derived for the original fractional-order system. Subsequently, the steady-state probability density function (sPDF) of the system's amplitude is obtained via stochastic averaging. The critical conditions for stochastic P-bifurcation (SPB) are then determined using singularity theory, and this demonstrates that the fractional derivative's order p and the correlation time, along with the intensity of recycling noise, can each trigger the SPB phenomenon, resulting in a transition from a single peak to three peaks in the sPDF curve of the system, contingent upon suitable unfolding parameters. And according to this, the system's response can be retained at the minor vibration close to equilibrium by taking suitable unfolding parameters and preventing the damage and instability caused by nonlinear jumps or large-amplitude vibrations in the system, offering valuable theoretical insights for the system design. The stationary PDF curves of the system's amplitude are qualitatively analyzed across regions delineated by the transition set curves. Finally, Monte Carlo simulations confirm the analytical findings, validating the theoretical framework. These results provide insights for improving system response control through fractional-order controller design.

sciforum-121763: Riesz Fractional Calculus on Power-Weighted Variable Generalized Hölder Spaces over Metric Measure Spaces

Yuri Drobotov

Southern Federal University

Riesz fractional integro-differentiation is recognized as an analytical framework that defines fractional powers of the Laplace operator through potentials and hypersingular integrals. Furthermore, hypersingular integrals are established as natural extensions of partial differential operators to fractional orders, thereby enabling the development of fractional calculus for multivariate functions based on these operator classes. This study is devoted to the generalization of Riesz fractional calculus to abstract metric measure spaces, where classical results are subsumed as particular instances. The central objective is to enhance the theoretical framework with new fundamental results on weighted continuity characterized by specific generalizaitons of the Hölder condition. Three principal contributions are presented. First, the local modulus of continuity is refined through a generalized definition compatible with advanced theoretical constructs, extending its applicability to broader function classes on metric measure spaces. Second, Zygmund-type estimates are derived for power-weighted functions via a novel analytical approach, resolving technical challenges introduced by power-law weights that are absent in unweighted settings. Third, boundedness theorems are established to characterize the behavior of potential-type operators and hypersingular integrals on power-weighted variable generalized Hölder spaces, thereby completing the analytical foundation of Riesz fractional calculus in these generalized settings. The scientific significance of this work lies in its advancement of fractional calculus as a discipline within function analysis and operator theory. Specifically, the developed theory rigorously formalizes continuity properties of functions on abstract metric measure spaces, offering an approach that unifies classical and generalized perspectives. These contributions are anticipated to hold substantial implications for applications in integral equations and mathematical modeling, where the derived continuity estimates and operator boundedness properties may be leveraged to analyze complex systems under non-standard regularity assumptions.

sciforum-118636: Symmetry and exact solutions of the (2+1)-dimensional generalized Burgers–Fisher equation

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In this paper, we focus on the (2+1)-dimensional generalized Burgers–Fisher equation. To fulfill our study aims, we make use of some mathematical approaches, namely the Lie symmetry method and the Generalized Bernoulli equation method. Through these methods, we successfully obtain exact analytical solutions to the generalized Burgers–Fisher equation. Firstly, we generate infinitesimal generators by using the Lie symmetry reduction method; the (2+1)-dimensional generalized Burgers–Fisher equation is reduced to a (1+1)-dimensional partial differential equation (PDE); and we obtain an ordinary differential equation (ODE). The reduced (1+1) dimensional equation we obtain can be symmetrized again into ODEs to obtain some invariant solutions. After that, we use the Generalized Bernoulli equation method. We determine the exact analytical solutions presented as different wave structures of solitons. The behaviors of various soliton wave structures are visually demonstrated through three-dimensional graphics and contour plots. The graphs are more useful and beneficial for physicists and mathematicians, helping them to understand the complex physical phenomena involved. As far as the author is currently aware, there has been no discussion in existing academic papers on the solution of equations with uncertain values of n. The solutions obtained through research in this article can assist scholars and researchers in gaining a deeper understanding of the generalized Burgers–Fisher equation.

sciforum-122463: Symmetry and Time-Delay Driven Dynamics of Rumor Dissemination

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The dissemination of rumors can lead to significant economic damage and pose a grave threat to social harmony and the stability of people's livelihoods. Consequently, curbing the dissemination of rumors is of paramount importance.The model in the text assumes that the population is homogeneous in terms of transmission behavior . This homogeneity is essentially a manifestation of translational symmetry . This paper undertakes a thorough examination of the impact of time delay on the dissemination of rumors within social networking services. We have developed a model for rumor dissemination, establishing the positivity and boundedness of its solutions, and identified the existence of an equilibrium point. The study further involved determining the critical threshold of the proposed model, accompanied by a comprehensive examination of its Hopf bifurcation characteristics. In the expression of the threshold R_0 , the parameters appear in a symmetric form, reflecting the balance between dissemination and suppression mechanisms. Furthermore, detailed investigations were carried out to assess both the localized and global stability properties of the system's equilibrium states.In stability analysis, the symmetry in the distribution of characteristic equation roots determines the system's dynamic behavior. Through numerical simulations, we have analyzed the potential impacts and theoretically examined the factors influencing rumor dissemination, thereby validating our theoretical analysis. An optimal control strategy has been formulated, incorporating three control variables to describe the strategy. The optimization framework incorporates a specifically designed cost function that simultaneously accounts for infection reduction and resource allocation efficiency in control strategy implementation. The optimal control strategy proposed in the study involves a comparison between symmetric and asymmetric interventions. Symmetric control measures may prove inefficient, whereas asymmetric control demonstrates higher efficacy—highlighting a trade-off in symmetry considerations for optimization problems.

sciforum-117285: The 3D Flow of a Compressible Micropolar Real Gas with Spherical Symmetry: The Global Existence of the Solution

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In this work, we study the existence of a solution for the spherically symmetric three-dimensional flow of a viscous, polytropic, and heat-conducting micropolar real gas within a container with solid and thermally insulated walls. The domain is also spherically symmetric and is defined as the region between two concentric spheres in R^3. Micropolarity incorporates local micro-movements in the fluid through a microrotational velocity vector, enabling a more precise model for fluids with a pronounced particle structure. We consider a generalized equation of state, in which the pressure depends on a power of the mass density and varies linearly with the temperature, making it more suitable for describing the behavior of gases under extreme conditions.

The model is governed by four quasilinear partial differential equations representing the conservation laws of mass, momentum, angular momentum, and energy. These equations are coupled with homogeneous Dirichlet boundary conditions for velocity and microrotation, a homogeneous Neumann boundary condition for absolute temperature, and appropriate initial conditions.

In this study, we establish the global existence of a generalized solution over an arbitrary finite time interval (0, T), with T>0. This is achieved in two steps: First, a local solution is constructed using the Faedo–Galerkin approach. Then, the global existence is proven by deriving a priori estimates for the solution and applying the extension principle to the local solution. A key ingredient in the proof is the assumption of the spherical symmetry of both the domain and the flow.

We follow up this theoretical result with numerical simulations of the described flow.

Session 3. Chemistry

sciforum-116462: α-Hydroxyphosphonates, α-Hydroxyphosphine Oxides and their Derivatives

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α-Hydroxyphosphonates (HPs), α-hydroxyphosphine oxides (HPOs) and their derivatives are the focus due their synthetic importance and potential bioactivity. HPs and HPOs may be obtained by the Pudovik reaction of the corresponding oxo compound (in our case, substituted benzaldehydes, acetaldehyde or acetone) and >P(O)H reagents, such as dialkyl phosphites and secondary phosphine oxides.

A part of the racemic hydroxyphosphonates was subjected to optical resolution to make the enantiomers avaliable [1,2]. Then, the adducts obtained were modified by reaction with arylsulfonyl chlorides and methylsulfonyl chloride to afford the respective sulfonyloxy derivatives [3,4].

A series of HP and HPO derivatives, as well as a few sulfonyloxy species, were subjected to single-crystal X-ray analysis. The HPs and HPOs appeared as a chain or dimer in the crystal structure [5].

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sciforum-121658: Molecular engineering of self-assembled monolayers for perovskite solar cells

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Perovskite and organic solar cells have emerged as the most promising new generation of photovoltaic technologies for commercialization. They are advantageous for solution-processing large-area devices with high power conversion efficiency (PCE). The lab efficiency record of 27% has been broken for single-junction perovskite solar cells (PSCs) in a ~0.05 cm^2 device area. The charge transport layers between light-absorbing layers and electrodes play a crucial role in device efficiency and stability. In the pursuit of high-performance PSCs, there are some challenges facing the use of traditional hole transport layer (HTL) materials (ca. PEDOT:PSS, PTAA, and Spiro-OMeTAD) and electron transport layer (ETL) materials (ca. C60, PCBM and SnO_2). High-quality films forming light-absorbing and efficient charge extraction and transport from charge transport layers have, thus, attracted great attention from researchers in the photovoltaic community. Approaches are in great demand that can suppress the non-radiative recombination of energy loss, promote efficient charge transport, and improve the operation stability of devices. We report herein our recent progress in the development of new self-assembled charge (both hole and electron) transport materials to achieve high-efficiency and stable solar cells. Their design principles will be discussed for molecular design to modulate molecular energy levels, aggregation/orientation, charge transfer, and solution processability. The potential for improving interface quality and suppressing non-radiative recombination energy loss has been explored in various types of solar cells, where record PCEs have been achieved together with outstanding device stability [1-6]. The rational design of self-assembled charge transport layer materials can, thus, be beneficial for the mass production of next-generation solar cells for practical applications.

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sciforum-117642: Optical Resolution: the Behaviour of Related Structures and the Role of Solvents

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Chirality refers to the property of molecules that cannot be superimposed on their mirror image, much like how a left and right hand are mirror images. Chiral compounds exhibit optical activity, meaning they can rotate plane-polarised light. These compounds are known as enantiomers. Optical resolution refers to the process of separating these enantiomers from a racemic mixture (a 1:1 mixture of enantiomers) to obtain a pure enantiomer.

The resolution of chiral compounds with related structures typically involves techniques that take advantage of the subtle differences in the interactions between enantiomers and various resolving agents. The most commonly used optical resolution methods include chiral chromatography, diastereomeric salt or complex formation, enzymatic resolution, and kinetic resolution.

The resolution of chiral compounds with similar or related structures, such as those with similar functional groups or spatial arrangements, can present a challenge. In these cases, the difference between enantiomers may be subtle, requiring more sophisticated methods or highly selective resolving agents. One possible solution is to use different solvents. Different solvents can be used to fine-tune the system and will give different results. It is also the case that if there is no chiral discrimination in one solvent, the only way to achieve resolution is to change the solvent. In extreme cases, even perfect enantiomer discrimination can be achieved.

The importance of optical resolution is evident in various fields, particularly in the pharmaceutical industry, where one enantiomer of a chiral drug may be therapeutically active, while the other may be inactive or harmful. Consequently, achieving high-purity enantiomers is essential to maximise the efficacy and safety of chiral-based drugs.

sciforum-114375: A Geometric Berry Phase Angle Induced in *Im-3m* H_3S at 200 GPa by Ultra-fast Laser Pulses

Samantha Jenkins

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We investigated *Im-3m* H_3S at 200 GPa, a pressure regime in which crystalline H_3S is widely considered to be a superconductor. Simulated circularly polarized 10 femtosecond (fs) laser pulses were applied, and we quantified their effects on electron dynamics both during the application of the ultra-fast laser pulse and 5.0 fs after the pulse was switched off. In addition, the carrier–envelope phase (CEP) angle ϕ, which quantifies the relationship between the time-varying direction of the electric (**E**) field and the amplitude envelope, was employed to control the time evolution of the wavefunction **y**(**r**). This was undertaken for the first application of the Next-Generation Quantum Theory of Atoms in Molecules (NG-QTAIM) to the solid state. Ultra-fast phenomena related to superconductivity were discovered, in the form of a geometric Berry phase angle associated with H--H bonding, in addition to very high values of the chirality–helicity function. Future applications are discussed, including chiral spin selective phenomena in addition to high-temperature superconductivity and organic superconductors.

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sciforum-120299: Anion-pillared metal–organic frameworks for gas separation

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Anion-pillared metal–organic frameworks (APMOFs) are a new class of organic–inorganic hybrid porous crystalline materials assembled by the orderly arrangement of inorganic anions, inexpensive transition metal ions and nitrogen-rich ligands through coordination/dative bonds. They have shown great promise in the separations of acetylene/ethylene, acetylene/carbon dioxide, propyne/propylene and other gas mixtures. In this report, we will discuss the strategy of regulating the pore interface, pore flexibility and pore hierarchy to realize the benchmark gas separation in APMOFs. To name a few examples, 1) ZNU-1 is a $B_{12}H_{12}^{2-}$ anion-pillared metal–organic framework with symmetrical interpenetration, distinct from analogue BSF-4 with asymmetrical interpenetration. ZNU-1 can realize benchmark acetylene/carbon dioxide separation with both high capacity and high selectivity. The IAST separation selectivity for acetylene/carbon dioxide (50/50) is as high as 56.6, overcoming all other robust porous materials without open metal sites. 2) ZNU-2 is a TiF_6^{2-} anion-pillared metal–organic framework with extremely high chemical and thermal stability. Due to the use of tridentate organic linkers, ZNU-2 displays rare ith-d topology and three-dimensional cage-like pores with two different sizes. The small pores can serve as single-molecule adsorption cages, and the large pores can store a lot of guest molecules. Therefore, ZNU-2 is a benchmark candidate for propyne capture from propylene. 3) The GeF_6^{2-} anion-embedded framework ZNU-6 with customized pore structure and pore chemistry was prepared for benchmark one-step C_2H_4 recovery from C_2H_2 and CO_2. ZNU-6 exhibits significantly high C_2H_2 (34.3 mL/g) and CO_2 (32.7 mL/g) capacity at 0.01 bar. Record-high C_2H_4 productivity is achieved from $C_2H_2/CO_2/C_2H_4$ mixtures in a single adsorption process under various conditions.

sciforum-123001: Chemical Equitable Partitions: A new Perspective on Molecular and Crystal Lattice Symmetries, and Its Implications for the Study of Structure–Property Relationships

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Introduction

The Equitable Partition (EP) of a graph is a partition of its nodes into "cells" such that the nodes in a cell, i, are linked to a fixed number, b_{ij}, of nodes in a cell, j, given i and j. Graphs with rich symmetries have coarser and simpler EPs than others. In this work, we use a special case of EP, the Chemical EP (CEP) [1], to shed new light on the symmetries of molecules and crystal lattices and their structure–property relationships.

Methods

The graphs of molecules are defined by chemical bonds, whereas those of periodic lattices are based on nearest neighbours under periodic boundary conditions, providing that coordination numbers are reproduced. CEP is defined as the coarsest EP that refines a partition of the original graph according to the atoms' chemical elements and valences. Then, two quantitative descriptors of symmetry are computed: the information content [2] and the compression ratio [1] of the CEP.

Results

Several organic molecules and inorganic lattices are sorted according to the above measures of symmetry. A comparison with densities and other physical properties reveals clear correlations and classifications, especially when combining this with additional graph-theoretic descriptors like the Perron–Frobenius eigenvalue or the Fiedler eigenvalue. The emergent clusters are neat generalisations of the concept of homologous series, which take symmetry into account.

Conclusions

The correlation between physical properties and graph-theoretic measures of symmetry attests to CEP as a promising approach for the study of structure–property relationships and the design of molecules and crystals with desired properties. Future research will extend this method to *embeddings* (the actual spatial arrangement) of graphs, offering a unified framework for the study of molecular symmetries.

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sciforum-119880: Chiral Perovskites and Their Chirality-Induced Spin Selectivity

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Chirality, or parity asymmetry, is one of the fundamental characteristics of the universe, playing a critical role in the fields of physics, chemistry, and biology. Utilizing asymmetry to generate chirality at the nano, micro, and macro scales, and endowing materials with polarization-related properties, is one of the hotspots in contemporary scientific research. Chiral Induced Spin Selectivity (CISS) refers to the spin-dependent transfer of electrons through chiral molecules, which links electron spin orientation to molecular symmetry, providing an unprecedented method for achieving spin-polarized electrons. This phenomenon has opened new avenues for the development of spintronic devices. In recent years, chiral perovskites have attracted widespread attention due to their unique polarized optical properties, strong spin-orbit coupling (SOC) effects based on heavy atoms, and chiral induced spin selectivity, showing great potential in the field of spintronics. We have designed various chiral perovskite materials, studied their spin-polarized optical activity modulation, and revealed the key factors influencing their spin-related properties. By leveraging chiral induced spin selectivity, we achieved room-temperature spin-polarized luminescence, demonstrating their application in room-temperature spin light-emitting diodes (spin-LEDs). These advancements not only deepen our understanding of chiral materials but also highlight their immense potential for groundbreaking applications in quantum computing, information storage, and optoelectronic devices.

sciforum-123013: Development of a method of synthesis of bis(4-hydroxy-6H-1,3-oxazine-6-ones), their alcoholysis and in silico assessment of biological activity

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Introduction

Among the 1,3-oxazine derivatives, there are compounds exhibiting antimicrobial and antioxidant activity. Moreover, they act as reagents that allow us to obtain heterocyclic and acyclic systems. Our attention was attracted by bis(4-hydroxy-6H-1,3-oxazine-6-one) derivatives. They are insufficiently systematized in literary sources, and therefore, the selection of optimal conditions for their synthesis and studying their structure and properties are promising directions in organic chemistry and pharmacy. Consequently, the aim of this work was to develop a laboratory method of synthesis of bis(4-hydroxy-6H-1,3-oxazine-6-ones), to prove their structure, to study the reaction of ethanolysis and to evaluate biological activity in silico.

Methods

Bis(4-hydroxy-6H-1,3-oxazine-6-ones) **(1-6)** were obtained by the interaction of terephthalic or isophthalic acid diamides with a twofold excess of substituted malonyl dichloride in absolute 1,2-dichloroethane for 40-60 hours. Ethyl esters of malonamic acids **(7-12)** were formed by ethanolysis of bis(4-hydroxy-6H-1,3-oxazine-6-ones) for 24 hours. The structure of the obtained compounds was proved by ^{1}H and ^{13}C NMR spectroscopy. Biological activity screening was carried out using GUSAR and PASS online programs.

Results

Compounds **1-6** were obtained with 56-83% yields. Prediction of their biological activity showed that these substances exhibit antioxidant and antitumor activity. Compounds **7-12** were obtained with 64-85% yields. According to biological activity screening performed in silico, compounds **7-12** exhibit anxiolytic, antieczematous and fibrinolytic activity. According to acute toxicity prediction, compounds **1-12** belong to toxicity classes 4 and 5 (OECD).

Conclusions

Through the interaction of phthalic acid diamides and an excess of substituted malonyl dichlorides in absolute 1,2-dichloroethane, a number of new bis(4-hydroxy-6H-1,3-oxazine-6-ones) were obtained. The latter interact with absolute ethanolproducing ethyl esters of malonamic acids. Biological activity and acute toxicity of synthesized substances in silico were determined.

sciforum-117844: Efficient Synthesis, Structural Characterization, Antibacterial Assessment, ADME-Tox Analysis, Molecular Docking, and Molecular Dynamics Simulations of New Functionalized Isoxazoles

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Abstract: This work describes the synthesis, characterization, and *in vitro* and *in silico* evaluation of the biological activity of new functionalized isoxazole derivatives. The structures of all new compounds were analyzed via IR and NMR spectroscopy. The structures of 4c and 4f were further confirmed by single-crystal X-ray and their compositions unambiguously were determined via mass spectrometry (MS). The antibacterial effect of the isoxazoles was assessed in vitro against Escherichia coli, Bacillus subtilis, and Staphylococcus aureus bacterial strains. Isoxazole 4a showed significant activity against E. coli and B. subtilis compared to the reference antibiotic drugs, while 4d and 4f also exhibited some antibacterial effects. The molecular docking results indicate that the synthesized compounds exhibit strong interactions with the target proteins. Specifically, 4a displayed a better affinity for E. coli, S. aureus, and B. subtilis in comparison to the reference drugs. The molecular dynamics simulations performed on 4a strongly support the stability of the ligand–receptor complex when interacting with the active sites of proteins from E. coli, S. aureus, and B. subtilis. Lastly, the results of the Absorption, Distribution, Metabolism, Excretion, and Toxicity Analysis (ADME-Tox) reveal that the molecules have promising pharmacokinetic properties, suggesting favorable drug-like properties and potential applications as therapeutic agents.

sciforum-118125: Selected Optically Active Organic Compounds Containing Stereo- and/or Nonsterogenic Heteroatoms: Historical Aspects and Recent Results

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In the development of stereochemistry, as an organic chemistry subdiscipline, optically active compounds with a stereogenic heteroatoatom, especially sulfur and phosphorus derivatives, have played and continue to play an important role. Historically, among other aspects, they have been used to support the view that a lone electron pair can be considered as an equivalent for areal substituent. And since the 1980s, these compounds have played an extremely important role as chiral auxiliary substances in asymmetric synthesis [1]. This lecture will open with some historical comments regarding developments on this topic, followed by a presentation of our unpublished or very recently published results on the synthesis, structural determination, and analytical usability of appropriately designed compounds. Our findings are related to the following topics (among others):

Attempts to obtain chiral ionic liquids based on racemic and optically active (enantiomeric and diastereomeric) sulfoxides, phopsphine oxides, and salts of optically active t-butylarylthiophosphinic acids.

Attempts to achieve asymmetric oxidation of aryl trifluoromethyl sulfides, $ArSCF_3$, in association with the corresponding optically active sulfoxides, $ArS(O)CF_3$, under standard and mechanochemical conditions

Synthesis of optically active thioureas derived from (*S*)-1-(2-pirydyl)ethylamine enantiomer [2].

The unexpected formation of a chiral spiro-system through the reaction of dilithio-derivative of hexafluorocumyl alcohol with *N*-(*t*-butylsulfenyl)phthalimide [3].

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sciforum-118009: Simple Primary Amino Amide Organocatalyst for Asymmetric Hetero Diels-Alder Reaction of Isatins with Enones

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Spirooxindoles **A** are considered to be promising scaffolds in drug discovery. The structure of **A** is contained in many compounds having pharmacological activities such as anti-HIV, anticancer drugs and so on. Therefore, the development of an effective strategy for the preparation of highly optically pure **A** is a significantly challenging task in research. Amino amides **B** are stable in air, and have the two advantageous features of easy preparation and desirable structural characteristics. Thus, they can be derived easily from the condensation of corresponding amino acids with amines. And also, they contain covalent site for enamine formation, steric influence site for controlling stereoselectivity, and non-covalent site for hydrogen bonding. Based on these functionalities, they may be act as satisfactory catalyst for asymmetric reactions. Asymmetric hetero Diels-Alder (hDA) reaction is one of the important tool to construct biologically active chiral heterocycles. In this presentation, we will report that two catalysts component system, simple primary amino amides **B** and protected amino acid co-catalyst, work as efficient catalysts system, in the hDA reaction of isatins with enones to afford the chiral spirooxindole-tetrahydrapyranones in comparatively good chemical yield (up to 95%), moderate diastereoselectivity (up to 54:46 dr) and enantioselectivity (up to 56% ee). The detail of this work will be reported.

sciforum-121072: Synthesis of a new bis(1,2,4-triazole) derivative with antimicrobial activity

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The importance of 1,2,4-triazole derivatives in modern pharmacy and medicine is extremely high. They are used as antifungal agents with high efficacy and a good safety profile (fluconazole, itraconazole). It is worth noting that some 1,2,4-triazole derivatives demonstrate significant therapeutic potential in the treatment of neurodegenerative disorders; in particular, they show promising results in modifying the treatment of Alzheimer's disease.

We have proposed a modernised method for the preparation of a new bis(1,2,4-triazole) derivative by the recyclization reaction of 4-hydroxy-2-(4-nitrophenyl)-5-phenyl-1,3-6H-oxazin-6-one with a bisnucleophilic reagent using m-phenylenedihydrazine. The preparation method described in the literature did not yield the desired product, so other reaction conditions were selected. As a result, a new 1,1′-(benzene-1,3-diyl)bis[5-benzyl-3-(4-nitrophenyl)-1H-1,2,4-triazole] was obtained by recyclization of 4-hydroxy-2-(4-nitrophenyl)-5-phenyl-6H-1,3-oxazin-6-one m-phenylene dihydrazine dihydrochloride in absolute methanol medium in the presence of sodium methylate for 48 hours in an optimum temperature range of 45-48 °C. The structure of the obtained compound was proved by ^{1}H and ^{13}C NMR spectroscopy and confirmed by mass spectrometry. The yield of the target bis(1,2,4-triazole) in terms of 4-hydroxy-2-(4-nitrophenyl)-5-phenyl-6H-1,3-oxazin-6-one was 76 %. The obtained compound exhibited antimicrobial activity against Staphylococcus aureus with a minimum inhibitory concentration of 62.5 μg/ml.

sciforum-122923: The Synthesis And In Silico Screening Of Biological Activity Of New Symmetric Bisazomethines With A 1,3-Diazine Fragment: Promising Perspectives In Chemistry And Pharmaceutics

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Introduction

In the field of organic and medicinal chemistry, compounds with a 1,3-diazine scaffold, particularly pyrimidines and their derivatives, have attracted significant interest. Simultaneously, Schiff bases have drawn the attention of researchers as potentially effective chelating agents for various ions. Undoubtedly, bridged 1,3-diazine systems possess a potentially broad spectrum of biological activity. In this context, the synthesis and study of new azomethine systems based on pyrimidines represent a promising research direction, opening up opportunities for the creation of new biologically active molecules.

Methods

The aim of this study was the synthesis of new bridged systems based on 4,6-dihydroxy-2-methylpyrimidine-5-carbaldehyde. As a result of the nucleophilic addition of m- and p-phenylenediamines to the carbon atom of the carbonyl group of 4,6-dihydroxy-2-methylpyrimidine-5-carbaldehyde, a series of new azomethines was obtained. The synthesis of the target products was carried out using methanol and water as solvents, with practical yields being comparable under these conditions. The structure of the obtained compounds was confirmed by NMR spectroscopy ^{1}H and ^{13}C. The screening of biological activity was carried out using the web resources PASS-online, CLC-pred, Antivir-pred, and GUSAR-online.

Results

New bisazomethines based on the 5-formyl derivative of 2-methylpyrimidine-4,6-diol were synthesized. According to the in silico screening data, the synthesized compounds exhibit a wide spectrum of biological activity, including antihypertensive, antibacterial, antifungal, antiviral, and antitumor activity, and belong to toxicity class 4 (OECD project), indicating their potentially high safety profile.

Conclusions

Thus, new bisazomethines based on the 5-formyl derivative of 2-methylpyrimidine-4,6-diol were synthesized, which possess a high safety profile and diverse biological activity according to in silico screening data. The obtained compounds are of significant interest as unique ligands for the synthesis of complex compounds with transition metals and also have high potential for application in pharmaceutics.

sciforum-117817: Transition-Metal-Catalyzed Desymmetrization to Access Different Organophosphorus

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Desymmetrization has become one of the most important, elegant, and powerful strategies for rapidly creating various molecules, introducing dramatically increased structural complexity from readily available prochiral or *meso* compound feedstocks in recent years. At present, numerous advances in this field have been achieved, including transition-metal- and organic-small-molecule-catalyzed desymmetrization reactions of different types of compounds. Organophosphorus compounds play very important roles and are ubiquitous. They can be found in a wide range of nucleotides, pharmaceuticals, and phosphine-containing ligands. Therefore, the exploration and development of new asymmetric synthesis strategies to construct chiral phosphonic compounds with different structures has been one of the hot topics of organic synthesis. In recent years, our research group has been working on the synthesis of organic phosphine compounds and has developed some new reactions involved in strategy of desymmetrization, which include transition-metal-catalyzed phosphine oxygen-oriented asymmetric C-H functionalization, NIS-prompted C-H amination, and selenium-catalyzed hydroxylation.

In summary, combined with different methods such as cyclization, olefination, esterification, and so on, desymmetrization provides a simple and efficient pathway leading to various phosphorus molecules.

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Session 4. Engineering

sciforum-119586: Altitude Control in an Unmanned Aerial Vehicle Through Elevator Deflection

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is research study is about controlling the altitude of an Unmanned Aerial Vehicle (UAV) through the elevator. We apply our knowledge of Control Engineering to solve this problem. Elevators are flight control surfaces which control the lateral altitude by changing the pitch balance. Elevators are usually hinged to a fixed or adjustable rear surface, thus forming a tailplane or horizontal stabilizer. The elevator is used to control the altitude by its movement, which gives lift to the UAV. It consists of two loops: an inner-loop controller to achieve stability and robustness to the expected parameter uncertainty and an outer loop for tracking reference performance. In the past, people have studied its longitudinal maneuver using elevator control input. In this research, we are going to control vertical height using the elevator control input of an Unmanned Aerial Vehicle. This work deals with the altitude maintenance of a UAV through a dual laser and ultrasonic deflection to graph the surroundings and maintain the minimum maintained altitude. Angle deflection, along with thrust from the propulsion system, is matched and guided by the system for the gain or loss of altitude over a desired range of distance. The significance of the system is that it could provide efficient increases and decreases in UAV altitude, along with making the drone easier to pilot; in military aspects, our results might provide stealth enhancements due to the low chances of the UAV being detected. An example is Lockheed Martin F-35 with vertical takeoff and landing. The tracing can also be used for collecting the terrain data and for the placement of unspecified objects. The expected result increases the efficiency of any Unmanned Aerial Vehicle along with low fuel consumption because it allows the UAV to achieve the desired altitude over a short range.

sciforum-118810: Application of Symmetry and Fractional-Order Mechanics of Bone in Physical Fractal Space

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As a typical bio-composite, bone has excellent mechanical properties. At the micro scale, mineral crystals with low toughness are interlaced into a collagen matrix with a low modulus, which forms the nano-composite structure of bone. After functional self-assembly at different levels, real bone with a high elastic modulus and fracture toughness is formed at the macro scale. From Wolff's law to tension shear chain models, the exploration of bone mechanics is based on "geometric fractals". This article creatively introduces the new concept of "physical fractals" into compact bone and abstracts the fractal cells of the chain-like microfibers from bottom to top. Based on Heaviside operational calculus and combining the symmetry evolution laws of a functional fractal tree, a fractional-order constitutive model of these cells is established, which characterizes the fractional-order mechanics of bone in the physical fractal space. The above fractal theory possesses universality and is widely applicable in biomaterials such as muscle/ligament fibers, nerve fibers, and arterial blood flows. It should be noted that the fractal operators in this article are all non-integer-order operators. Such non-integer-order operators are suitable tools for characterizing non-localization effects. Therefore, the following concepts will be strengthened further: the mechanics in physical fractal space is the non-localized mechanics, the non-integer-order mechanics, and the mechanics controlled by non-elementary functions.

sciforum-119589: Design of a Magnetic Levitation Control System

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Magnetic levitation technology is gaining attention because it helps eliminate frictional losses due to mechanical contact. The goal of this project is to model and control a laboratory-scale magnetic levitation system. In this study, a scientific model of a magnetic field-based levitation system was implemented with the help of electromagnetic attraction. Some engineering applications include high-speed maglev trains, magnetic bearings, and precision platforms. This paper summarises the details of the levitation of metallic objects by magnetic attraction. Magnetic levitation technology is garnering attention for its potential to eliminate frictional losses in mechanical systems. This project aims to model and control a laboratory-scale magnetic levitation system using electromagnetic attraction. While magnetic levitation has numerous engineering applications, this study delves into the levitation of metallic objects through magnetic attraction. The study of this topic is much more relevant in the current circumstances as society is evolving to make the systems more efficient and provide better returns on energy, and this study contributes that. A company called hyper-loop, which plans to deploy energy-efficient solutions, utilises this system. The system is inherently unstable and nonlinear, making it a challenging control problem. In this paper, we discuss the implementation of a controller to stabilise the system, which also sets the stage for exploring non-metallic object levitation. We will delve into this in subsequent sections.

sciforum-118823: Physical Fractal and Fractal Operators Abstracted from Arterial Blood Flow

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A re-established physical fractal circuit model of arterial blood flow is presented, which incorporates the shunt effect of the branch vessels. By selecting fundamental admittance operators, we abstract a family of fractal operators from the model and investigate the kernel function and properties thereof. The fractal operator family abstracted from the fractal circuit model constitutes the fundamental graph of the apparent 1/2-order operators. The symmetry of the apparent 1/2-order operators is focused on when they are investigated.

Based on fractal operators, the intrinsic relation between the Bessel function and Struve function is revealed, and some new special functions are found.

We found that the Bessel function and Struve function are related through explicit integration; symmetrically, the modified Bessel function and modified Struve function also exhibit analogous connection. The above connections could be employed for constructing the kernel functions of the symmetric operators {[(p^2+a^2)]^(1/2)}/p and {[(p^2-a^2)]^(1/2)}/p, where p is the fundamental derivative operator.

Additionally, under certain conditions, the operator [(p+b)^2-a^2]^(1/2) and its relevant operators demonstrate notable symmetry with the operator [(p+b)^2+a^2]^(1/2) and its relevant operators, respectively. The constructions of the kernel functions for those operators necessitates the introduction of novel special functions, which possess properties challenging to articulate by elementary functions, and could be used tocharacterize nonlocal phenomenon.

The results provide mathematical tools for biomechanics and automatic control.

sciforum-117411: A Fault Identification Method for Ferroresonance based on Gramian Angular Summation Field and Improved Cloud Model

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Due to the broad frequency domain and nonlinear characteristics of ferroresonance signals, traditional time-frequency analysis methods often face challenges such as misjudgment, difficulty in threshold setting, and noise interference when extracting features from ferroresonance overvoltage signals. A fault identification method for ferroresonance based on the Gramian Angular Summation Field (GASF) and an improved cloud model is proposed to address the identified problems. Firstly, this paper employs Symplectic Geometric Mode Decomposition (SGMD) to denoise the ferroresonance overvoltage signal, extract its characteristic modal components, and reconstruct the signal. Secondly, the reconstructed one-dimensional signal is transformed into a two-dimensional image using GASF. Subsequently, We extract texture features of GASF images with different resonance types by grey-level co-occurrence matrix (GLCM), a powerful tool for analyzing image spatial relationships, and establish the corresponding cloud distribution model to characterize these textures. Finally, we calculate the membership degree between the standard cloud for the signal to be identified and the index cloud in the cloud distribution model, enabling accurate identification of the type of ferroresonance based on this membership degree. The feasibility and effectiveness of the proposed method are validated through comprehensive analyses of both simulation and actual measurement data, demonstrating its potential for practical applications in power system fault diagnosis.

sciforum-118101: A Key optoelectronic measurement technology for space gravitational wave detection

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Space gravitational wave detection uses a three-satellite formation, and the distance between these satellites can reach hundreds of thousands or even millions of kilometers. According to the principle of laser heterodyne interferometry, gravitational wave events can be measured through small distance changes in the inertial reference between satellites. Picometer-level measurement sensitivity is an internationally recognized challenge. Inertial reference construction, laser heterodyne interferometry measurement, and ultra-stable satellite platform control are the key technologies for space gravitational wave detection.
As an inertial reference, an inertial sensor is an important payload that includes key technologies such as capacitive sensing and electrostatic actuation, charge management, test mass and sensor housing, and caging and release mechanisms. The phasemeter, telescope, and interferometer constitute the laser heterodyne interferometry measurement system. The drag-free control technology enables satellites to follow the inertial references. To meet the ultra-high precision requirements of a space gravitational wave detection system, noise analysis is crucial. This report focuses on the progress of the key optoelectronic measurement technologies of the above-mentioned inertial sensors and laser heterodyne interferometry. The main contents of the report describe the composition of the core payload; its important role, functions, indicator allocation, and key optoelectronic measurement technology solutions; the current research progress; and subsequent research plans.

sciforum-123360: A shuffled frog leaping algorithm with Q learning for distributed hybrid flow shop scheduling problem with missing operations

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Distributed manufacturing introduces new challenges to traditional production shop scheduling, and the combination of machine learning and metaheuristic algorithms offers new approaches to solve these problems. To address the distributed hybrid flow shop scheduling problem with missing operations (DHFSP-MO), a shuffled frog leaping algorithm with Q learning (QSFLA) is proposed to minimize the maximum completion time. A dual-string encoding method is proposed to represent factory assignment and job sequencing, with heuristic methods utilized during decoding to determine machine assignments. The state set is constructed based on changes in the minimum and average objective values of solutions in the population, while the action set is built from different optimization objects during the memeplex search process. Q-learning is employed to dynamically adjust the optimization objects based on the state of the population. Testing on 140 benchmarks and a real-life example shows that Q-learning plays a positive role within QSFLA, and QSFLA effectively solves the DHFSP-MO. The superior performance of QSFLA stems from its designed global search strategies and local search strategies, as well as the dynamic search process based on Q-learning. The search strategies are designed based on the problem characteristics to ensure the acquisition of high-quality solutions after executing the searches. The dynamic search strategy based on Q-learning allows for the effective allocation of limited search resources to valuable solutions according to the population status. Therefore, QSFLA can effectively solve the DHFSP-MO.

sciforum-117722: A study on symmetric truncated icosahedral tensegrity

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Tensegrity systems represent a unique class of prestressed reticulated structures characterized by discontinuous compression elements (struts) embedded within continuous tensile networks (cables). These mechanically balanced configurations exhibit remarkable structural efficiency and adaptive stiffness properties, finding applications across multiple domains, including deployable aerospace systems, architectural engineering, and the biomechanical modeling of cellular structures. While numerical methods have dominated recent research efforts due to their capacity to handle complex geometries, this study demonstrates the critical advantages of analytical approaches through a focused investigation on truncated regular icosahedral tensegrities.

In these polyhedron-derived systems, tensile cables precisely map to edge connections while compressive struts occupy well-defined spatial diagonals, creating inherent three-dimensional prestress distributions. Central to the analysis is the spectral decomposition of the force density matrix, a mathematical construct encoding nodal connectivity and prestress magnitudes. For viable three-dimensional realization, the matrix must satisfy two distinct eigenvalue conditions: (1) a rank deficiency of at least four to ensure a non-degenerate spatial equilibrium, and (2) strictly positive remaining eigenvalues to guarantee super-stability, which is a robustness property enabling structural integrity under arbitrary loading conditions.

This work introduces a novel group-theoretic framework leveraging the irreducible representation theory of the icosahedral symmetry group. Through the systematic block-diagonalization of the force density matrix, we decouple its spectral properties into symmetry-adapted subspaces. This transformation reduces complex system-wide eigenvalue analysis to tractable submatrix investigations, enabling the derivation of closed-form stability criteria. This methodology demonstrates how symmetry principles can transform intractable nonlinear problems into structured analytical solutions, providing fundamental insights for the design of tensegrity systems.

sciforum-122016: Application Of A Mathematical Index To Assess Harmful Algal Blooms

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Harmful Algal Blooms (HABs) have emerged as a pressing environmental concern worldwide over the past few years. These blooms can lead to the closure of vital water reservoirs, cause the death and illness of animals, and pose significant health risks to humans. To effectively monitor and manage HABs, our laboratory has developed a specialized trophic index known as TRINDEX. This index has been applied to a reservoir in Moncton, New Brunswick, Canada, to assess the potential for algal blooms. TRINDEX employs a logarithmic transformation method, which is crucial for converting non-normal data distributions into a normal form. This transformation enhances the accuracy and reliability of the data analysis, making it easier to identify patterns and trends associated with HABs. Several key parameters are used to define TRINDEX and estimate the thresholds for HABs. These parameters include the concentrations of nitrate (NO3) and phosphate (PO4), which are essential nutrients for algal growth, as well as phycocyanin (PC), pigment found in cyanobacteria. Additionally, the absolute deviation of oxygen levels is considered, as changes in oxygen concentration can indicate the presence of algal blooms.

To determine the thresholds for HABs, the Receiver Operating Characteristic (ROC) curve is utilized. This statistical method helps evaluate the performance of the TRINDEX model in predicting algal blooms by assessing the trade-off between sensitivity and specificity.

The practical applications of TRINDEX for predicting the onset of algal blooms in freshwater reservoirs are substantial. By providing early warnings, this index can aid in the proactive management of water quality. Ultimately, the development of TRINDEX aims to support water quality management efforts and enable lake residents to take prompt action to protect themselves and their pets from the health risks associated with consuming water contaminated by HABs.

sciforum-121100: Design and Validation of Stair-Stepping Mechanical Metamaterials with Programmable Load Plateaus

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Materials engineered to exhibit specific load plateaus hold significant promise for the development of advanced vibration suppression and isolation systems, applicable to satellite platforms, submarines, and electric vehicles. However, the practical implementation of such materials presents substantial challenges. This study introduces stair-stepping mechanical metamaterials with programmable load plateaus, fabricated through a comprehensive three-tiered construction strategy involving unit, module, and three-dimensional object levels. Drawing inspiration from inverse design principles, this approach facilitates the customization of both the number and characteristics of load plateaus within the metamaterials' force-displacement profiles. The resulting stair-stepping response patterns have been rigorously validated through experimental testing and finite element simulations, demonstrating their effectiveness. Notably, reconfiguring the metamaterial units from their initial state to a “zero stiffness” configuration significantly enhances vibration isolation performance. Additionally, the study proposes two reversible methods for transitioning between various unit configurations: shape memory programming and payload support. This innovative design paradigm for programmable load plateaus not only enables the creation of metamaterials with tailored force-displacement responses but also opens avenues for integrating multimodal vibration isolation capabilities into precision devices. The findings thus provide a robust foundation for the advancement of customizable mechanical metamaterials, offering versatile solutions for complex vibration management challenges in critical applications.

sciforum-118015: Distribution regulation of chaos based on offset boosting

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Offset boosting is an important issue for chaos regulation due to the broadband property and polarity control of chaotic signal. There are two main approaches of offset boosting, one of which is resort to the single independent system parameter, and the other one is only based on the initial conditions resulting in all kinds of distribution regulation. With the assistance of periodic function, absolute value function or other piecewise linear function, the coexisting solutions of the system can form various regimes, such as attractor self-reproducing, attractor doubling, conditional symmetry or even dynamics editing. In this case, a specific initial condition can extract out the attractor locating at different positions in phase space. Through the relation analysis of the variable-dependence according to the nonlinear functions, the attractors within a dynamical system can be regulated via non-bifurcation offset parameter or initial conditions. By means of balancing the polarity with offset function, the corresponding derived systems of symmetry, conditional symmetry, self-reproducing system or dynamics editable system can be coined outputting pairs of or lattice of coexisting attractors, or even outputting any combination of parameter-selected attractors. Based on the technology of offset boosting, further distribution regulation of chaos can be achieved whatever in continuous systems or in discrete maps.

sciforum-123152: Federated transfer learning in multi-disease prediction: Why, How, and What Should?

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Introduction

The early prediction of multiple diseases is critical for improving healthcare outcomes and enabling timely medical interventions. However, the development of robust disease prediction models is hindered by challenges such as fragmented healthcare data and privacy concerns. Federated Transfer Learning (FTL) provides an effective solution by enabling collaborative model training across decentralized datasets while preserving data privacy. This research explores the application of FTL for multi-disease prediction, leveraging decentralized health data to enhance prediction accuracy and scalability without compromising privacy. **Objectives:** The main objective of this study is to develop an efficient, scalable, and privacy-preserving deep learning model for multi-disease prediction using Federated Transfer Learning. The study focuses on preprocessing the dataset, extracting relevant features, and optimizing model performance through hybrid optimization techniques. The goal is to demonstrate the potential of FTL in accurately predicting multiple diseases while ensuring the privacy of decentralized healthcare data.

Methods

This research utilizes the Multiple Disease Prediction Dataset from Kaggle, which includes various health parameters such as blood samples for predicting multiple diseases. Min-Max Scaling is used for preprocessing to normalize the dataset, ensuring all features are within a specified range. Feature extraction is performed using Linear Discriminant Analysis (LDA) and Independent Component Analysis (ICA), which help reduce dimensionality and identify essential components for disease classification. The model is trained using FTL, allowing decentralized collaborative learning. To optimize the model's performance, Hybrid Optimization, combining CuckooBee Search Optimization blend of Cuckoo Search Optimization (CSO) and Artificial Bee Colony (ABC), is employed for hyperparameter tuning.

Results

The proposed methodology significantly improves the accuracy of multi-disease prediction. Federated Transfer Learning ensures model scalability and privacy preservation, while hybrid optimization techniques enhance prediction performance.

Conclusion

This research highlights the effectiveness of FTL for multi-disease prediction, offering a robust, privacy-preserving framework for collaborative disease prediction in healthcare settings.

sciforum-118818: Fractal operators with fractional orders in fractal spaces abstracted form biological systems

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Fractional calculus has been widely applied across various disciplines, but researchers have long been challenged by the following fundamental questions: Where does the fractional operator originate? What is its relationship with fractals? What factors determine the order of fractional operator? This report attempts to provide answers to these questions.

In recent years, we have made progress in the study of bio-fractal dynamics. We discovered an interesting spatial form abstracted from living organisms—physical fractal spaces. Within these spaces, fractal operators are commonly found. Unlike classical operators, fractal operators characterize the intrinsic properties of biological materials, structures, and movements. We confirmed that fractal operators are generally fractional-order operators; the order of fractionality mainly depends on the topological invariants or topological indices of the physical fractal space.

The following contents will be included in the report: (a) the physical fractals abstracted from muscle fibers, ligament fibers, nerve fibers and arterial blood flows; (b) the fractal cell abstracted from the physical fractal; (c) the concept of fractal operator defined in the fractal cell; (d) the algebraic equation of the fractal operator; (e) the solution of the algebraic equation of the fractal operator and the order of the fractal operator; (f) the relation between the fractional order of the fractal operator and the topology of the fractal cell (or physical fractal space); (g) the kernel function of the fractal operator; (h) the relation between the fractal operator and fractional calculus.

Based on the new developments mentioned above, we can make a judgment that most of the motions in the living body can be attributed to the fractional dynamics with 1/2-order.

sciforum-117588: Illustration of the non-perturbation method for in-depth observation of jet engine vibration

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Nonlinear differential equations are widely used in nature to describe various complex phenomena such as fluid mechanics, engineering, and the dynamic behavior of ecosystems. The study of the vibration system of jet engines is crucial for understanding the performance of aircraft engines and reducing engine vibration, which can improve the reliability and durability of jet engines, reduce the maintenance cost, and improve the safety of air travel. In physics, symmetry is the foundation of conservation laws. Time symmetry leads to energy conservation, while spatial symmetry leads to momentum conservation. In this paper, we have modified the jet engine vibration model by using energy conservation and introducing nonlinearity as well as damping with or without external force, and used the non-perturbation method to explain its various phenomena. This study uses a non-perturbation method to linearly approximate and explicitly solve the nonlinear differential equations of the jet engine vibration system, demonstrating the effectiveness of this method in dealing with complex jet engine vibration equations under various operating conditions. The accuracy of the method is verified by comparing it with the numerical solutions obtained by the Runge–Kutta method in MATLAB. The method cansimplify analysis and provide a faster way to obtain approximate solutions without the need for iteration and perturbation calculations. Periodic solutions in a general form are derived, and various cases for jet engine system dependent on damping and driving forces are considered. This research provides important insights into the vibration reduction and performance optimization of jet engines and has profound implications for aerospace engineering.

sciforum-108735: Investigation of Self-Collimation Properties in Nonlinear, Low-Symmetry Photonic Crystal Structures

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hotonic crystals (PCs) are periodic optical structures that create photonic bandgaps, prohibiting the propagation of certain wavelengths of light. Mathematical calculations in photonic crystals reveal complex interactions between light and periodic structures, leading to phenomena such as bandgaps, negative refraction, nonlinearity, and bistability. Understanding these relationships through rigorous calculations (in frequency and time domains) is essential for designing advanced photonic devices, telecommunications, and optical sensing applications.

While conventional photonic crystals are usually designed with unit cells with high symmetry, structures with low rotational symmetry emerge by breaking this symmetry. Due to their geometrical diversity, low-symmetry structures are more sensitive to light manipulation and provide more control and flexibility over light.

Nonlinear (NL) PCs, which exhibit a refractive index dependent on the intensity of the incident light, create conditions for enhanced light–matter interactions, enabling the control and manipulation of light propagation within the crystal.

Self-collimation (SC), a key effect in photonic crystals, refers to the ability of certain PCs to direct light beams through the crystal without divergence. This occurs when the equi-frequency contours (EFCs) in the photonic band structure are nearly flat. A flat EFC implies that the group velocity of light is consistent across different wavevectors, resulting in the self-collimation of light.

EFC analysis in nonlinear photonic crystals is crucial for understanding how different modes propagate within the crystal. In linear PCs, EFCs provide information on the allowed propagation modes and their associated group velocities. However, in nonlinear PCs with Kerr-type nonlinearity, the EFCs become intensity-dependent.

In this study, nonlinearity is used in combination with low symmetry. The self-collimation properties of a low-symmetry hexagonal photonic crystal structure consisting of Kerr-type nonlinear LiNbO3 materials were extracted, and its equi-frequency contours and transmission properties were examined according to the nonlinear index change of C2-type low-symmetry rods.

sciforum-117616: Modeling of the Discrete Memristor and Its Applications: An Anticipation

Shaobo He

Xiangtan University

Since 2020, the development of discrete memristor designs, which are grounded in integer- and fractional-order difference operators, has emerged as a novel approach and topic within the realm of memristor modeling. This innovative type of memristor is applicable to discrete domain modeling and its associated applications. Notably, the modeling of nonlinear chaotic systems using discrete memristors and the utilization of artificial neural networks have garnered significant scholarly interest both domestically and internationally. Initially, this report introduces the method of discrete memristor modeling based on difference operators, focusing on the discretization techniques for continuous memristor models and the equivalence issues between discrete and continuous memristor models. Subsequently, it summarizes the current accomplishments in the application of discrete memristors to the modeling of nonlinear chaotic systems and discrete neural networks, highlighting the potential engineering applications of discrete memristors. Finally, this report explores the physical realizability of discrete memristors, detailing their implementation through digital and analog circuits. This document encapsulates the existing research advancements in discrete memristor technology and delineates potential future research trajectories for its various components. In particular, the theory of Z-transform is employed for the modeling of discrete memristors. When it comes to the modeling of discrete memristor spiking neural networks, attention is paid to applications pertinent to the modeling of spiking neural networks. Regarding circuit implementation, the pivotal role of the sample-and-hold circuit design is emphasized.

sciforum-118031: Multi-Component Yarn with Graphene/Silver Wire for Wearable Sensors

Md Hasan Mahmud

Textile Engineering

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sciforum-122676: Novel non-probabilistic uncertainty-based fault diagnosis method considering sample distribution

Qiang Xin * and Wang Chong

Beihang Universtity

Fault diagnosis is regarded as an essential technique for monitoring the anomalous status of complex systems, significantly improving operational safety while preventing unexpected downtime. Nevertheless, uncertainty factors are ubiquitous in various engineering practices, and the underestimation of these uncertainties limits the accuracy of traditional data-driven fault diagnosis methods. To tackle this challenge, this study proposes a non-probabilistic uncertainty-based fault diagnosis method that systematically incorporates sample distribution characteristics to achieve more accurate fault classification. Firstly, the original experimental data are partitioned and statistical features are extracted from each segment, thereby yielding representative samples with scattered manners. For the problem with inaccurate samples, a local similarity-based identification method is developed to mitigate outlier-induced data deviations. For those available samples with dispersed distributions, the Bayesian Gaussian mixture model is employed for clustering, where the number of clusters can be adaptively determined by minimizing the Bayesian information criterion. Based on the above data preprocessing procedure, a data-driven modeling method is further utilized to construct the parallelepiped-formed uncertain features, wherein independent and dependent statistical features are characterized simultaneously. Under the evidence theory framework, an improved volume-based strategy is presented to quantitively calculate the basic probability assignment of focal elements, wherein the maximum probability decision criterion is applied to deliver pattern matching results. Eventually, two numerical cases are investigated to validate the effectiveness of the proposed models and methods.

sciforum-118077: Photoresponse and synapse characteristics of Ga_2O_3 based devices

Longxing Su

Dongguan University of Technology

Emerging wide bandgap semiconductor Ga_2O_3 shows distinct characteristics for optoelectronic applications and a stable crystal phase of Ga_2O_3 is highly desired. In this work, Ga_2O_3 thin films with different crystal structures including amorphous, ε, and β phases are prepared through different methods. In addition, doping of N into the Ga_2O_3 film layer can reduce its bandgap from 4.8 eV to 4.3 eV. GaN/Ga_2O_3:N heterostructure photodetector is fabricated and shows superior response performance in deep UV region,and the response speed of the photodetector is measured at millisecond scale. The concentration of the oxygen vacancies in Ga_2O_3 is deliberately introduced by controlling the flux of oxygen source, which plays a key role in the origin of the persistent photocurrent. Then, Ga_2O_3 based photodetectors are fabricated for studying the UV artificial synaptic functions. The photonic device exhibits primary synaptic functions including excitatory postsynaptic current (EPSC), short term memory (STM), pair pulse facilitation (PPF), long term memory (LTM), and STM-to-LTM conversion. In addition, stronger and repeatedly stimulus can naturally contribute to the higher learning capability, and thus prolonging the memory time. These findings show that the photonic synaptic device fabricated on the Ga_2O_3 provide a potential strategy for future information processing.

sciforum-121479: Space Heating Demand Prediction of Residential Houses using High-Frequency, Imprecise Data from Smart Thermostat with AI/ML Techniques

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This research paper aims to use a data-driven machine learning-based model to predict the hourly space heating demand of residential houses suitable for predictive and supervisory control. It briefly discusses current energy industry practices pertaining to the use of Machine Learning (ML) techniques to optimize energy usage and costs in buildings and contrasts different types of models such as white-, gray-, and black-box models. The use of physics-based white-box models has become difficult since they require an understanding of system dynamics and contain a large number of parameters. In addition, contemporary white/gray box models result in higher energy consumption, costs, GHG emissions, compromised thermal comfort and equipment degradation. Model Predictive Control (MPC) provides an alternative and solves the above problems due to its ability to reach a steady state in a shorter time and exhibit lower offsets compared to conventional PID controllers. In this paper, a case study was also conducted to forecast the natural gas furnace run time of a test house in Toronto, ON using the high frequency, imprecise Wi-Fi-connected smart thermostat sensor dataset along with climatic data from NASA and Environment and Climate Change Canada (ECCC). This dataset comprised indoor and outdoor thermodynamic parameters and the furnace usage, in terms of run-time, for the test house. Variants of deep-learning and feed-forward neural networks such as RNN, LSTM and GRU and other regression models like SVM, GBR, RFR, MLPR, and Ensemble were developed and fine-tuned to the test dataset resulting in a maximum R-squared (coefficient of determination) value of 0.91 with an MAE (mean absolute error) of 0.098 and an MSE (mean squared error) of 0.2.

sciforum-122940: The Continued Fraction Structure in Physical Fractal Theory

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This study systematically uncovers the profound mathematical isomorphism between physical fractal theory and continued fraction theory. By constructing a bridge through generating mappings, we demonstrate for the first time that fractal operators inherently possess an algebraic structure of periodic continued fractions. The research begins by reviewing the historical development of continued fractions and the foundational framework of physical fractal theory, highlighting that although these concepts originate from distinct disciplines—the former as a pure mathematical tool and the latter as a method for modeling physical systems—they share the core feature of "infinite recursive nesting."

Based on the fractal ladder model, we derive the explicit expression of fractal operators, revealing their essence as periodic continued fractions with a cycle of 2. This structure is proven to stem from the fractional linear mapping properties of circuit series-parallel rules. By introducing contraction transformations of continued fractions, the original structure is simplified into a characteristic continued fraction with a period of 1. Leveraging convergence theory, we rigorously establish the universal convergence of fractal operators, resolving the long-standing assumption of operator existence in physical fractal theory.

Furthermore, the study reinterprets the traditional method for solving fractal operators as the process of solving fixed-point equations, providing a rigorous mathematical foundation for the approach. The derivative criterion is employed to justify the selection of positive roots, offering theoretical clarity to a previously empirically guided step.

The findings of this work establish a robust algebraic framework for physical fractal theory while endowing continued fractions with a concrete physical interpretation. Potential applications extend to fields such as biomechanics and rock mechanics, paving the way for future interdisciplinary research. This research not only advances theoretical understanding but also opens new avenues for practical engineering solutions.

Session 5. Computer Science

sciforum-122974: An Enhanced TSA-PNN (Tree Seed Algorithm–Probabilistic Neural Network) Model for the Identification of Medical Insurance Fraud

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Healthcare insurance fraud detection is a challenging task. With the diversification and concealment of fraudulent methods, traditional detection methods based on rules and historical data are no longer sufficient to meet the demands. This paper combines swarm intelligence with Probabilistic Neural Networks (PNNs) to improve the precision and efficiency of detection. **The PNN perform well in handling uncertainties and noise, but it may encounter issues with local optima and slow convergence when dealing with large-scale datasets.** This paper aims to address the issue of medical insurance fraud detection, proposing a PNN model incorporating an improved Tree Seed Algorithm (GTSA-PNN). **By integrating three innovative heuristic strategies, this model enhances convergence speed and accuracy while also strengthening robustness against outliers and noise.** Additionally, this study introduces a GTSA-KNN feature selection model. **To ensure the accuracy and fairness of model evaluation, the Borderline-SMOTE technique was employed to address the issue of class imbalance within the real medical insurance datasets utilized in this study.** The experimental results demonstrate that **the GTSA-PNN model achieves outstanding performance in medical insurance fraud detection tasks, with an accuracy of 96.35%, a precision of 93.59%, and an F1 score of 96.46%, surpassing other PNN models optimized by various optimization algorithms across multiple key performance metrics.** Moreover, **the GTSA algorithm exhibits an excellent exploration capability and ability to avoid local optima in the evaluation of IEEE CEC 2014 benchmark test functions, outperforming the TSA, EST-TSA, STSA, RSA, and GA algorithms.**

sciforum-118104: Computer System Life Cycle Model

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This article considers a generalized approach to formalizing the life cycle of an arbitrary computer system. This approach is an extension of the Demming cycle and has symmetry in constructing a diagram of the life cycle stages. Models of the life cycle of a computer system during its development and maintenance are proposed. The life cycle model for maintaining a computer system includes the following stages: system delivery, commissioning/decommissioning, restoration of operability, updating, operation, etc. The life cycle model for developing a computer system includes the following stages: drawing up a technical specification, designing the system, implementation, testing, eliminating vulnerabilities, etc. It is shown that a similar approach can be applied to describing the life cycle of regulatory documents, the life cycle of employees in an organization, and the life cycle of software (hardware and software). The proposed approach to formalizing the life cycle allows the processes of managing a computer system (including managing service personnel) to be systematized and the key threats to system security that arise at various stages of the life cycle to be formulated. At the same time, for each stage, the threats to integrity (disruption of the correct operation of the system) and confidentiality (the acquisition of sensitive information about the system by an attacker) are taken into account. Examples of such threats may be the introduction of vulnerabilities by an attacker during the design of the system or the disclosure of information about the results of testing the system.

sciforum-118060: Computer technologies in speech rehabilitation of patients with malignant tumors of the head and neck

Evgeny Yu. Kostyuchenko [1,*], Lidiya N. Balatskaya [2,3], Evgeny L. Choinzonov [2,3], Svetlana Y. Chizhevskaya [2], Denis E. Kulbakin [2], Elena A. Krasavina [2], Alexander A. Shelupanov [1], Dariya I. Novokhrestova [1], Anton A. Konev [1] and Sergey N. Novikov [4]

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The purpose of the work is to analyze the effectiveness of personalized application of methods for restoring voice and speech function in patients with malignant neoplasms of the head and neck after surgery using computer technology.

An analysis was conducted of 280 patients with laryngeal and laryngopharyngeal cancer T2-4N0-2M0, oropharyngeal cancer T1-3N0-2M0, who received combined treatment at the Tomsk National Research Medical Center Oncology Research Institute. After surgery, all patients experienced impaired voice and speech functions. Together with scientists from the Institute of System Integration and Security of Tomsk State University of Control Systems and Radioelectronics, modern methods of restoring voice and speech functions using computer technologies have been developed, physiologically substantiated and introduced into clinical practice.

A mathematical model of the voice formation mechanism with esophageal voice in patients after complete removal of the larynx has been developed. Computer modeling of voice formation processes has proven that in the phase of the fundamental tone, the tension of the air bubble equivalent under the pseudo-glottic gap and the equivalent of the pressure in the lungs remain constant. The use of biological feedback using the computer-software complex "Realog" allows for an objective assessment of the pseudo-voice, individual selection of parameters and types of voice training. According to the results of the study, the esophageal voice was formed in 92% of cases within three weeks, in the control group 86% within 5-6 weeks. For a personalized approach to speech rehabilitation of patients with oral cancer after hemiglossectomy, the computer-software complex "OnkoSpeech v4.0" was developed and introduced into clinical practice for the purpose of planning rehabilitation tactics based on spectral analysis of pronunciation disorders in comparison with reference indicators. It has been proven that acoustic indicators approach reference speech indicators in almost all patients.

sciforum-121363: A Visual Chain of Thought System Based on the Concept of Symmetry: Solving the Dilemma of Complex Reasoning in Large Language Models

Shun Nain Luo * and Yicheng Jin

Sanda University

In recent years, large language models (LLMs) have made substantial progress in natural language processing. However, when confronted with logic-intensive tasks such as logical reasoning and mathematical computations, LLMs frequently exhibit problems, including opaque reasoning procedures and suboptimal accuracy. The "Chain of Thought" (CoT) strategy has been proposed to solve these problems, and it can significantly improve a model's reasoning capabilities. Nevertheless, constructing and managing CoT leads to difficulties such as high abstraction and intricate operations. Tools like LangChain were developed to address these complexities, and this study introduces the concept of symmetry to guarantee consistent and harmonious operations at every stage.

Notwithstanding the considerable assistance provided by symmetry, challenges remain in CoT construction and optimization, particularly for intricate logical reasoning and multi-level tasks, which pose difficulties for users. Thus, in this study, we develop a visual CoT system. Through an intuitive graphical interface and dynamic interactions, it simplifies CoT construction, adjustment, and management, effectively reducing the technical operation complexity for users. It offers real-time feedback and optimization suggestions, greatly enhancing the model's performance in handling complex tasks. In conclusion, the visual CoT system, based on symmetry, is crucial in streamlining reasoning and reducing technical barriers, making it a core element for enhancing LLMs' performance in complex reasoning tasks.

sciforum-122976: ADTSA: an Adaptive Dual-subpopulation based Tree Seed Algorithm for Local Optima Avoidance and Fast Convergence

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The Tree Seed Algorithm, a symmetry-driven metaheuristic inspired by biomimetic tree-seed evolution, shows promise for complex optimization but suffers from local optima entrapment and slow convergence. We propose ADTSA to resolve these limitations.

To avoid local optima, ADTSA employs a symmetric double-layer framework that partitions populations into elite and non-elite subpopulations through fitness ranking. Elite subgroups implement Golden Sine updates, while others follow global-best guidance, with dynamic inter-subpopulation migration ensuring information exchange. Additionally, historical optimal solutions are archived and periodically injected via K-Means clustering to replace underperforming individuals. Late-stage optimization incorporates solution memory retention and t-distribution perturbations to escape local optima.

To enhance convergence characteristics, ADTSA features an adaptive symmetry modulation scheme that dynamically optimizes subpopulation ratios based on search states. During exploration, elite subgroup proportions expand to accelerate convergence. In later iterations, convergence speed is further enhanced by merging subgroups with adjacent high-fitness subpopulations and replacing memory solutions through convex lens symmetric reverse learning from global best solutions.

Experimental validation on IEEE CEC 2014 benchmark functions shows that ADTSA outperforms the widely recognized top-performing algorithms like LSHADE, JADE, and recent TSA variants (STSA, EST-TSA, fb-TSA, MTSA), as well as other optimization algorithms including GWO, PSO, BOA, GA, and RSA. In 30 test functions, ADTSA achieved 17/30 top rankings in 30D/50D cases and 22/30 in 100D problems, demonstrating its superior performance in problems.

In engineering applications (spring design, truss optimization, beam engineering) and high-dimensional SDVRP instances (261D, 400D, 1000D), ADTSA achieved the fastest convergence and best solutions, proving its superiority over traditional TSA in complex optimization tasks.

All in all, the proposed symmetric framework enhances TSA's local optima avoidance through dynamic subpopulation management and solution archiving. Convergence acceleration stems from adaptive ratio modulation, subgroup merging, and convex lens symmetric learning, establishing ADTSA's effectiveness in complex optimization tasks.

sciforum-122994: AMTSA: Adaptive and Migration-enhanced Tree Seed Algorithm for Complex Optimization Problems

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The Tree-Seed Algorithm (TSA) is a swarm intelligence algorithm driven by symmetry principles. It uses symmetric processes for the evolution of trees and seeds. However, the TSA is limited by early convergence and struggles with high-dimensional, complex problems. To address these challenges, the Adaptive and Migration-enhanced Tree Seed Algorithm (AMTSA) is proposed. It improves the TSA's computational performance by integrating multiple strategies.

First, to effectively avoid local optimality, an adaptive tree migration mechanism is proposed. This mechanism adjusts step size and direction based on each tree's situation. Second, to enhance adaptability and efficiency of the algorithm across different search stages, an adaptive seed generation strategy based on the dynamic Weibull distribution is introduced. This strategy allows for flexible seed adjustment and symmetric dispersion across search stages. Third, to resolve instability and oscillations in the global search, AMTSA dynamically adjusts the step size using a nonlinear function based on iterations, inspired by the GBO algorithm, which improves search stability.

Through experimental validation on the IEEE CEC 2014 benchmark functions, the AMTSA outperforms JADE and LSHADE, which are considered among the best algorithms in the field. Furthermore, it surpasses several recent TSA variants, including STSA, EST-TSA, fb-TSA, and MTSA, in overall performance. To validate the AMTSA's effectiveness in complex optimization problems, experiments were conducted on 30 benchmark functions at dimensions of 30, 50, and 100. AMTSA ranked first in the number of functions it optimized best, outperforming all algorithms on at least 20 functions. Additionally, the AMTSA converged faster than all other algorithms, highlighting its efficiency in finding optimal solutions.

Further experiments show that the AMTSA, using optimized multi-threshold CT image segmentation and an SVM-based lung cancer detection model, achieves 89.5% accuracy. This accuracy is higher than that of other models, including SVM (76.22%), DE-SVM (82%), GA-SVM (79.33%), TSA-SVM (84.44%), and JADE-SVM (89.12%).

In summary, the AMTSA enhances the TSA's symmetry by introducing three strategies, improving its ability to address complex optimization problems.

sciforum-122987: ASTSA: an Adaptive Synergistic Tree Seed Algorithm for Complex Optimization Problems

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The Tree Seed Algorithm (TSA) is a meta-heuristic algorithm for solving optimization problems. Its symmetry is reflected in the uniformity of seed propagation and the fairness of the fitting function. Its symmetric design improves solution efficiency. However, the TSA suffers from the disadvantages of poor adaptability, high randomness in seed position updating, ease of falling into local optimization, and limited population diversity. In this paper, an Adaptive Synergistic Tree Seed Algorithm (ASTSA) is proposed to solve these drawbacks through four improvements.

First, the Search Tendency (*ST*) is dynamically adjusted to adapt the algorithm to different stages. Second, a symmetric search strategy is used in updating the seed locations. An adaptive scale factor is introduced to adjust the step size to reduce the randomness of seed position updates. Third, a threshold-based tree escape mechanism is introduced to reduce the possibility of falling into a local optimum. Finally, partial individual fusion is utilized to increase population diversity.

Through experimental validation on the IEEE CEC 2014 benchmark functions, the ASTSA outperforms the strongest algorithms such as JADE, LSHADE, and SHADE in 23 functions. The performance advantage is further extended to 25 functions when compared to the latest TSA variants such as the STSA, EST-TSA, and fb-TSA. To verify the effectiveness of the ASTSA in complex optimization problems, experiments are conducted on 30 benchmark functions in 30, 50, and 100 dimensions. The ASTSA is ranked first in all of them.

Practical application experiments show that due to the complexity of adjusting the parameters of colon cancer histopathology images and the tendency to fall into local optimization, the ASTSA achieves 90.0% detection accuracy by optimizing the symmetric design strategy. This accuracy is significantly better than that of other optimized algorithms, including SVM (78.95%), BOA-SVM (87.11%), PSO-SVM (85.67%), and DE-SVM (83.2%).

The ASTSA is able to output the optimal solution stably when dealing with multimodal, high-dimensional, and constrained optimization problems by introducing a symmetric search strategy.

sciforum-121821: Blockchain-Based Software-Defined UAV Secure Connectivity Framework and Architecture for 6G Networks

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Unmanned Aerial Vehicles (UAVs) have been used in various fields, such as agriculture, pharmaceuticals, remote sensing, and telecommunications. UAV networks can be connected in two ways: through a conventional UAV network or a software-defined UAV (SDUAV) network. SDUAV networks offer several advantages over conventional UAV networks. These networks feature centralized control through the deployment of an SDN controller. The various attractive features of SDUAV networks have drawn the attention of researchers, industry professionals, telecommunications companies, and device manufacturers seeking integration with future sixth-generation (6G) networks. SDUAVs connected to cellular networks to provide wide-area coverage face numerous security challenges, with secure connectivity and the protection of sensitive information being major concerns. To understand the potential attack scenarios in the existing SDUAV communication network architectures better, we provide a detailed description of each scenario. To address these security issues, this study proposes a modified SDUAV communication network architecture and a secure connectivity framework for future 6G networks, enhanced by blockchain technology—a novel and advanced approach to securing sensitive information. Before presenting the proposed framework, we provide a comprehensive background and introduction to the current SDUAV communication network architectures. The proposed framework outlines the connectivity and authentication processes for the SDUAVs with the SDN controller, following identification by a blockchain-based authentication server. However, we have not implemented the proposed secure connectivity framework at this stage. Finally, we present a detailed discussion and outline future plans for implementing the blockchain-based secure connectivity framework.

sciforum-122963: Bridging Real-Time Information Asymmetry in Urban Traffic: A Reinforcement Learning-Based Smart Mobility Framework for Indian Cities

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Rapid urbanization in India has led to mounting transportation challenges in cities like Bengaluru, Delhi, and Hyderabad. Increasing vehicle ownership, limited public transport expansion, and inefficient infrastructure management have caused severe congestion, longer travel times, and higher emissions. A core issue is the asymmetry in real-time information among key stakeholders—drivers, commuters, and traffic authorities—resulting in poor decision-making and underutilized transport modes. In response, smart mobility has emerged as a strategic approach within the smart cities framework, leveraging digital technologies to enhance transportation systems. However, most Indian cities still lack integrated platforms capable of effectively capturing and utilizing real-time traffic data. This study introduces a smart mobility framework that combines Multi-Agent Reinforcement Learning (MARL) with IoT-enabled sensor networks to mitigate information asymmetry and optimize urban traffic flow. By leveraging real-time data from traffic cameras, GPS devices, and RFID sensors, the system dynamically adjusts signal timings, redistributes road space, and optimizes public transport operations. The model is validated using real-world data and simulations on selected corridors in Bengaluru, Delhi, and Hyderabad, utilizing the SUMO (Simulation of Urban Mobility) platform. Results demonstrate the potential for reduced congestion, improved travel time reliability, and enhanced public transport efficiency. The proposed solution offers a scalable and adaptive framework aligned with India's vision for smart, sustainable, and data-driven urban transportation systems.

sciforum-115221: Digital Twins for Assured Safety of Collaborative Robots Driven by Generative AI

Zhou Zhang

SUNY Farmingdale State College

Collaborative robots (cobots) have become integral in modern manufacturing, where their ability to work alongside humans enhances productivity and efficiency. However, ensuring safety during their operation remains a critical challenge, particularly when Generative AI drives these systems. This paper introduces a novel approach to integrating digital twins within the Unity game engine to ensure the safety and efficiency of cobots.

The proposed framework leverages Generative AI to interpret narrative job descriptions, generate commands, and simulate actions in a virtual environment. By incorporating innovative algorithms, such as deep reinforcement learning (DRL), multi-objective evolutionary algorithms (MOEAs), and physics-informed neural networks (PINNs), the system optimizes the robot's movements within the digital twin. These algorithms enable precise motion planning, energy-efficient operations, and dynamic adaptability to unforeseen scenarios. The digital twin functions as a robust safety layer, identifying and mitigating potential risks such as collisions, inefficiencies, or deviations in real time.

Furthermore, advanced explainable AI (XAI) tools are integrated into the system to provide transparency and trust in Generative AI decision-making, particularly in safety-critical applications. Real-time data from IoT sensors further enrich the simulation, ensuring that cobot operations remain adaptive to dynamic manufacturing environments. The framework significantly mitigates risks and enhances operational decision-making, providing a comprehensive solution for safe and efficient cobot deployment in industrial settings.

sciforum-118057: Distinctive features of voiced plosives in continuous speech and vocal performances for different languages.

Anton A. Konev *, Evgeny Yu. Kostyuchenko, Alexander A. Shelupanov and Alexey G. Sabanov

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This study investigates the distinctive features of voiced plosives in continuous speech and vocal performances across three languages: Russian, English, and Arabic. Five key behavioral characteristics of voiced plosive sounds were identified: a decrease in fundamental frequency values, the formation of gaps in the fundamental frequency, the identification of the second harmonic as the fundamental instead of the first, distortion of values at the third harmonic, and incorrect determination of the fundamental frequency. The recognition accuracy of voiced plosives in continuous speech was compared with vocal performance, revealing no significant difference based on the gender of the performer. The significance of these features was analyzed for various pronunciation variants and languages, providing recommendations for their use in identifying voiced plosives. The findings suggest that continuous speech offers more accurate recognition of voiced plosives compared to vocal performance, primarily due to differences in power, volume, and vowel duration. This research contributes to the development of more precise speech recognition algorithms by highlighting the phonetic nuances of voiced plosives in different linguistic contexts. Additionally, the study underscores the importance of considering language-specific phonetic variations when designing speech recognition systems, as the occurrence and behavior of voiced plosives vary significantly across languages. The results also indicate that while some features, such as frequency declines, are consistent across languages, others, like harmonic distortions, are more prevalent in vocal performances.

sciforum-118099: Formation of a data set for conducting a study of the speech signal in normal and pathological conditions.

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Abstract

This paper analyzes existing datasets containing voice and speech recordings of patients who have undergone various surgical interventions on the organs of the speech-forming tract. The main goal of the study is to build our own dataset that will take into account the specifics of Russian-speaking patients and provide the ability to conduct a comprehensive analysis of speech quality after surgery. The paper presents an overview of five main datasets used in international studies and conducts a comparative analysis.

The datasets contain data on patients who have undergone such surgeries as tonsillectomy, functional endoscopic sinus surgery, septoplasty, laryngectomy, glossectomy, tongue reconstruction, surgical treatment of snoring and obstructive sleep apnea syndrome.

The main conclusions of the analysis of existing datasets are as follows:

1. The absence of Russian-language datasets with postoperative recordings.
2. Among the foreign datasets, only one is in the public domain.
3. The need to create our own Russian-language dataset to conduct more relevant research.

Based on the analysis, the authors propose the structure of our own dataset, which includes the following elements:

- Personal data of the patient (full name, year of birth, diagnosis, volume of surgery).
- Speech therapy diagnosis and information about sessions with a speech therapist.
- Recordings of audio files and their assessment by various parameters (syllabic and phrasal intelligibility).
- Using tables of speech units from GOST 50840-95 to assess speech quality.

The proposed structure of the dataset allows us to systematize and store information about patients, their diagnoses, operations performed, and the results of speech therapy work. This provides the ability to accumulate data for further analysis and development of methods for automatic speech quality assessment. The work emphasizes the importance of creating a Russian-language dataset for conducting research in the field of voice and speech rehabilitation.

sciforum-120828: Harnessing AI to Predict Lower Limb Varicose Veins: A Study among Healthcare Providers in Jordan

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Abstract. Lower Limb Varicose Veins (LLVV) are a common problem among healthcare providers. Once it occurs, it will seriously affect the productivity and the quality of life of the affected person. Therefore, early prediction and preventing of Lower Limb Varicose Veins can improve pa tient prognosis. This study constructed different machine learning models to explore their efficiency in predicting LLVV. Five prediction models were applied to the study, including a Support Vector Machine (SVM) model, XGBoost model, decision tree (DT) model, Random Forests (RF) model, and Logistic Regression (LR) model. Afterward, the performance of the obtained prediction models was evaluated by Cross-validation, ROC-AUC (area under the curve), Precision-Recall AUC. The results showed that XGBoost outperformed the other models, achieving the highest accuracy (0.85 ± 0.03), ROC-AUC (0.98), and Precision-Recall AUC (0.97), demonstrating its strong predictive power. While models like Logistic Regression, Support Vector Machine, and Random Forest also performed well with AUC values above 0.9, XGBoost consistently delivered the best results. Moreover, our study was conducted on a limited set of demographic and clinical variables without considering other possible determinants of LLVV such as lifestyle factors or genetic susceptibility. Thus, the model still needs external verification research before its clinical application.

This study constructed different machine-learning models to explore their effectiveness in predicting LLVV among nurses. Five prediction models were ap plied to the study, including a Support Vector Machine (SVM) model, XGBoost model, decision tree (DT) model, Random Forests (RF) model, and Logistic Regression (LR) model. Afterward, the performance of the obtained prediction models was evaluated by Cross-validation, ROC-AUC (area under the curve), Precision-Recall AUC. The implementation of machine learning in healthcare of fers numerous benefits. ML algorithms can analyze vast amounts of data quickly and accurately, helping to identify patterns that may go unnoticed by human observers. This can lead to earlier detection of LLVV and more targeted treatment approaches.

sciforum-122977: KMBCA: A K-Means clustering-based Besiege and Conquer Algorithm with adaptive and multi-strategy enhancements

Jialing Han, Aobo Zhang * and Jianhua Jiang

JiLin University of Finance and Economics

The Besiege and Conquer Algorithm (BCA) is a newly proposed meta-heuristic algorithm inspired by warfare. It has exhibited outstanding performance in optimization problems due to its symmetrical search pattern. Aiming to resolve the problems of excessive randomness in soldier grouping, single strategy, and parameter sensitivity encountered by the traditional BCA in complex optimization problems, this paper presents an adaptive multi-strategy improved algorithm based on K-means clustering (KMBCA).

Firstly, in order to solve the problem of excessive randomness in soldier grouping, the algorithm innovatively introduces a target space clustering mechanism. During the exploration, the population is dynamically divided into different soldier groups based on the mean of the entire cluster, and the clustering results in the target space are symmetrically mapped to the decision space. Secondly, aiming at the singularity of strategies, differentiated update strategies are respectively adopted for each soldier group, and a three-stage collaborative exploration mode is designed. Finally, a balance mechanism and the idea of symmetry are incorporated through boundary reflection to balance global exploration and local exploitation, thereby resolving the problem of parameter sensitivity.

To showcase the performance of the KMBCA in various optimization problems, the experimental part of this study is based on the IEEE CEC 2022 benchmark test set, encompassing uni-modal, multi-modal, hybrid, and composite functions. The results indicate that the average convergence accuracy of the KMBCA in optimization problems is significantly improved compared to the BCA. With the support of the Friedman ranking, the KMBCA demonstrates obvious advantages over PSO, AGWO, and others. In the application verification, the KMBCA successfully optimizes the weights and bias parameters of the Multi-Layer Perceptron (MLP), and the classification accuracy on the UCI standard dataset is significantly higher than that of comparison algorithms like SSA and JADE. This study provides a novel idea for the collaborative optimization of swarm intelligence algorithms and machine learning models.

sciforum-118094: Learn From Human Eyes: Zero-Shot Recurring Pattern Detection on a Multi-Perception Benchmark

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The human perception of similarity, particularly of symmetric structures and recurring patterns (RPs), is subjective and context-dependent, posing challenges for computer vision. This ambiguity is prominent when analyzing complex scenes, where observers often diverge in interpreting identical stimuli. To bridge this semantic gap, we propose a framework formalizing RPs to capture both the collective consensus and individual perceptual variations, focusing on symmetry-rich environments where translational, rotational, or reflective symmetries are common.

We establish the first large-scale, multi-perception RP dataset, containing 4,625 images with dense annotations from an average of 30 observers each, yielding over 220,000 unique RP perceptions across diverse symmetry types. While acknowledging inherent limitations like potential annotator bias, this dataset captures the spectrum of human pattern perception. To resolve perceptual ambiguities, we developed a Consensus Aggregation Algorithm, employing multi-stage hierarchical clustering based on instance-level feature embeddings to distill statistically significant, symmetry-aware ground truths from conflicting annotations.

Building on this foundation, we introduce a Zero-Shot RP Detection Algorithm mimicking human generalization. By leveraging vision foundation models (e.g., SAM, DINO) for the candidate proposal and feature extraction, followed by recurrence-based refinements and similarity-aware clustering, our method effectively detects RPs without task-specific training. We demonstrate its state-of-the-art performance through rigorous, metric-based evaluations on both our novel dataset and existing public benchmarks (e.g., ROPE), comparing against traditional, learning-based methods (e.g., CutLER) and achieving comparable results to those of the multi-modal large language model (MLLM) baselines. This work offers new insights and computational tools for harmonizing human perceptual intelligence with machine vision, particularly in complex, structured environments.

sciforum-118059: Machine learning methods in Parkinson's disease diagnostics from handwritten data.

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The article is devoted to the application of machine learning methods for the diagnosis of Parkinson's disease based on the analysis of handwritten data. The authors consider various approaches to extracting features from patients' handwriting, including dynamic and static characteristics such as speed, acceleration, pressure, and pen tilt. The paper presents three datasets: NewHandPD, PaHaW, and Parkinson_HW, which contain information on handwritten tests performed by healthy people and patients with Parkinson's disease. Various machine learning methods are used for data analysis, including the nearest neighbor method, support vector machine, decision trees, discriminant analysis, naive Bayes classifier, and ensemble methods such as AdaBoost and Tree Bagger.

The experimental part of the study includes data preprocessing, feature extraction, and classifier training. The accuracy, recall, and F-measure metrics are used to evaluate the effectiveness of the models. The results show that the best results are achieved using ensemble methods such as Tree Bagger and AdaBoost, which demonstrate accuracy above 95% on the Parkinson_HW and NewHandPD datasets. The PaHaW dataset also shows high results, but with slightly lower accuracy.

The authors compare their results with similar studies that use deep learning methods such as CNN and SVM, and note that their proposed machine learning methods demonstrate comparable or even higher accuracy. In conclusion, it is concluded that handwritten data analysis using machine learning methods can be an effective tool for early diagnosis of Parkinson's disease, which can improve the quality of life of patients through timely treatment.

sciforum-117782: Measuring the Tangibility Level of IT Project Benefit Realization: A Fuzzy Logic Approach

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In the process of benefit management, measuring benefits is regarded as a crucial phase. But only 20% of organizational projects are able to justify their high-cost investments. IT is a cross-functional domain that has an extensive benefit scope for automation projects. In this context, benefit analysis leading to monitoring becomes an acid test. The objective of this paper is to develop a benefit measurement for total evaluation. Also, the Benefit Realization (BR) of the Project Program Portfolio (PPP) will be measured in order to facilitate decision-making by project hierarchy managers. This study analyzed 14 IT managers who gave insights in the form of a quantitative survey on a five-point scale. The data were analyzed with SPSS and fuzzy simulations.

The study revealed that technology benefits have an increasingly positive relationship with benefit realization. Tech-oriented enterprise benefits go beyond financial benefits. Customer value, stakeholders, value for money, HR cost, operation automation, time, and performance have an increasingly positive effect on BR. The BR was recorded at five fuzzy linguistic hedges: a=1=very high; b=2=high; c=3=moderate; d=4=low; e=5=very low. This study has modern philosophical value because tech-related benefits, once measured and monitored, can give a plethora of social value to society. Non-profit goods are needed for future sustainability and the discovery of modern utility for stakeholders. This study will also have an outward policy effect on the tech industry and government, enabling the streamlining of benefit analysis in mega projects driven by IT. This study concludes that project benefits have five CRISP values of tangibility.

sciforum-122693: Multi-threshold CT Image Segmentation and Lung Cancer Detection Based on a Novel Alpaca Optimization Algorithm

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Lung cancer is one of the leading causes of cancer-related deaths worldwide, and early diagnosis is crucial for improving patient survival rates. Traditional methods for analyzing lung cancer CT images often face challenges such as high computational complexity and susceptibility to local optima, which limit the accuracy and efficiency of early diagnosis. To address these issues, this study proposes a multi-threshold lung cancer CT image segmentation and recognition model based on the Alpaca Optimization Algorithm (AOA), aiming to enhance the precision and efficiency of early lung cancer diagnosis.

First, this paper innovatively introduces a novel meta-heuristic algorithm: the Alpaca Optimization Algorithm (AOA). By simulating the social behavior of alpacas in the natural world, the AOA effectively balances global exploration and local exploitation. Based on this and combined with the Minimum Symmetric Cross Entropy (MSCE) criterion, an AOA-optimized multi-threshold lung cancer CT image segmentation model is constructed, achieving the accurate separation of lung nodules from the lung background. Simultaneously, for the lung cancer recognition problem, an AOA-optimized Support Vector Machine (SVM) model is built, which effectively extracts the texture features of lung CT images, improving the accuracy of lung cancer recognition. The experimental results demonstrate that, compared to traditional methods and other optimization algorithms, the AOA proposed in this paper has significant advantages in image segmentation metrics such as the Structural Similarity Index (SSIM) and Peak Signal-to-Noise Ratio (PSNR) and also achieves significant improvements in lung cancer recognition metrics such as accuracy, recall, and F1-score. The research results suggest that this is an efficient and accurate image analysis tool for the early diagnosis of lung cancer, which has an important clinical application value and also provides new ideas and methods for development in the field of medical image analysis.

sciforum-121956: Provably Secure Searchable Symmetric Encryptions: Definition, Construction, Attacks and Defenses

Jianting Ning

Wuhan University

The pay-as-you-go model and the powerful capabilities of cloud computing have driven individuals and organizations to outsource data storage and computational tasks to cloud servers. This paradigm has been widely adopted due to the limitations of local storage (such as geographical constraints, high labor costs, and machine maintenance expenses) and the advantages of cloud computing (such as flexibility, scalability, and cost-effectiveness). However, outsourcing data to the cloud results in a loss of user control, making data privacy a critical concern. While traditional encryption algorithms can be used to protect data before outsourcing, they significantly hinder data usability, making efficient access and computation challenging. Consequently, there is a strong demand for techniques that enable privacy-preserving searches over encrypted data.

Searchable Symmetric Encryption (SSE) is one such approach that has attracted significant interest. SSE allows users to perform searches over encrypted data while preserving privacy. In recent years, numerous advancements have emerged, particularly in attacks targeting SSE and corresponding privacy-preserving defenses. SSE has been extensively studied and holds promising applications across various domains. This talk revisits existing research, providing a comprehensive analysis and summary. It categorizes SSE schemes based on query expressiveness and delves into attacks and corresponding defense mechanisms in detail. Finally, it explores future research directions in SSE.

sciforum-117814: Researches On The Defenses And Out-Of-Distribution Detection In Trustworthy Deep Learning

Jie Yang

Shanghai Jiao Tong University, China

The rapid advancement of deep learning has had a transformative effect on the development of technology and society across a multitude of sectors. In safety-critical contexts, the potential for neural network models to produce unreliable outputs in response to “malicious” or “unanticipated” inputs poses a severe risk. This talk delves into the output reliability from neural network models within the domain of trustworthy deep learning. 1) inputs that involve pixel perturbations, exemplified by adversarial examples,w.r.t the task of adversarial and certified robustness; 2) inputs that represent distribution shifts, exemplified by Out-of-Distribution (OoD) data, w.r.t the task of out-of-distribution detection. We introduce a novel strategy of model augmentation, adopt a multi-head neural network structure, and pose diversity constraints related to adversarial robustness into the model parameters.We adopt a multi-head neural network structure, use the ensemble of multiple heads in place of the ensemble of multiple neural networks,which significantly reduces the computational load in both training and certification phases. We propose that the non-linearity in InD and OoD data hinders PCA from learning a subspace that fully embodies their diversities. We propose a mode ensemble method that not only enhances detection performance but also significantly reduces the performance variance among independent modes.We propose performing linear dimension reduction on the gradient using a designated subspace that comprises principal components.

Papers about above topics have been published in TPAMI, IJCV, PR, NIPS in recent years.

sciforum-117904: Review on Fractal Analysis in Tsunami Modeling by symmetric analysis: A New Perspective for Predicting Tsunami Behavior

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This comprehensive review undertakes an in-depth exploration of the application of fractal analysis within tsunami modeling, with a strong focus on its symmetric analysis. It meticulously examines how the incorporation of the fractal and symmetric features of tsunami-related phenomena occurrences into the model that can lead to more accurate forecasts of tsunami behavior, especially its motion direction. Tsunamis are extremely destructive, and traditional models often fall short. Fractal analysis considers the self-similarity in various aspects such as ocean floor topography and wavefronts, providing a new way. The review presents a detailed and profound overview of the mathematical expressions utilized in fractal tsunami models that take symmetry into account. It also elaborates on the specific data necessities for these models and showcases the validation findings acquired through symmetric-based analysis. For example, it might compare the model's predictions with historical tsunamis. Furthermore, it engages in a thorough discussion regarding the extensive and profound implications of this integrated fractal and symmetric analysis for tsunami warning systems. A more accurate model can enhance the warning system's effectiveness. Additionally, it maps out prospective research directions that capitalize on symmetric analysis in this field, aiming to offer valuable guidance and impetus for the advancement of tsunami research and disaster prevention.

sciforum-123003: Symmetric Trees, Lexicographic Ordering, Scale Invariance, and Universal Formulas for Quantum Circuits

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Introduction

Generic quantum circuits are composed of single layers of the parallel application of 2×2 unitary matrices together with some higher-order entangling ones, yielding an expression of matrix products where each term is a Kronecker product. A bijective map can be established between the elements of any Kronecker product and an equivalent outer product, giving rise to a class of permutations associated with the plane-filling Lebesgue Z-curve.

Methods

The equivalence of lexicographical order with the set of all k-ary words of length N generated as coefficients of the multinomial expansion $(\mathbf{U}_0 + \ldots + \mathbf{U}_{k-1})^N$ allows for the expression of all products of 2×2 unitary matrices, each parameterized by three angles per symbol, from any minimal set of simple 1-qubit gates. This way, we can extract global maps of all possible single-layer circuits. If this is available, studying scale invariances as $N \to N+1$ is also possible. General expressions beyond the minimal Solovay–Kitaev set are possible due to the reduction of products of harmonic functions into Fourier summands. Analogously, 4×4 entangling gates can be handled using the hexadecimal alphabet [1].

Results

The resulting matrix elements always appear as sums of powers of roots of unity, implying deep connections with number theory, but also physical effects where analogous results are derivable, such as the Talbot effect from optics [2] based on Gauss sums and the recently introduced 'Dispersive Quantization' [3].

Conclusions

This line of research seeks reductions of whole circuits with minimal Kolmogorov complexity and possibly alternative optical and other analog implementations of circuit parts based on the observed analogies and the fractal symmetries of the resulting global maps.

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sciforum-118105: Symmetry Features in Space Target Radar Detection and Imaging

Junling Wang *, Wensuo Qian, Hao Yang, Xiaole He and Linyi Meng

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In the field of space target radar detection and recognition, significant progress has been made through various technical approaches, particularly in the areas of target feature extraction, sensor design, and information processing. However, research specifically focused on the exploration and application of symmetry features remains relatively limited and lacks in-depth systematic investigation. This paper comprehensively analyzes the symmetry features in space target radar detection and recognition from three perspectives: the target, the sensor, and information processing. It covers target geometric symmetry, motion symmetry, spatiotemporal symmetry of echoes, signal periodic symmetry, symmetry constraints in data processing, symmetry in the transformation domain, and symmetry in radar sensor networks. By considering these different aspects, this paper highlights the potential for symmetry to enhance detection accuracy, reduce computational complexity, and improve target recognition performance. Additionally, it provides models for these symmetry features and methods for feature extraction, and it discusses the benefits of incorporating these features into radar systems. Existing technological solutions and their limitations are reviewed. Finally, an outlook on future research directions is presented, including the integration of symmetry with emerging technologies such as sparse representation, deep learning, and optimization techniques, which are expected to significantly enhance target detection, imaging accuracy, and overall system performance.

sciforum-122350: WIGformer: Wavelet-based Illumination-Guided Transformer

Wensheng Cao *, Tianyu Yan, Zhile Li and Jiongyao Ye

East China University of Science and Technology

Low-light image enhancement remains a challenging task in computer vision due to the complex interplay of noise, asymmetrical artifacts, illumination non-uniformity, and detail preservation. Existing methods, including traditional histogram equalization, gamma correction, and Retinex-based approaches, often struggle to balance contrast improvement and naturalness preservation. Deep learning methods, such as CNNs and Transformers, have shown promise but face limitations in modeling multi-scale illumination and long-range dependencies.To address these issues, we propose WIGformer, a novel Wavelet-based Illumination-Guided Transformer framework for low-light image enhancement. The method extends the single-stage Retinex theory to explicitly model noise in both reflectance and illumination components. It introduces a wavelet illumination estimator with a Wavelet Feature Enhancement Convolution (WFEConv) module to capture multi-scale illumination features and an illumination feature-guided corruptions restorer with an Illumination-Guided Enhanced Multi-Head Self-Attention (IGEMSA) mechanism. WIGformer leverages the symmetry properties of wavelet transforms to achieve multi-scale illumination estimation, ensuring balanced feature extraction across different frequency bands. The IGEMSA integrates adaptive feature refinement and illumination guidance to suppress noise and artifacts while preserving fine details. IGEMSA mechanism further exploits symmetrical dependencies between illumination and reflectance components, enabling robust and natural enhancement of low-light images. Extensive experiments on the LOL-V1, LOL-V2-Real, and LOL-V2-Synthetic datasets demonstrate that WIGformer achieves state-of-the-art performance, outperforming existing methods with PSNR improvements of up to 26.12 dB and SSIM scores of 0.935. The qualitative results demonstrate WIGformer's superior capability to not only restore natural illumination but also maintain structural symmetry in challenging conditions, preserving balanced luminance distributions and geometric regularities that are characteristic of properly exposed natural scenes.

sciforum-118064: Zeros For Data Science

Yanxi Liu

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The world around us is neither totally regular nor completely random. Our (and robots') reliance on spatiotemporal patterns in daily life cannot be over-stressed, given the fact that most of us can function (perceive, recognize, navigate) effectively in chaotic and previously unseen physical, social and digital worlds. Data science has been promoted and practiced as an interdisciplinary academic field for over 50 years (John Tukey) and the word "pattern recognition" is commonly used in machine learning for seeking patterns from data. The seminal work on Pattern Theory (Ulf Grenander) was the first to articulate the concept of patterns in data in precise mathematical terms, instead of algorithms only. Yet, what and where are the "ZEROS" in a pattern space for real world datasets remains unspecified. Regularities with varying form and scale pervade our natural and man-made world. From insects to mammals, the ability to sense regular patterns has a neurobiological basis and has been observed in many levels of intelligence and behavior. From Felix Klein's Erlanger program, D'Arcy Thompson's Growth-and-Form, to the Gestalt principles of perception, much of our understanding of the world is based on the perception and recognition of repetitions, generalized by the mathematical concept of symmetry and symmetry groups. Given the ubiquity of symmetry in both the physical and the digital worlds, a computational model for symmetry-based regularity perception is especially pertinent to computer vision, computer graphics, robotics and machine intelligence in general. In this talk, I will illustrate, from both a group theoretic basis and a set of diverse applications that, just as important as the use of numerical zero in the decimal Hindu-Arabic numeral system (500 AD), a mathematically well-defined **ZERO**-state in multi-modality, multidimensional data regularity space exists and is computationally feasible to work with for pattern recognition tasks.

Session 6. Regular Session

sciforum-120672: Application of AI in Credit Risk Scoring for Small Business Loans: A case study on how AI-based random forest model improves a Delphi model outcome in the case of Azerbaijani SMEs

Nigar Karimova

Columbia University, USA

The research investigates how the application of a machine-learning random forest model improves the accuracy and precision of a Delphi model. The context of the research is Azerbaijani SMEs and the data for the study has been obtained from a financial institution which had gathered it from the enterprises (as there is no public data on local SMEs, it was not practical to verify the data independently).

The research used accuracy, precision, recall and F-1 scores for both models to compare them and run the algorithms in Python. The findings showed that accuracy, precision, recall and F-1 all improve considerably (from 0.69 to 0.83, from 0.65 to 0.81, from 0.56 to 0.77 and from 0.58 to 0.79, respectively).

The implications are that by applying AI models in credit risk modeling, financial institutions can improve the accuracy of identifying potential defaulters which would reduce their credit risk. In addition, an unfair rejection of credit access for SMEs would also go down having a significant contribution to an economic growth in the economy.

Finally, such ethical issues as transparency of algorithms and biases in historical data should be taken on board while making decisions based on AI algorithms in order to reduce mechanical dependence on algorithms that cannot be justified in practice.

sciforum-118083: LGBTQ: the Symmetry-Breaking as the Highest Form of Life Evolution

Weijiang Shi

Freelance Researcher

Transgenderism, as a form between the two sexes, can promote self-transformation and then frequently shine. Humans have been familiar with it since ancient times and have formed a primitive image, and then displayed it in art forms such as myths, sculptures and portraits. However, human understanding of transgenderism has long been stagnant, often suffering from superficiality and prejudice, resulting in frequent discrimination and persecution. Although people have thought seriously for a long time, there are few philosophical reflections. This article attempts philosophical speculation.

System theory believes that the reason why life evolves is that as a self-organizing system, the living body produces symmetry breaking in the process of continuous exchange of matter, information, energy and negative entropy with the outside world, resulting in the emergence of the system. Similarly, if humans want to achieve lasting progress and development, they must have a profound "know yourself", know yourself and know the others, and treat everything in human beings from the perspective of "symmetry breaking".

Aristotle created the "Four Causes Theory", which is a system of entity development and can provide a theoretical basis for the creation system of the life world. This article believes that human progress and development are also catalyzed by the "Four Causes" and achieved through countless symmetry breaking

sciforum-118637: Quantum Trade and Symmetries: Exploring Symmetry Principles in Quantum Economic Systems

Fatih Mangir

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A fundamental concept that can be observed throughout a variety of scientific subfields is symmetry. Understanding how natural processes operate is facilitated by this. "Powerful symmetry principles have guided physicists in their quest for nature's fundamental laws," according to Frank Wilczek in his statement. In this paper, an investigation into the function of symmetry in quantum trading systems is carried out. Quantum theory (QT) is a relatively young topic that utilizes economic theory and quantum physics. It does this by utilizing quantum concepts such as superposition, entanglement, and interference in order to improve the efficiency of decision-making processes and international commerce systems. The purpose of this study is to investigate the ways in which discrete and continuous symmetries can be utilized to improve the efficiency, fairness, and resilience of quantum trade models. By taking a look at the patterns that are built into quantum economic systems, we provide a method for the creation of trading protocols that are naturally resistant to changes in the market as well as attacks. In addition to this, we investigate the consequences that arise when symmetry is broken in quantum commerce and how this may influence the development of economic theory. By presenting a fresh perspective on the ways in which concepts of symmetry could influence commerce in a society that makes use of quantum technologies, this work connects quantum physics and economics and brings them closer together.

sciforum-118103: Symmetry in the motion of the simple pendulum: An educational approach based on scientific argumentation

Guillermina Ávila García

Instituto Politécnico Nacional

Symmetry is a fundamental principle in nature, present in multiple areas of knowledge, from theoretical physics to engineering and computer science. In this work, the simple pendulum is explored as a system that exemplifies symmetry in space and time, in line with the concepts that Feynman sets forth on symmetry operations. This study aims to analyze how experimentation with the simple pendulum and the analysis of its behavior can foster the development of critical and argumentative thinking with students at a high school in study of Physics and Mathematics at the National Polytechnic Institute in Mexico.

An experimental activity was designed in which students recorded the movement of the pendulum and analyzed its symmetrical properties using the Tracker software. Subsequently, they answered a questionnaire designed to evaluate their capacity for scientific argumentation around the concepts of temporal and spatial symmetry. The results show that, although students were able to identify certain symmetry patterns in the system, the quality of their arguments is still limited, with difficulties in justifying their answers in a rigorous manner. However, progress is observed in the construction of explanations based on experimental data and in the connection between theory and observation.

The conclusions highlight the importance of designing teaching strategies that not only promote the understanding of physical principles but also encourage argumentation and critical thinking in the classroom. This interdisciplinary approach to symmetry not only reinforces the teaching of physics but also allows students to develop analytical skills essential for their scientific training.

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