

Preface

Dear Colleagues

I would like to invite you on behalf of the International Organization Committee.

I am pleased to invite you to the conference in Seoul, Korea, based on the accomplishments of the ICGAC community in the Asia-Pacific region over the past 26 years and the academic friendship that has been achieved through relativistic astrophysics between Italy and Korea for 30 years.

The evidence of the gravitational wave released in February of last year, have made the belief to Einstein's relativity theory even stronger, and have contributed greatly to the creation of a new observation field of gravitational wave physics, so called "New Window to our Universe". In addition, many forms of observation and discovery of our universe have played a role in astrophysics and cosmology to expand the horizon. In the coming decade, these new compasses will direct the direction of our knowledge advancement and will do important work in human history. As a result, our understanding of the universe will be expanded and applied to the world, and a new era of physics will emerge.

The 13th International Conference on Gravitation, Astrophysics, and Cosmology (ICGAC-XIII) and the 15th Italian-Korean Joint Symposium on Relativistic Astrophysics (IK15) are combined at the prestigious Ewha Womans University with a history of more than 130 years and an integrated conference will be held. I hope that you will have valuable time to make good conclusions by learning, discussing and sharing recent issues during the conference. I also hope that many young scholars attending this conference learn and acquire a lot of skills and design to carry on future astrophysics.

I hope you will take time to enjoy the values of Ewha Womans University as well as to have a meaningful time to explore Seoul, Korea.

Thank you to all IAC, IOC, LOC committee members and organizations that helped make this conference happen. I am deeply grateful to all of you, especially the Korean Physics Society Astrophysics Division, International Center for Relativistic Astrophysics Network (ICRANet), Asia-Pacific Center for Theoretical Physics (APCTP), Division of Astrophysics, Cosmology and Gravitation (DACG) of Asia Pacific Physics Society (AAPPS), National Research Foundation of Korea, Consiglio Nazionale delle Ricerche (CNR, Italy), Institute for Basic Science (IBS), Ewha Womans University, Konkuk University, Kunsan National University, Physics Department and Professor Leung Memorial Fund at University of Massachusetts Dartmouth, and Springer Verlag.

Without their supports, this conference will not be held here, at this time.

Welcome to ICGAC-XIII & IK15 !

Sung-Won Kim
Chair of IOC, ICGAC-XIII & IK15

International Organizing Committee

Sung-Won Kim (EWU, Chair), **Remo Ruffini** (ICRANet, Co-Chair), **Sang-Pyo Kim** (Kunsan Nat'l U., Co-Chair), **Gungwon Kang** (KISTI, Co-Chair), **Jonghyuk Yoon** (Konkuk U., Co-Chair), **Warrick Couch** (AAO), **Bruce Dawson** (U. Adelaide), **Yungui Gong** (HUST), **Zhong-Hong Zhu** (BNU), **Yipeng Jing** (SJTU), **Pascal Chardonnet** (CNRS), **Jutta Kunz** (U. Oldenburg), **Claus Lammerzhahl** (U. Bremen), **She-Sheng Xue** (ICRANet), **Gregory Vereshchagin** (ICRANet), **Takahiro Tanaka** (Kyoto U.), **Jun'ichi Yokoyama** (U. Tokyo), **Jiro Soda** (Kobe U.), **Kiwoon Choi** (KAIST), **Hyung Won Lee** (Inje U.), **M.H.P.M. van Putten** (Sejong U.), **V.N. Melnikov** (MSU), **A.A. Starobinsky** (ITP Russia), **Pisin Chen** (NTU), **Hoi-Lai Yu** (Sinica)

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Host Organization

- Research Institute of Curriculum Instruction,
Ewha Womans University

Managing Organizations

- Astrophysics Division of Korea Physical Society
- International Center for Relativistic Astrophysics Network (ICRANet)

Supporting Organizations

- Asia Pacific Center for Theoretical Physics
- Division of Astrophysics, Cosmology and Gravitation in the Association of Asia Pacific Physics Society (DACG-AAPPS)
- National Research Foundation of Korea
- Consiglio Nazionale delle Ricerche (CNR, Italy)
- Konkuk University
- Institute for Basic Science (IBS)
- Kunsan National University
- Physics Department and Professor Leung Memorial Fund at University of Massachusetts Dartmouth
- Springer Verlag



Program Timetable

Place: Lee Sam Bong Hall (B4F, Main Rm), B147, and B149 in ECC, Ewha Womans University

Time (Mon.)	3 Mon.		4 Tue.			5 Wed.	6 Thu.		7 Fri.		Time (T/W/T/F)
08:00–09:00	Registration										08:50–09:00
09:00–09:45	V. Frolov (Main Rm)		Yungui Gong (Main Rm)			Bum-Hoon Lee (Main Rm)	Y. Neiman (Main Rm)		Jong-Ping Hsu (Main Rm)		09:00–09:35
09:45–10:30	R. Ruffini		Hyung Mok Lee			J. Yokoyama	Rong-Gen Cai		D. Brill		09:35–10:15
10:30–10:50	Coffee Break		Coffee Break			Coffee Break	Coffee Break		Coffee Break		10:15–10:45
10:50–11:10	Opening Ceremony		S. Miyoki			Il Hung Park	D. Grumiller		Yong-Seon Song		10:45–11:20
11:10–11:55	M. Sasaki		Wei-Tou Ni			K. Maeda	Jeong-Hyuck Park		Eunil Won		11:20–11:55
11:55–12:40	Yongmin Cho		Ho Jung Paik			J. A. Rueda	Chiang-Mei Chen		M. Muccino		11:55–12:30
12:40–14:00	Lunch		Lunch			Lunch	Lunch				12:30–14:00
14:00–15:30	P1-1 Classical Gravity (Main Rm)	P2-1 Quantum Gravity (B147)	P3-1 Astro physics (Main Rm)	P4-1 Gravita tional Waves (B147)	P5-1 Inflation and Dark Matter (B149)	Free Time for Excursions, Discussions, Informal Meetings, etc.	P3-3 Astrophysics (Main Rm)	P6-1 Gravity in String Theory (B147)	P7-1 Cosmology (Main Rm)	P8-1 Black Holes (B147)	14:00–15:30
15:30–16:00	Coffee Break						Coffee Break				15:30–16:00
16:00–18:00	P1-2 Classical Gravity (Main Rm)	P2-2 Quantum Gravity (B147)	P3-2 Astro physics (Main Rm)	P4-2 Gravita tional Waves (B147)	P5-2 Inflation and Dark Matter (B149)		P3-4 Astrophysics (Main Rm)	P6-2 Gravity in String Theory (B147)	P7-2 Cosmology (Main Rm)	P8-2 Black Holes (B147)	16:00–18:00
							Closing Remark				
			Banquet								

Plenary Sessions

✂ **Place: Lee Sam Bong Hall (B4F, Main Rm)**

3 July, Monday

Chair: Sang-Pyo Kim (Kunsan Nat'l U.)

08:00 - 09:00 Registration

09:00 - 09:45 Valeri P. Frolov (U. Alberta) Remarks on non-singular black holes

09:45 - 10:30 Remo Ruffini (ICRANet) From Supernovae, to Hypernovae to Binary Driven Hypernovae

10:30 - 10:50 Coffee Break

10:50 - 11:10 Opening Ceremony

Chair: Gungwon Kang (KISTI)

11:10 - 11:55 Misao Sasaki (Kyoto U.) Inflationary massive gravity

11:55 - 12:40 Yongmin Cho (Konkuk U.) Cosmic Production of the Electroweak Monopole

12:40 - 14:00 Lunch

4 July, Tuesday

Chair: Misao Sasaki (Kyoto U.)

09:00 - 09:35 Yungui Gong (Huazhong U. Sci. Tech.) On the polarization of gravitational waves in scalar-tensor theories of gravity

09:35 - 10:15 Hyung Mok Lee (Seoul Nat'l U.) What have we learned from the detection of gravitational waves?

10:15 - 10:45 Coffee Break

Chair: Medeu Abishev (Al Farabi Kazakh Nat'l U.)

10:45 - 11:20 Shinji Miyoki (ICRR) Current Status of KAGRA Gravitational Wave Telescope

11:20 - 11:55 Wei-Tou Ni (Nat'l Tsing Hua U.) Gravitational Wave Classification and the Space GW Detection Sensitivities

11:55 - 12:30 Ho Jung Paik (U. Maryland) Superconducting Tensor Gravitational-Wave Detector and Mitigation of Newtonian Noise

12:30 - 12:40 Photo Session

12:40 - 14:00 Lunch

18:30-20:30 Banquet (B403 ECC Theater)

5 July, Wednesday

Chair: Yongmin Cho (Konkuk U.)

09:00 - 09:35 Bum-Hoon Lee (Sogang U.) Higher Curvature Gravity

09:35 - 10:15 Jun'ichi Yokoyama (U. Tokyo) Creation of the inflationary universe from a black hole?

10:15 - 10:45 *Coffee Break*

Chair: Jun'ichi Yokoyama (U. Tokyo)

10:45 - 11:20 Il Hung Park (Sungkyunkwan U.) Status and Perspectives in GRB observations

11:20 - 11:55 Kei-ichi Maeda (Waseda U.) Inflation and Disformal Transformation

11:55 - 12:30 Jorge Armando Rueda (ICRANet) On the rate and on the gravitational wave emission of short and long GRBs

6 July, Thursday

Chair: Dieter Rudolf Brill (U. Maryland)

09:00 - 09:35 Yaakov (Yasha) Neiman (Perimeter Institute) Towards a working model of causal-patch physics in dS/CFT

09:35 - 10:15 Rong-Gen Cai (Chinese Academy of Science) Standard sirens and dark sector with Gaussian process

10:15 - 10:45 *Coffee Break*

Chair: Valeri P. Frolov (U. Alberta)

10:45 - 11:20 Daniel Grumiller (Vienna U. of Technology) Soft Heisenberg Hair

11:20 - 11:55 Jeong-Hyuck Park (Sogang U.) Stringy Gravity & solution to dark matter problem

11:55 - 12:30 Chiang-Mei Chen (Nat'l Central U.) Pair Production of Scalar Dyons in Kerr-Newman Black Holes

12:30 - 14:00 *Lunch*

7 July, Friday

Chair: Wei-Tou Ni (Nat'l Tsing Hua U.)

09:00 - 09:35 Jong-Ping Hsu (U. of Massachusetts Dartmouth) Experiments on the CMB Spectrum and Their Implications for the Missing Half of the Universe

09:35 - 10:15 Dieter Rudolf Brill (U. Maryland) The revival of General Relativity at Princeton.

10:15 - 10:45 *Coffee Break*

Chair: Rong-Gen Cai (Chinese Academy of Science)

10:45 - 11:20 Yong-Seon Song (KASI) Cosmological Implications of RSD

11:20 - 11:55 Eunil Won (Korea U.) Status of the GroundBIRD experiment

11:55 - 12:30 Marco Muccino (ICRANet) What can we learn from gamma-ray bursts?

12:30 - 14:00 *Lunch*

17:50 - 18:00 *Closing Remark*

Parallel Sessions

※ All talks are for 20 minutes unless being marked with (15 mins)

3 July, Monday- Parallel Sessions 1, 2

P1. (Main Rm) Classical Gravity – Classical gravity, Modified gravity, etc.

P1-1. 14:00-15:30 (10 minutes for overall discussions)

Chair: Jong-Ping Hsu (U. of Massachusetts Dartmouth)

Jong Hyuk Yoon (Konkuk U.) Hamiltonian reduction of Einstein's gravity without isometries

Seung Hun Oh (Konkuk U.) Solution-generating methods of Einstein's equations by (2+2) Hamiltonian reduction

Chulmoon Yoo (Nagoya U.) Gravitational collapse of massless fields in an expanding universe

Hyeong-Chan Kim (Korea Nat'l U. Transportation) Matter Equation of State in General Relativity

15:30-16:00 Coffee Break

P1-2. 16:00-18:15

Chair: Seung Hun Oh (Konkuk U.)

Jia-Rui Sun (Sun Yat-Sen U.) Analogue gravity in BEC and its gravity dual

Alexey Toporensky (Sternberg Astron. Inst.) A viable compactification scenario in Gauss-Bonnet gravity

Jong-Ping Hsu (U. of Massachusetts Dartmouth) Experiments on the Frequency Dependence of the Deflection of Light in Yang-Mills Gravity

Inyong Cho (Seoul Nat'l U. of Science & Technology) Black Holes in S3 and H3

(15 mins) Laura Marcela Becerra Bayona (Sapienza University of Rome and IcrANet) SPH simulations of the Induced Gravitational Collapse

Atsushi Naruko (Tohoku U.) Extended vector-tensor theories

J. Rodriguez (ICRANet) Strong-field gravitational-wave emission in Schwarzschild and Kerr geometries: some general considerations

P2. (B147) Quantum Gravity – Quantum gravity, Black hole thermodynamics, Black hole entropy, etc.

P2-1. 14:00-15:35

Chair: Chiang-Mei Chen (Nat'l Central U.)

Sang Pyo Kim (Kunsan Nat'l U.) Quantum Gravity Effects in Cosmology

Ehsan Bavarsad (U. Kashan) Effect of a magnetic field on Schwinger mechanism in de Sitter spacetime

Eoin O Colgain (APCTP) Calibrated Entanglement Entropy
Wonwoo Lee (CQeST) Tunneling decay of false vortices with gravitation
(15 mins) Taishi Ikeda (Nagoya U.) Oscillon in Einstein-scalar system with double well potential and its properties

15: 35-16:00 Coffee Break

P2-2. 16:00-18:00

Chair: Hyung Won Lee (Inje U.)

Hyun Seok Yang (CQeST) Dark Matter and Dark Energy from Emergent Spacetime Picture

Alex Giacomini (U. Austral de Chile) On the compatibility of thermodynamic equilibrium conditions with lattice propagators

Muhammad Sharif (U. Punjab) Study of Generalized Second Law of Thermodynamics in Curvature-Matter Coupling Gravity

Yoonbai Kim (Sungkyunkwan U.) Entropy in Spacetime with Topological Hair

Hideki Maeda (Hokkai-Gakuen U.) Throat quantization of the Schwarzschild-Tangherlini(-AdS) Black Hole

Wontae Kim (Sogang U.) Origin of Hawking radiation

4 July, Tuesday- Parallel Sessions 3, 4, 5

P3. (Main Rm) Astrophysics - Relativistic astrophysics, Observation, Cosmic rays, GRB, etc.

P3-1. 14:00-15:35

Chair: Myeong-Gu Park (Kyungpook Nat'l U.)

Medeu Abishev (Al Farabi Kazakh Nat'l U.) The orbital stability of a test particle motion in the field of two massive rotating bodies

Giovanni Battista Pisani (Sapienza University of Rome and ICRANet) The 1st ICRANet Catalog of Binary-driven HyperNovae

Gregory Vereshchagin (ICRANet) Cosmic horizon for GeV sources and photon-photon scattering

Naser Ahmadinia (Institute for Basic Science) Master formulas for the dressed scalar propagator in a constant field

(15 mins) Mehbub Khan (UMass) Baryonic Force for Accelerated Cosmic Expansion and Generalized Yang-Mills Symmetry

15:35-16:00 Coffee Break

P3-2. 16:00-18:00

Chair: Gregory Vereshchagin (ICRANet)

Myeong-Gu Park (Kyungpook Nat'l U.) Accretion onto Black Holes with Outflow

Sehrish Iftikhar (Lahore College for Women U.) Particle Dynamics Around a Charged Black Hole

Mohammad Wali Hossain (APCTP) Quintessential inflation: A unified scenario of inflation and dark energy

(15 mins) Daria Primorac (ICRANet & Sapienza U. Roma) Analysis of the GRB110731A within the fireshell model

(15 mins) Yongsoo Jho (Yonsei U.) Search for Sphaleron from the Ultra-High-Energy cosmic rays and neutrinos

(15 mins) Rahim Moradi (Sapienza U. of Rome and ICRANet) Charged Cosmological Black holes

(15 mins) Julio David Melon Fuksman (Sapienza U. Rome & ICRANet) Simulation of an electron-positron plasma in the context of the IGC paradigm

18:30-20:30 Banquet (B403 ECC Theater)

P4. (B147) Gravitational Waves – Gravitational wave astronomy/astrophysics, Numerical relativity, etc.

P4-1. 14:00-15:30

Chair: Muhammad Sharif (U. Punjab)

Dong-Hoon Kim (Seoul Nat'l U.) Gravitational waves with effects of radiation reaction,

Toshinori Matsui (KIAS) Gravitational waves from the first order electroweak phase transition in the Z_3 symmetric singlet scalar model

Hyung Won Lee (Inje University) TaylorF2 CBC waveform with eccentricity corrected phase

(15 mins) Luis Gabriel Gómez (Sapienza U. Rome & ICRANet) Gravitational wave emission versus dark matter dynamical friction in the evolution of compact star binaries

(15 mins) Gihyuk Cho (Seoul Nat'l U.) Theory of Gravitational Radiation

15:30-16:00 Coffee Break

P4-2. 16:00-18:00 (10 minutes for overall discussions)

Chair: Hyung Mok Lee (Seoul Nat'l U.)

Jinn-ouk Gong (APCTP) Induced gravitational waves

Hisaaki Shinkai (Invited, Osaka Inst. Tech.) Gravitational waves from merging intermediate-mass black holes

Sunghoon Jung (Invited, Seoul Nat'l U.) Angular Resolutions of Mid-Frequency Gravitational Wave Detectors

Gungwon Kang (KISTI) Structural analysis of the SOGRO platform

(15 mins) Dawoo Park (Seoul Nat'l U.) Black Hole Binaries Dynamically Formed in Globular Clusters

(15 mins) HanGil Choi (Seoul Nat'l U.) Finding Quasi-Spherical Orbit Initial Condition of Black Hole Binary using Effective-One-Body Model

18:30-20:30 Banquet (B403 ECC Theater)

P5. (B149) Inflation and Dark Matter

P5-1. 14:00-15:40

Chair: Jae-Weon Lee (Jungwon U.)

Hyun Min Lee (Chung-Ang U) Flattening the inflaton potential beyond the minimal gravity
Aditya Aravind (APCTP) Higgs Portal Inflation with Fermionic Dark Matter
(15 mins) Echal Chang (Chungnam Nat'l U.) Toward a more realistic Randall-Sundrum Brane World
(15 mins) Zhu Yi (Huazhong U. Sci. Tech.) Nonminimal coupling and inflationary attractors
(15 mins) Yongwan Gim (Sogang U.) On the thermodynamic origin of the initial radiation energy density in warm inflation
(15 mins) Dong Woo Kang (Yonsei U.) Electroweak Kaluza-Klein Dark Matter

15:40-16:00 Coffee Break

P5-2. 16:00-18:00 (10 minutes for overall discussions)

Chair: Yungui Gong (Huazhong U. Sci. Tech.)

Jae-Weon Lee (Jungwon U.) Brief History of Ultra-light Scalar Dark Matter Models
Sichun Sun (National Taiwan U.) New views on dark matter from modified gravity
Yasuhiro Yamamoto (Yonsei U.) Protophobic Light Vector Boson as a Mediator to the Dark Sector
Seodong Shin (Yonsei U.) Non-minimal dark matter search in dark matter colliders
(15 mins) Soo Min Choi (Chung-Ang U) SIMP dark matter and its cosmic abundances
(15 mins) Yoo-Jin Kang (Chung-Ang U) Forbidden Channels and SIMP Dark Matter

18:30-20:30 Banquet (B403 ECC Theater)

6 July, Thursday- Parallel Sessions 3, 6

P3. (Main Rm) Astrophysics - Relativistic astrophysics, Observation, Cosmic rays, GRB, etc.

P3-3. 14:00-15:30 (10 minutes for overall discussions)

Chair: Hyun Kyu Lee (Hanyang U.)

Anna Pollmann (Invited, U. Wuppertal) Searches for magnetic monopoles with IceCube
Insik Hahn (Ewha Womans U.) Nuclear astrophysics experiments related to the rp-process using rare isotope beams
Myung-Ki Cheoun (Invited, Soongsil U.) Modified Gravity in Nuclear Astrophysics and Big Bang Nucleosynthesis
Chang-Hwan Lee (Pusan Nat'l U.) Strangeness in Neutron Star Cooling

15:30-16:00 Coffee Break

P3-4. 16:00-18:00 (5 minutes for overall discussions)

Chair: Jorge Armando Rueda (ICRANet)

Hyun Kyu Lee (Hanyang U.) Hadronic matter with emergent symmetries at high density
Hongjun An (Invited, Chungbuk Nat'l U.) Studying intrabinary shock emission in pulsar binaries
Dong-Hoon Kim (Seoul Nat'l U.) Pulsar radiation with general relativistic effects

Alexander Yushchenko (Sejong University) Velocity distribution in the clusters of galaxies
Hisaaki Shinkai (Osaka Inst. Tech.) Nonlinear dynamics in Gauss-Bonnet gravity
(15 mins) **Andreas Krut (ICRANet)** Dark matter and galactic structures

P6. (B147) Gravity in String Theory

P6-1. 14:00-15:30 (10 minutes for overall discussions)

Chair: Chanju Kim (Ewha Womans U.)

Jae-Hyuk Oh (Hanyang U.) Phase transition in anisotropic holographic superfluids with arbitrary z and α

Run-Qiu Yang (KIAS) Strong energy condition and complexity growth bound in holography

Yun-Long Zhang (APCTP) Bell inequality from holographic gravity

Sunyoung Shin (CQUeST) Walls of massive Kähler sigma models on $SO(2N)/U(N)$ in three dimensions

15:30-16:00 Coffee Break

P6-2. 16:00-18:00

Chair: Keun-Young Kim (GIST)

Chanju Kim (Ewha Womans U.) Holographic micro state deformations of BTZ black holes

O-Kab Kwon (Sungkyunkwan U.) Exact holography of massive M2-brane theories and entanglement entropy

Kyung Kiu Kim (Sejong U.) Thermodynamic volume in AdS/CFT

Taejin Lee (Kangwon Nat'l U.) Gravitational Scattering Amplitudes and Closed String Field Theory in the Proper-Time Gauge

Hongsu Kim (KASI) 3rd Quantization of Taub Universe

Hongsu Kim (KASI) Callan-Rubakov Effect could answer the baryon asymmetry puzzle

7 July, Friday-Parallel Sessions 7, 8

P7. (Main Rm) Cosmology – Cosmology, CMB, Perturbations, Structure formation, Quantum effect, etc.

P7-1. 14:00-15:30 (10 minutes for overall discussions)

Chair: Wonwoo Lee (CQUeST)

Seokcheon Lee (Gyeongsang Nat'l U.) Conformal equality

Dong-han Yeom (Nat'l Taiwan U.) Hartle-Hawking wave function and large-scale power suppression of CMB

Mu-In Park (Sogang U.) On Gauge Invariant Cosmological Perturbations in UV-modified Horava Gravity

Tae Hoon Lee (Invited, Soongsil U.) Quintessence in low-energy effective theory

15:30-16:00 Coffee Break

P7-2. 16:00-17:50 (10 minutes for overall discussions)

Chair: Seokcheon Lee (Gyeongsang Nat'l U.)

Ki-Young Choi (Chonnam Nat'l U.) Lower-Bound on the reheating temperature with dark matter

Kyungjin Ahn (Chosun U.) Small-scale structure formation under the large-scale density and CDM-baryon drift velocity environment

Sungwook E Hong (KASI) Small-scale Features of Thermal Inflation: CMB Distortion and Substructure Abundance

Maurice H van Putten (Invited, Sejong U.) Fast evolution of the deceleration parameter in surveys of $H(z)$

Muhammad Sharif (U. Punjab) Stability Analysis of Bulk Viscous Cosmology

17:50-18:00 Closing Remark

P8. (B147) Black Holes – Black holes, Wormholes, etc

P8-1. 14:00-15:40

Chair: Jong Hyuk Yoon (Konkuk U.)

Masakatsu Kenmoku (Nara Sci. Academy) Superradiant Phenomena for Spinor Fields in Rotating Black Hole Geometry

Khalid Saifullah (Quaid-i-Azam U.) Thermodynamics of rotating non-Kerr black holes

Bogeun Gwak (Invited, Sejong U.) Upper Limit of Radiation from Coalescence of Rotating Hayward Black Holes

Sung-Won Kim (Ewha Womans U.) Wormhole cosmological model

Jin Young Kim (Kunsan Nat'l U.) Wormholes in Einstein-Born-Infeld Gravity

15:40-16:00 Coffee Break

P8-2. 16:00-17:50 (10 minutes for overall discussions)

Chair: Bogeun Gwak (Sejong U.)

Kimitake Hayasaki (Invited, Chungbuk Nat'l U.) Detection of gravitational wave emission by supermassive black hole binaries through tidal disruption flare

Medeu Abishev (Al Farabi Kazakh Nat'l U.) Dilatonic dyon black hole solutions in the model with two Abelian gauge fields

Seung Hun Oh (Konkuk U.) Poisson algebra of gauge-invariant quasilocal angular momentum and its asymptotic limit

Deniz Olgu Devecioglu (Sogang U.) Lifshitz black holes in Einstein-Yang-Mills theory

Lunchakorn Tannukij (Hanyang U.) Black holes in dRGT Massive Gravity

17:50-18:00 Closing Remark

Exploring Curved Spacetime---LIU Liao's Adventure

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In 1999, Prof. LIU, with the help of the Chinese Physical Society and the Chinese Society of Gravitation and Relativistic Astrophysics, among others, organized the Fourth International Workshop on Gravitation and Astrophysics at Beijing Normal University. The purpose was to promote exchange of scientific ideas, which was in line with DENG Xiaoping's open policy after the Culture Revolution. The following year, the Proceedings of the Fourth International Workshop on Gravitation and Astrophysics was published by the World Scientific. During the political turmoil, LIU Liao suffered for 22 years---demoted from “assistant professor” in 1957 to a reference staff in the physics department library until 1979. In spite of these difficulties, he taught himself general relativity, quantum field theory and particle physics. LIU Liao became a pioneer of general relativity in China and established a major center for research of black holes, cosmology and gravitational waves at Beijing Normal University. He is respected among the scientific community in China and abroad.

LIU Liao (12/24/1928 - 4/27/2016) was born in Shen-Yang city. His father LIU Po was a prominent Professor of Chinese Literature at Northeast University. He married Dr. ZHANG Ruiying and had one son LIU Yi. During his student years before 1949, he actively participated in the students' political movement against the Nationalist government. In 1952, LIU Liao graduated from Peking University.

LIU Liao joined Beijing Normal University (BNU) in 1956 to teach physics. In 1957, because LIU Liao honestly expressed his critical opinion with the good intention of helping the Party to improve its operation, he was strongly criticized and denounced repeatedly. Unexpectedly, he became a despised ‘rightist’ for 18 years. He could no longer teach physics and became reference staff in the physics department library. Then the Cultural Revolution exploded, LIU Liao and many others were rounded up as criminals, “reformed through labor” and subjected to barbarous treatment. As a result, young LIU Liao suffered from lower back pain, which persisted throughout his life. LIU Liao's family also suffered for a long period of time, and his whole family lived in one single room. Every night, he put upz bed boards to sleep. He had no desk to study at and write on, so he used a large bench as a desk. In order for his wife, Dr. Zhang, to sleep better while he studied late at night, she slept in a shower booth.

Through all these years of being a “rightist” and being “reformed through labor,” he studied and thought about the profound idea of curved space-time and all that. It was no longer just to satisfy his thirst for understanding the physical universe and for the joy of comprehension; it also helped him to forget the suffering of daily life. In this aspect, Beethoven was a model and hero for him because he also refused to be beaten and crushed

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by such a difficult situation of political turmoil. He was also comforted by Beethoven's music and spirit: "I shall seize Fate by the throat; it shall certainly not bend and crush me completely."

During the Cultural Revolution, LIU Liao already had some in-depth understanding of curved space-time based on books such as Einstein's *The Meaning of Relativity*, Møller's *The Theory of Relativity* and Landau and Lifshitz's *The Classical Theory of Fields*. He happened to meet two physics students, YANG Yihon and LIU Zhongzhu. Both of them were labeled as counter-revolutionary students because they posted big-character posters against LIN Biao, who enjoyed Mao's complete trust at that time. These students realized that LIU Liao was not a criminal. Actually, they came to admire LIU Liao's self-study of general relativity. Since they were also interested in general relativity, they secretly came to LIU Liao's home in the night to discuss and to learn general relativity, etc. Fortunately, LIU Liao lived outside the campus at that time. Otherwise, such a secret meeting to learn physics at night would have been a serious crime of 'counter-revolutionary networking', if discovered by those bad people.

Naturally, YANG Yihong and LIU Zhongzhu were the first two bright students of LIU Liao when he became an associated professor in 1979. In 1980, YANG Yihong was one of the first group of students helped by CUSPEA (initiated and managed by T. D. Lee at Columbia University) to pursue a Ph.D. degree in the U.S. He earned his Ph.D. degree in 1984 at the University of Utah. After he returned, Beijing Normal University broke rules for the first time to promote him to be a full physics professor. Unfortunately, YANG Yihong died young in 1988 because of his poor health related to long-term persecution. LIU Zhongzhu, LIU Liao's protégé, also became a professor at Huazhong University of Science and Technology.

When DENG Xiaoping brought the Spring of Reform and Opening to China around 1978, LIU Liao saw hope and future. He made a great effort to spread general relativity theory everywhere in China. He established one of the three centers for general relativity research at Beijing Normal University. The other two centers were at the Institute of Theoretical Physics at the Chinese Academy of Sciences and at the Chinese University of Science and Technology. Their leaders were those who persisted in doing physics research under the very harsh environment of political turmoil.

In 1979, LIU Liao became an Associate Professor and a Member of the Board of Directors of the Chinese Society of Gravitation and Relativistic Astrophysics (CSGRA). From 1983 to 1994, he became a Professor of Physics and the Associate Chairman and the Chairman of CSGRA. From 1991 to 2008, he served as a member of The Chinese Physical Society, an editor of the Russian journal 'Gravitation and Cosmology,' and a member of The International Society of General Relativity and Gravitation.

As a student at BNU in 1978, ZHAO Zhen was surprised that LIU Liao appeared to be the only physicist in China who knew general relativity thoroughly by himself in those years of political turmoil. As far as he knew, others were gifted young men, who formed a group to study and discuss general relativity. LIU Liao also taught himself particle physics and quantum field theories. He enjoyed classical music, literature and philosophy. He also had a good knowledge of languages and could read books in English, German and Russian.

ZHAO Zheng joined LIU Liao's research group and immediately realized that he was easy to approach and very considerate to his students. He stressed that students must follow the

process of ‘Learning by Doing’ and pay attention to the literature for recent physics activities abroad. He also advised students that the most effective way to learn theoretical physics was both to follow a book and derive all equations. Simply reading books without deriving equations may be easier and more enjoyable, but the understanding is only superficial.

LIU Liao was completely dedicated to physics research and education throughout his life. Around 1973, his first research on particle physics resulted in an interesting empirical formula for hadron masses, which gave a better fit than the usual Gell-Mann-Okubo mass formula. In the 1980’s, he initiated the teaching and research on black hole physics and quantum field theory in curved space-time in China. Later, he led his group of students into a broad research of the inflationary universe, quantum cosmology, worm holes and time machines. His research interest and results include the following in order of importance:

- (a) *Proving that (i) the most general stationary states of black hole emit Dirac particles through thermal radiations. and (ii) future horizons of all stationary space-time must have thermal radiations. (LIU Liao, XU Dianyan--Prof. of Peking Univ.).*
- (b) *Hawking thermal radiation and calculations of the temperature and entropy of a non-stationary black hole. (LIU Liao, ZHAO Zheng).*
- (c) *The membrane model of black holes (HUANG Chaoguang, LIU Liao, XU Feng).*
- (d) *A new idea that worm holes could be produced from vacuum fluctuation. (LIU L. Phys. Rev. **D** 1993, 48, R5463).*
- (e) *The cosmological origin of Higgs fields, (LIU Liao, PEI Shouyong).*
- (f) *A new approach to the quantization of evaporating black hole. Any evaporating black hole has a remnant left and a quantized Schwarzschild black hole approaches its ground state.*
- (g) *A new approach to removing the divergence difficulties in QED by using worm holes.*
- (h) *Quantum cosmology, inflationary cosmology, and time machines.*

LIU Liao published more than 60 scientific papers in refereed journals with numerous students and colleagues. He also published nine monographs and books with colleagues and students:

- [1] *Quantum Field Theory in Curved Space-Time and Quantum Cosmology (LIU Liao, HUANG Chaoguang, Beijing, Science Press, 2013).*
- [2] *Black Hole and Properties of Time (LIU Liao, ZHAO Zheng, TIAN Guihua, ZHANG Jingyi, Beijing, Peking University Press, 2008).*
- [3] *Inflationary Cosmology and Cosmic String (JIANG Yuanfang, LIU Liao, QIAN Zhenhua, Shanghai, East China Normal University Press, 1993).*
- [4] *Introduction to Lie group and Lie algebra (LIU Liao, CAO Yufang, Beijing, Beijing Normal Univ. Press, 1987).*
- [5] *Special Relativity, second edition. (LIU Liao, FEI Baojun, ZHANG Yunzhong,*

- Beijing, Science Press, 2008).
- [6] General Relativity, second edition (LIU Liao, Zhao Zheng, Beijing, Higher Education Press, 2004).
 - [7] Gravitation and Astrophysics, the Proceedings of the Fourth International Workshop. (LIU Liao, LUO Jun, LI Xin-Zhou, HSU Jong-Ping. World Scientific, Singapore, 2000).
 - [8] Quantum Field Theory (Flat Space-time) (LIU Liao, Beijing, Beijing Normal University Press, 2003).
 - [9] LIU Liao Collected Literary Works, (LIU Liao, Changsha, Hunan Science and Technology Press, 2008).

In 2003, LIU Liao eloquently summarized his life and hopes in the Afterword of his book *Quantum Field Theory (Flat Space-Time)* as follows:

“My life has been a rugged journey, full of unthinkable adversity and calamity. That I was able to survive penitentiary, cowsheds[A] and all other hardship is most fortunate.

In the old days, I loved Beethoven's Symphony #5 and admired him tremendously. At the worst moments of my life, I would quote his "Ich will dem Schicksal in den Rachen greifen...."[B] to help me endure the hardship. His "I will grab fate by the neck, To force fate to comply, Not be crushed or surrender " became my mantra. But a "professional fighter" I am not. During the Anti-Rightist Movement and the Cultural Revolution, I experienced and witnessed all kinds of evil doings and atrocity. I was powerless. I was often thinking of living as a recluse, yet nowhere could I find peace and serenity but tribulations without end. I could only take to reading to find shade "under the greenwood tree" [C] that would shelter me from the extreme torture to my body and soul. What I learned from my study during that period not only gave me some pleasure and relief but helped me persevere.

I spent half a century of my life studying the microscopic and cosmic worlds, keeping company with the creator and all the immortals in the universe. That was critical for my survival and remained a lasting pleasure.

Now I am old and feeble. I wish to pass on to the young the truth and solid laws of nature that I discovered under the shade of the greenwood tree.”

Footnotes:

[A] ‘Cowsheds refer to flimsy structures with dank floors and reed mats for prisoners of the Red Guards, where starving was magnified by physical exertion and the constant threat of beating.’

[B] "I will grab fate by the neck, To force fate to comply, not be crushed or surrender" is quoted from Ludwig van Beethoven- Famous Quotes and Quotations: “Ich will dem Schicksal in den Rachen greifen, ganz niederbeugen soll es mich gewiß nicht.”

[C] Greenwood tree refers to Shakespeare's poem: “Under the greenwood tree/Who loves to lie with me/And turn his merry note/Unto the sweet bird's throat/Come hither, come hither, come hither!/Here shall he see/No enemy/But winter and rough weather.”

We would like to thank L. Haseltine, H. Jiang and A. Parelman for their help.



Seminar at BNU.



Reference room in the physics department library at BNU---LIU Liao's universe. ('....
keeping company with the creator and all the immortals in the universe.')



1999 International Workshop on Gravitation and Astrophysics at BNU.



HSU Jongping, LIU Liao, ZHAO Zheng (from left to right)



LIAN Zhujian, LIU Liao, HSU Jongping, PEI Shouyong, SHI Tianyi (from left to right)

Remembering Vitaly N. Melnikov

Jong-Ping Hsu^{1,}, Sang Pyo Kim^{2,**}, and Sung-Won Kim^{3,***}*

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Vitaly Nikolayevich Melnikov (1941-2017) was a major organizer for the Asia-Pacific International Conference on Gravitation, Astrophysics and Cosmology (ICGAC) in the past 24 years. He organized two conferences in 2001 and 2015 at Peoples' Friendship University of Russia (PFUR) in Moscow. His endeavor gave a big boost to the status of ICGAC in the international arena. He commanded respect among the scientific community.

Vitaly was born on January 24, 1941 in Moscow, son of Nikolai Melnikov and Revecce Melnikova. He married Inna Fyodorovna Krutsenko and had three children: Andrey, Oleg and Igor. He completed his undergraduate studies at the Faculty of Physics of Lomonosov Moscow State University (MSU) in 1964. In 1968 he earned a Ph.D. degree at MSU specializing in Theoretical Physics under the supervision of Academician N. N. Bogoliubov. In 1983, he defended at MGU^a the degree of Doctor of Sciences and passed with flying colors. In 1990, he became a full professor.

From 1967 to 1995, Melnikov was a researcher, a section head and the head of the Theoretical Department at Russian State Committee Standards in Moscow. From 1972 to 1993, he was a professor of theoretical physics at Moscow State University. In 1994, he joined Peoples' Friendship University of Russia (PFUR), Moscow. Since 1995, he served as the head of the Center of Gravitation and Fundamental Metrology VNIIMS. He was the President of the Russian Gravitational Society in Moscow. He was a founder and Editor-in-Chief of the international journal 'Gravitation and Cosmology' (published by Springer).

Melnikov was an Academician of the Russian Academy Metrology and a member of the Scientific Council in Astronomy of the Russian Academy of Sciences.

Melnikov was a visiting Professor in many scientific institutes, including Observatoire Paris-Mendon (1999); LUTH, Observatoire de Paris (2004, 2005, 2006, 2007); Paris Diderot University (2005, 2006); ITP, Universite de Provence, Marseille, France (1996, 1999); Aegean University, Greece (1998, 1999); NWU, Nara, Japan (1999-2000); CINVESTAV, Mexico (2000-2001); CBPF, Brazil (1993, 1995, 2002, 2004, 2006, 2008).

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^a Moscow State University (Moskovskij Gosudarstvennyj Universitet or MGU, in short) is the oldest University of Russia. It was founded on 12th of January 1755 on the initiative of the great Russian scientist M. V. Lomonosov, after whom it was named.

As a research physicist, Melnikov appeared to have had abundant grant support. He was the head of scientific grants Minobrnauki, Russian Foundation Basic Research, since 1995; the German Research Foundation (Deutsche Forschungsgemeinschaft), Germany, 1994-2006; the Conselho Nacional de Pesquisa Brazil.

He also served as the chairman of organizing committees for 12 Russian gravitational conferences (starting from 1989), the director of courses of International School in Gravitation and Cosmology in Erice (Sicily) in 1987, 2003 and 2004, the chairman of joint scientific seminar PFUR-VNIIMS and a co-chairman of the scientific seminar of the Russian Gravitational Society.

Melnikov had seven monographs and proceedings:

- (1) Hydrodynamics, Fields and Constants in the Theory of Gravitation (K. P. Stanyukovich and V. N. Melnikov, 1971).
- (2) Gravitational Measurements, Fundamental Metrology and Constants (V. de Sabbata, Vitaly N. Melnikov; Springer Science and Business Media, Dec 2012, 552 pages; Proceedings of the NATO Advanced Study Institute, Erice, Italy, May 2-12, 1987).
- (3) Multidimensional classical and quantum cosmology and gravitation. Exact solutions and variations of constants, Centro Brasileiro de Pesquisas Fisicas (CBPF) Publ.NF- 051/93 (Rio de Janeiro, 1993).
- (4) Multidimensional cosmology and gravitation, CBPF, Publ., MO-002/95 (Rio de Janeiro, 1995).
- (5) Exact solutions in multidimensional gravity and cosmology III, CBPF, Publ.MO-03/02 (Rio de Janeiro, 2002).
- (6) The Gravitational Constant: Generalized Gravitational Theories and Experiments (Ed. V. de Sabbata, George T. Gillies, Vitaly N. Melnikov, 2004).
- (7) Gravitation, Astrophysics, and Cosmology: Proceedings of the Twelfth Asia-Pacific International Conference (Ed. V. N. Melnikov and Jong-Ping Hsu, World Scientific, Feb. 2016, 400 pages).

Melnikov has been completely dedicated to physics research and education throughout his life. He published 289 scientific papers in refereed journals with numerous students and colleagues. [46 papers in Russian (1985- 2009), 192 papers in English (1988-2009) and 51 papers (2010-2016)]. His research interests include (a) Gravitation and cosmology in diverse dimensionalities, exact solutions; (b) Quantum cosmology; (c) Fundamental metrology, fundamental physical constants and their stability; (d) dark energy and dark matter; (e) theory of gravitational experiments, particularly cosmic (satellite) experiments.

Vitaly Melnikov, with his colleagues and students, has created new trends in the field of gravity. He has been one of the founders of a new trend in metrological science, Gravitational-Relativistic Metrology, connected with a thorough study of possible variations of fundamental physical constants and their influence on various physical measurements. Much of his work was devoted to exact solutions to the equations of gravity

in four and more dimensions and interpretations of these solutions, describing various cosmological models, black holes and solitons. Together with Prof. A. Sanders (University of Tennessee), he headed the group which developed a theoretical foundation of Project Satellite Energy Exchange aimed at measuring a number of parameters of gravity (including the constant G) with unprecedented accuracy. [1,2]

In a lecture on 'Cosmological Models with Fluids, Scalar Fields and Forms in Diverse Dimensions,' Melnikov explained: The discovery of accelerated expansion of the Universe and the fact that flat Friedmann model with the cosmological constant or quintessence now fits best the set of observational data, created problems of dark matter and dark energy. This is a real revolution in modern physics as we do not know now what really the dark matter (0.20 of 0.30) and what the dark energy (0.70) of the total energy are..... In the lectures I describe our different attempts to solve some basic problems of modern cosmology using exact solutions with different matter sources in diverse dimensions.

In another paper (2000), he expressed his view that 'Gravity as a Key Problem of the Millennium.' Gravitation is a fundamental interaction that governs all phenomena at large and very small scales, but still not well understood at a quantum level, is a missing cardinal link to unification of all physical interactions. Problems of the absolute G measurements and its possible time and range variations are reflections of the unification problem. Integrable multidimensional models of gravitation and cosmology make up one of the proper approaches to studying basic issues and strong field objects, the Early Universe and black hole physics in particular.

His collaborator Kirill Bronnikov (VNIIMS, Moscow) observed: 'He has always been very quiet, positive and friendly, he had many friends not only close around him but throughout the world, just to mention (certainly not all) such countries as the USA, Germany, France, Brazil, Korea and Japan. He had been a very good manager: he was a leader of our research group for about half a century, he was a founder of the Russian Gravitational Society in 1988 and headed it for 29 years; he also founded and headed the Gravitation and Cosmology journal. As a group leader, he always supported his colleagues and was ready to give a good advice. So for us he was always a friend, and we are really missing him.'

Sang Pyo Kim friendship with Melnikov dates back to his surprising invitation to the International School and Conference on Multidimensional Gravity and Cosmology at Yaroslavl, Russia in June 1994. The Conference was organized by the Russian Gravitational Society, which was founded by Melnikov. It was two years after Kim settled down at Kunsan National University, located in his parent hometown. Probably the local organizers would have noticed his papers on quantum cosmology in Physical Review D based on his thesis at Pennsylvania State University in 1991, since he received another letter from Alexander Zhuk asking for hard copies of these papers before the invitation letter arrived. It was an era of airmails rather than emails, and published journals rather than e-journals.

At that international conference Sung-Won Kim and Sang Pyo Kim met many good friends, Kirill A. Bronnikov and Vladimir D. Ivashchuk as local organizers, and Eduardo I. Guendelman, Vladimir N. Lukash, Paulo V. Moniz as speakers, to name a few. Sang Pyo Kim since then oftentimes met Melnikov at ICGA(C) and other conferences. Sang Pyo Kim once chaired a session for Melnikov at the 2nd ICGA, Hsinchu, Taiwan in 1995, which was organized by Wei-Tou Ni and truly the first international conference series of ICGA(C). Melnikov was absorbed in his own talk and enthusiastic about his research and so could not

finish the talk on time and continued for additional 15 more minutes.

With Melnikov, Sang Pyo Kim co-chaired ICGAC 10 at Quy Nhon, Vietnam in 2011, ICGAC 11 at Almaty, Kazakhstan in 2013, and then ICGAC 12 in Moscow, Russia in 2015. Kim felt heartbreaking sadness when he heard of Melnikov's passing away from Medeu Abishev, another co-chair of ICGAC 11, since Kim was expecting to see him again at ICGAC 13 in Seoul, Korea in 2017. Melnikov was always kind and gentle in organizing activities with an enthusiasm for science. Those who knew him will remember his enthusiasm and leadership in the field of gravitation and cosmology.

Melnikov and Sung-Won Kim had been good friends since 1994. Kim remembers Melnikov as a good friend to colleagues all over the world, a great leader of the Russian Gravitational Society, and a well-intentioned boss to the members of VNIIMS. Kim organized and chaired the last five ICGAC conferences in 1999, 2003, 2007, 2009, and 2017. He first met Melnikov in 1994 at the Yaroslavl meeting and continued the contact at the 1996 Novgorod and the 1999 Vladimir meetings. Melnikov was then invited to the International Organizing Committee (IOC) and became an active member of The Asia-Pacific International Conference on Gravitation and Astrophysics (formal name prior to ICGAC). Because of their special relationship, Kim served as a member of IAC or IOC at eight international conferences organized by Melnikov and held in Russia. Melnikov's enthusiasm for the international journal "Gravitation & Cosmology" prompted him to invite Kim to be a member of its editorial board. Melnikov also visited Ewha and collaborated with Kim for a month in 2003, publishing two papers as co-author with Vladimir Ivashchuk (JMP 1999, G&C 2004).

The first time Jong-Ping Hsu got in touch with Melnikov was related to the proceedings of the 2015 ICGAC Conference. They corresponded and agreed that it would be nice if there was a record of the conference free for physicists who participated, and then they set out to realize the proceedings. As the organizer, Melnikov was responsible for selecting papers from presentations in planetary and parallel sessions. Hsu dealt with the publisher World Scientific and the in-house editor. Hsu sent the publisher a camera-ready manuscript and made sure that they would send a free copy to each researcher who contributed a paper. Melnikov and colleagues made an effort to make sure that the contents of papers in the proceedings were in line with the contemporary level of world research in gravitation, astrophysics and cosmology. In a draft of the Preface, there was a statement 'these works (including Einstein and Grossmann's 1913 paper) are milestones in our understanding of the universe.' Melnikov revised it to read '.... are milestones in our *present* understanding of the universe.' Hsu was impressed and realized that this was a truly researcher with admirable insight of the evolution of ideas in physics.

In 2001, Melnikov led the Russian Gravitational Society (that he headed for 13 years) and the Center of Gravitation and Fundamental Metrology VNIIMS to organize the Asia-Pacific Conference ICGA-5 in Moscow. In 2015, Melnikov, with the help of RGS, the Institute of Gravitation and Cosmology, PFUR, VNIIMS, BLTP JINR, again organized a most successful, large and exciting Conference ICGAC-12 at the People's Friendship University of Russia, Moscow. More than 130 leading and young Russian participants were joined by 45 distinguished and young guests from Brazil, Estonia, Germany, Italy, Kazakhstan, and Ukraine, in addition to the Asia-Pacific countries. A trip for participants to enjoy the spectacular views of the Moscow River Cruise was incomparable. Melnikov arranged a delightful banquet with bountiful foods and Russian wines, and Dmitry Galtsov spontaneously went to a piano and played Chopin music to entertain colleagues. It was an

exciting international conference. Young Min Cho (who initiated the series of ICGAC conference in 1993 in Korea) proposed the idea of expanding the future ICGAC conference from the Asia-Pacific region to the international arena, similar to GRG and the Marcel Grossmann conferences. The idea was discussed and agreed upon in the last-day meeting of the Organizing and Advisory Committees chaired by Melnikov in Moscow. It was gratifying that the first step had been realized in the 2017 conference organized by Sung-Won Kim in Seoul by establishing the Standing Committee to decide policies and to oversee future ICGAC conferences.

Melnikov was a very cheerful, friendly and energetic person, careful and responsive in research to his colleagues and students, with a good sense of humor and intelligence. [1]

Melnikov's life is a symphony of global friendship and collaboration.

With Love from the Asia-Pacific and beyond.

[1] We would like to thank V. Ivashchuk and K. Bronnikov (VNIIMS, Moscow) for materials regarding Melnikov, and A. Parelman for help.

[2] Selected Works:

K. P. Staniukovich and V. N. Melnikov, *Hydrodynamics, Fields and Constants in the Theory of Gravitation* (Energoatomizdat, Moscow, 1983) [book, in Russian].

V. N. Melnikov, *Gravity as a key Problem of the Millennium*, Proc. 2000 NASA/JPL Conf. on Fundam. Physics in Microgravity, NASA Document D-21522, 2001, pp. 4.1.17 (CA, USA).

V. D. Ivashchuk and V. N. Melnikov, *Sigma-Model for Generalized Composite p -Branes*, Class. Quantum Grav. **14**, 3001-3029 (1997); **15**, 3941 (1998).

V. D. Ivashchuk and V. N. Melnikov, *Multidimensional Cosmological and Spherically Symmetric Solutions with Intersecting p -Branes*, Lecture Notes in Physics, **537** (2000).

K. A. Bronnikov and V. N. Melnikov, *p -Brane Black Holes as Stability Islands*, Nucl. Phys. B **584**, 43658 (2000).

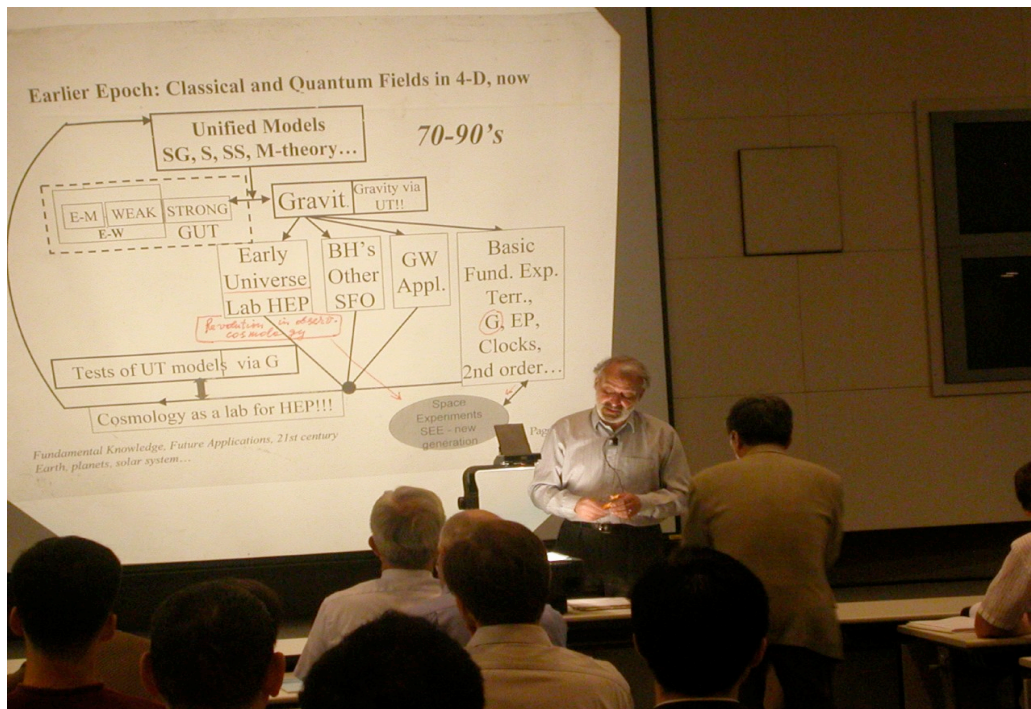
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A. D. Alexeev, A. Bronnikov, I. Kolosnitsyn, Y. Konstantinov, N. Melnikov and J. Sanders, *Measurement of the gravitational constant G in space (SEE project): sensitivity to orbital parameters and space charge effect*. Metrologia **38**, 397 (2001).





First three photos courtesy of Kirill Bronnikov, Center of Gravitation and Fundamental Metrology VNIIMS, Moscow, Russia.





Fourth and fifth photos (2003 ICGAC) courtesy of S. W. Kim, Ewha Womans University, Seoul, Korea.



Sixth photo (2015) courtesy of J. P. Hsu, University of Massachusetts Dartmouth, USA.

Abstracts

3 July, Monday

Plenary Presentations

Valeri P. Frolov (U. Alberta): “Remarks on non-singular black holes”

We discuss spherically symmetric metrics which represent non-singular black holes in four- and higher-dimensional spacetimes. We first consider static metrics, which obey the following conditions: (i) Regularity at the center and (ii) Validity of the limiting curvature condition. We describe the Hayward model and its generalizations, which obey these properties. After this we discuss quantum radiation of a massless scalar field from an evaporating spherically symmetric non-singular black hole with finite lifetime. We demonstrate that in a general case there exists a huge outburst of the quantum radiation, emitted from the black hole interior from the domains close to the inner horizon. We discuss a relation of this phenomenon with the mass inflation effect. Finally, we shall make remarks on attempts to solve this problem and to provide self-consistency of the non-singular model in the quantum domain.

Remo Ruffini (ICRANet): “From Supernovae, to Hypernovae to Binary Driven Hypernovae”

Our concept of Induced Gravitational Collapse (IGC paradigm) from an incipient Supernova into a companion Neutron Star, has unlocked the understanding of seven different families of GRBs, indicating the path for the formation of Black Holes in the Universe. An authentic laboratory of relativistic astrophysics has been unveiled in which new paradigms have been introduced in order to advance in the knowledge of the most energetic, distant and complex systems of our Universe. A novel paradigm of the Cosmic Matrix has been introduced which parallel, in a relativistic cosmic level, the concepts of an S Matrix introduced by Feynmann, Wheeler and Heisenberg in the quantum world of microphysics. Here the "in" states are represented by a Neutron Star and a Supernova, the "out" states, generated, in less then a second, by a new Neutron Star and a Black Hole. This novel field of research needs very powerful technological observations in all wavelength ranging from Radio, to Optical, to X and Gamma radiation all the way to ultra-high-energy cosmic rays.

Misao Sasaki (Kyoto U.): “Inflationary massive gravity”

Inflation is a natural platform for modified gravity. Here we present a new massive gravity theory in which the gravitational wave (GW) modes become massive during inflation. Then we discuss its observational signatures, which are particularly intriguing in this coming era of GW physics/astronomy.

Yongmin Cho (Konkuk U.): “Cosmic Production of the Electroweak Monopole”

We discuss the cosmological production and the successive evolution of the electroweak monopole in the standard model, and estimate the remnant monopole density at present universe. We confirm that, although the electroweak phase transition is of the first order, it is very mildly first order. So, the monopole production arises from the thermal fluctuations of the Higgs field after the phase transition, not the vacuum bubble collisions during the phase transition. Moreover, while the monopoles are produced copiously around the Ginzburg temperature $T_G \simeq 59.6 \sim \{\rm TeV\}$, most of them are annihilated as soon as created. This annihilation process continues very long, until the temperature cools down to about 29.5 MeV. As the result the remnant monopole density in the present universe becomes very small, of 10^{-11} of the critical density, too small to affect the standard cosmology and too small comprise a major component of dark matter. We discuss the physical implications of our results on the ongoing monopole detection experiments, in particular on MoEDAL, IceCube, ANTARES, and Auger.

P1. Classical Gravity – Classical gravity, Modified gravity, etc.

Jong Hyuk Yoon (Konkuk U.): “Hamiltonian reduction of Einstein's gravity without isometries”

I apply the Hamiltonian reduction procedure to general spacetimes of 4 dimensions in the (2+2) formalism and find privileged spacetime coordinates in which the physical Hamiltonian is expressed in terms of the conformal two metric and its conjugate momentum. Physical time is the area element of the spatial cross-section of null hypersurfaces, and the physical radial coordinate is defined by equipotential surfaces on a given spacelike hypersurface of constant physical time. The physical Hamiltonian is local and positive in the privileged coordinates. I present the complete set of Hamilton's equations and find that they coincide with the Einstein's equations written in the privileged coordinates. This shows that the Hamiltonian reduction is self-consistent and respects general covariance.

Seung Hun Oh (Konkuk U.): “Solution-generating methods of Einstein's equations by (2+2) Hamiltonian reduction”

The purpose of this talk is to demonstrate a new method of generating exact solutions to the Einstein's equations obtained by the Hamiltonian reduction. The key element to the successful Hamiltonian reduction is finding the privileged spacetime coordinates in which physical degrees of freedom manifestly reside in the conformal two-metric, and all the other metric components are determined by the conformal two-metric. In the privileged coordinates the Einstein's constraint equations become trivial; the Hamiltonian and momentum constraints are simply the defining equations of a non-vanishing gravitational Hamiltonian and momentum densities in terms of conformal two-metric and its conjugate momentum, respectively. Thus, given any conformal two-metric, which is a constraint-free data, one can construct the whole 4-dimensional spacetime by integrating the first-order superpotential equations. As the first examples of using Hamiltonian reduction in solving the Einstein's equations, we found two exact solutions to the Einstein's equations in the privileged coordinates. Suitable coordinate transformations from the privileged to the standard coordinates show that they are just the Einstein-Rosen wave and the Schwarzschild solution.

The local gravitational Hamiltonian and momentum densities of these spacetimes are also presented in the privileged coordinates.

Chulmoon Yoo (Nagoya U.): “Gravitational collapse of massless fields in an expanding universe”

Gravitational collapse of nonlinear massless fields (scalar fields, gravitational waves) with a periodic boundary condition in a box is considered. We show the existence of the threshold value of the initial amplitude of the local inhomogeneity for black hole formation. The late time expansion law of the universe is also discussed.

Hyeong-Chan Kim (Korea Nat'l U. Transportation): “Matter Equation of State in General Relativity”

We study how a strong gravity affects the equation of state of matters. For this purpose, we employ a canonical ensemble of classical monoatomic ideal gas inside a box in a Rindler spacetime. The total energy decreases monotonically with the increase of the external gravity representing its attractiveness. It is however bounded below, which is different from that of the Newtonian gravity case. As for the entropy, it decreases with the external gravity in the Newtonian regime. However, in the presence of strong gravity or ultra-relativistic high temperature, the entropy increases with the gravity. This result can be a resolution of the negative entropy problem of the ideal gas in the Newtonian gravity. In the presence of strong gravity, the bottom of the box is very close to the event horizon of the Rindler spacetime mimicking a blackhole and the gas behaves as if it is on an effective two dimensional surface located at the bottom of the box. Investigating the equation of state in the strong gravity regime, the temperature of the system is found to be not a free parameter but to approach a fixed value proportional to the external gravity, which is reminiscent of the Unruh temperature.

Jia-Rui Sun (Sun Yat-Sen U.): “Analogue gravity in BEC and its gravity dual”

Analogue gravity appeared in non-gravitational systems show many features resemble to real gravitational systems such as the appearance of curved geometry and horizon. However, deep dynamical connections between the analogy gravity and the real gravity are still lacking. In this paper, we will show that the analogy gravity formed from the Bose-Einstein condensation (BEC) can be dynamically connected with a real gravitational system by using the approach of the gauge/gravity duality. In this sense, the analogy gravity in BEC is no longer just an analogy.

Alexey Toporensky (Sternberg Astron. Inst.): “A viable compactification scenario in Gauss-Bonnet gravity”

We propose a scenario in which a multidimensional anisotropic Universe starting with some non-zero measure set of initial conditions tends to a situation with three big almost isotropic

dimensions and inner dimensions with constant radius. The stabilization of compact dimensions occurs due to negative spatial curvature. In contrast to earlier work on this type of compactification the present scenario does not require exact isotropy of big and inner dimensions.

Jong-Ping Hsu (UMass): “Experiments on the Frequency Dependence of the Deflection of Light in Yang-Mills Gravity”

Yang-Mills gravity is based on 4-dimensional translational gauge symmetry in flat space-time, can be quantized and is consistent with all known experiments. The eikonal equation for a light ray is derived from a version of Maxwells wave equations modified by gravity in the limit of geometric-optics. One obtains a Hamilton-Jacobi equation for the light ray, $G_{\mu\nu}\partial\mu\psi\partial\nu\psi = 0$. Thus, in Yang-Mills gravity, light rays move as if they were in a curved space-time with the effective metric tensor $G_{\mu\nu}$. The deflection angle of a light ray by the sun is about 1.53'' for optical frequencies $\approx 10^{14}$ Hz. It is roughly 12% smaller than the usual value 1.75''. However, the experimental data for the bending of light by the sun in optical frequencies have uncertainties of 10-20% due to large systematic errors. If one does not take the geometric-optics limit, the eikonal equation is $G_{\mu\nu} [\partial\mu\psi\partial\nu\psi + (\partial\mu\partial\nu\psi)\tan\psi] = 0$. This eikonal equation implies that the angle of light deflection by the sun should be frequency dependent. All recent accurate measurements of the light deflection angle by the sun have been performed in radio frequencies near 109 Hz, which is too far away from optical frequencies to see this effect. Yang-Mills gravity could be tested by detecting the frequency-dependence of the deflection angle by the sun. We propose carrying out a new experiment using frequencies 10¹² Hz which would have an uncertainty of 0.1%, which is technically possible. This experiment could test new implications of Yang-Mills gravity.

Inyong Cho (SeoulTech): “Black Holes in S3 and H3”

The black-hole solutions in closed (S3) and open (H3) spaces are introduced. These black holes are formed in the presence of static perfect fluid. The charged case is also discussed. The spacetime structure, the geodesics, and the stability of the black holes will be discussed.

Laura Marcela Becerra Bayona (Sapienza University of Rome and IcrNet): “SPH simulations of the Induced Gravitational Collapse”

The induced gravitational collapse (IGC) paradigm will be presented. This has been applied to explain the long gamma ray burst (GRB) associated with type Ic supernova, and recently the X-ray flashes (XRFs). The progenitor is a carbon-oxygen core (CO) and a neutron star (NS) tight binary system. The CO core collapses and undergoes a supernova explosion (SN) which triggers the hypercritical accretion onto the NS companion (up to $10^{-2} M_{\odot} s^{-1}$). For the binary driven hypernova (BdHNe), the binary system is enough bound, the NS reach its critical mass, and collapse to a black hole (BH) with a GRB emission characterized by an isotropic energy $E_{\text{iso}} > 10^{52}$ erg. Otherwise, for binary systems with larger binary separations, the hypercritical accretion onto the NS is not sufficient to induced its gravitational collapse, a X-ray flash (XRF) is produced with $E_{\text{iso}} < \sim$

1052 erg. With the SPH code, we're going to simulate the SN ejecta motion under the gravitational attraction of the NS in order to identify the binary parameters that limits the BdHNe systems with the XRFs systems.

Atsushi Naruko (Tohoku U.): “Extended vector-tensor theories”

Recently, several extensions of massive vector theory in curved space-time have been proposed in many literatures. In this talk, we consider the most general vector-tensor theories that contain up to two derivatives with respect to metric and vector field. By imposing a degeneracy condition of the Lagrangian in the context of ADM decomposition of space-time to eliminate an unwanted mode, we construct a new class of massive vector theories where five degrees of freedom can propagate, corresponding to three for massive vector modes and two for massless tensor modes. We find that the generalized Proca and the beyond generalized Proca theories up to the quartic Lagrangian, which should be included in this formulation, are degenerate theories even in curved space-time. Finally, introducing new metric and vector field transformations, we investigate the properties of thus obtained theories under such transformations.

J. Rodriguez (ICRANet): “Strong-field gravitational-wave emission in Schwarzschild and Kerr geometries: some general considerations”

We show how the concurrent implementation of the exact solutions of the Einstein equations, of the equations of motion of the test particles, and of the relativistic estimate of the emission of gravitational waves from test particles, can establish a priori constraints on the possible phenomena occurring in Nature. Two examples of test particles starting at infinite distance or from finite distance in a circular orbit around a Kerr black hole are considered: the first leads to a well defined gravitational wave burst the second to a smooth merging into the black hole. We notice a difference between our treatment and the one by Ori and Thorne (2000) which will affect the gravitational wave signal. This analysis is necessary for the study of the waveforms in merging binary systems.

P2: Quantum Gravity – Quantum gravity, Black hole thermodynamics, Black hole entropy, etc.

Sang Pyo Kim (Kunsan Nat'l U.): “Quantum Gravity Effects in Cosmology”

Within the geometrodynamics approach to quantum cosmology, we studied the quantum gravity effects in cosmology. The Gibbons-Hawking temperature is corrected by quantum gravity due to spacetime fluctuations and the power spectrum also gets a quantum gravity effect.

Ehsan Bavarsad (U. Kashan): “Effect of a magnetic field on Schwinger mechanism in de Sitter spacetime”

We investigate the effect of magnetic field background on the scalar QED pair production in de Sitter spacetime (dS). We obtained the pair production rate, which agrees with the known Schwinger result in Minkowski spacetime and with the Hawking radiation in the limit of zero electric field in dS. It implies how the cosmic magnetic field affects on the pair production rate. In addition, using the zeta function regularization scheme we calculate the induced current and examine the effect of magnetic field on the vacuum expectation value of the current operator. We find that in the strong electric E or magnetic B field the current responds as $E.B$, instead in the infrared regime, it responds as B/E , which leads to a phenomenon of infrared hyperconductivity. Those results of the induced current would be important for discussing the cosmic magnetic field evolution.

Eoin O Colgain (APCTP): “Calibrated Entanglement Entropy”

Entanglement entropy can be determined holographically through the identification of minimal surfaces in Anti-de Sitter (AdS) spacetimes. We report on the application of calibrated cycles for identifying minimal surfaces in both unwarped and warped AdS geometries.

Wonwoo Lee (CQeST): “Tunneling decay of false vortices with gravitation”

We investigate the tunneling decay of vortices initially trapped in the false vacuum of scalar electromagnetic theory with gravitation in three spacetime dimensions. This paper is the extension of our previous paper, tunneling decay of false vortices, with gravitation. In this study, the false vacuum contains metastable vortex solutions instead of the homogeneous configuration at the initial moment. The vortex solution can have inside true vacuum state and the magnetic flux with the thin-wall in the present of gravitation. We present the numerical solutions for the gauge, scalar field, and metric functions. In the limit of vanishing gravitational coupling we smoothly retrieve our previously found results for the decay of the false vortex.

Taishi Ikeda (Nagoya U.): “Oscillon in Einstein-scalar system with double well potential and its properties”

We focus on the Einstein-scalar system with double well potential. In case of a scalar field with double well potential in Minkowski background, it is known that there is a longevity localized solution. This solution is called oscillon. Therefore, when we consider the gravitational collapse of the bubble in the Einstein-scalar system with double well potential, it is possible that oscillon appears as an intermediate state. In many previous researches, the oscillon in a scalar field with double well potential in Minkowski background has been examined. In this study, we examined the fundamental properties of the oscillon in the Einstein-scalar system with double well potential, and found the several interesting properties.

Hyun Seok Yang (CQeST): “Dark Matter and Dark Energy from Emergent Spacetime

Picture”

We emphasize that noncommutative (NC) spacetime necessarily implies emergent spacetime if spacetime at microscopic scales should be viewed as NC. The emergent gravity from NC U(1) gauge theory is the large N duality and the emergent spacetime picture admits a background-independent formulation of quantum gravity. We show that dark matter and dark energy arise as a holographic (UV-IR) manifestation of the coherent vacuum of Planck energy condensate. It turns out that emergent gravity distinguishes dark matter and dark energy according to the causal structure of emergent spacetime.

Alex Giacomini (U. Austral de Chile): “On the compatibility of thermodynamic equilibrium conditions with lattice propagators”

In this paper the compatibility is analyzed of the non-perturbative equations of state of quarks and gluons arising from the lattice with some natural requirements for self-gravitating objects at equilibrium: the existence of an equation of state (namely, the possibility to define the pressure as a function of the energy density), the absence of superluminal propagation and Le Chatelier's principle. It is discussed under which conditions it is possible to extract an equation of state (in the above sense) from the non-perturbative propagators arising from the fits of the latest lattice data. In the quark case, there is a small but non-vanishing range of temperatures in which it is not possible to define a single-valued functional relation between density and pressure. Interestingly enough, a small change of the parameters appearing in the fit of the lattice quark propagator (of around 10~\%) could guarantee the fulfillment of all the three conditions (keeping alive, at the same time, the violation of positivity of the spectral representation, which is the expected signal of confinement). As far as gluons are concerned, the analysis shows very similar results. Whether or not the non-perturbative quark and gluon propagators satisfy these conditions can have a strong impact on the estimate of the maximal mass of quark stars.

Muhammad Sharif (U. Punjab): “Study of Generalized Second Law of Thermodynamics in Curvature-Matter Coupling Gravity”

This paper explores the non-equilibrium behavior of thermodynamics at the apparent horizon of isotropic and homogeneous universe model in $f(G,T)$ gravity (G and T represent the Gauss-Bonnet invariant and trace of the energy-momentum tensor, respectively). We construct the corresponding field equations and analyze the first as well as generalized second law of thermodynamics in this scenario. It is found that an auxiliary term corresponding to entropy production appears due to the non-equilibrium picture of thermodynamics in first law. The universal condition for the validity of generalized second law of thermodynamics is also obtained. Finally, we check the validity of generalized second law of thermodynamics for the reconstructed $f(G,T)$ models (de Sitter and power-law solutions). We conclude that this law holds for suitable choices of free parameters.

Yoonbai Kim (Sungkyunkwan U.): “Entropy in Spacetime with Topological Hair”

Global topological solitons of the hedgehog ansatz are added to Schwarzschild black hole or de Sitter spacetime in arbitrary dimensions larger than three, and thermodynamic law is checked at the horizon without additional horizons. All geometric and thermodynamic quantities are varied in the presence of this interacting matter distribution including pressure, however the area law is satisfied in exact form.

Hideki Maeda (Hokkai-Gakuen U.): “Throat quantization of the Schwarzschild-Tangherlini(-AdS) Black Hole”

Adopting the throat quantization pioneered by Louko and Makela, we derive the mass and area spectra for the Schwarzschild-Tangherlini black hole and its anti-de Sitter (AdS) generalization in arbitrary dimensions. We obtain exact spectra in three special cases: the three-dimensional BTZ black hole, toroidal black holes in any dimension, and five-dimensional Schwarzschild-Tangherlini(-AdS) black holes. For the remaining cases the spectra are obtained for large mass using the WKB approximation. For asymptotically flat black holes, the area/entropy has an equally spaced spectrum, as expected from previous work. In the asymptotically AdS case on the other hand, it is the mass spectrum that is equally spaced.

Wontae Kim (Sogang U.): “Origin of Hawking radiation”

The origin of Hawking radiation will be discussed in connection with the firewall issue in the Unruh vacuum.

4 July, Tuesday

Plenary Presentations

Yungui Gong (Huazhong U. Sci. Tech.): “On the polarization of gravitational waves in scalar-tensor theories of gravity”

According to the Newman-Penrose formalism, in general there are six polarizations for general theories of gravity. In particular, the presence of the longitudinal mode means that the theory has all six polarizations. For massive scalar-tensor theory of gravity or $f(R)$ theory, the longitudinal mode presents, but the theory has only three dynamical degrees of freedom, it seems that there is inconsistency somewhere. We point out that the Newman-Penrose formalism is not directly applicable to massive mode, the polarization of the massive scalar field is a mix of breathing and longitudinal mode and the longitudinal mode is proportional to the mass, when the mass becomes zero, the mix mode becomes the pure breathing mode which is consistent with the Newman-Penrose formalism. Since the longitudinal mode is proportional to the mass, so it can be detected only in very low frequency band, like the PTA band.

Hyung Mok Lee (Seoul Nat'l U.): “What have we learned from the detection of

gravitational waves?”

The advanced LIGO detected three black hole binary mergers and one candidate during two observing runs. We are still in very early stage of gravitational wave astronomy, but we already learned many new things in astrophysics. The existence of the binary black hole was never established observationally until the LIGO made detections of binary black hole mergers. The binary neutron star merger have been considered to be the most robust source of gravitational waves for LIGO type detectors but such an event has not been detected yet. The masses of the black holes in the binaries before the merger appear to be systematically larger than the typical masses of the black hole candidates in X-ray binaries in the Galaxy. The black hole binary merger detected most recently appear to have spins that are not aligned to the orbital angular momentum. These results pause many fundamental questions regarding the evolution of massive stars, the epoch of formation of the black holes and origin of the compact black hole binaries. We need many more detections with high signal to noise ratios in order to answer these questions. In this talk, I will focus on the astrophysical significances of the detected gravitational waves so far and discuss future prospects of gravitational astrophysics with current and future generation of gravitational wave detectors.

Shinji Miyoki (ICRR): “Current Status of KAGRA Gravitational Wave Telescope”

I will talk about the present status and future commissioning plan of KAGRA gravitational wave telescope in Japan.

Wei-Tou Ni (Nat'l Tsing Hua U.): “Gravitational Wave Classification and the Space GW Detection Sensitivities”

After reviewing the gravitational wave (GW) spectral classification, we discuss the sensitivities of GW detection in space aimed at low frequency band (100nHz–100mHz) and middle frequency band (100mHz–10Hz) with the science goals of detecting GWs from (i) Supermassive Black Holes; (ii) Extreme-Mass-Ratio Black Hole Inspirals; (iii) Intermediate-Mass Black Holes; (iv) Galactic Compact Binaries and (v) Relic GW Background. We present an overview on the sensitivity, orbit design, basic orbit configuration, angular resolution, orbit optimization, deployment, time-delay interferometry (TDI) and payload concept of the current proposed GW detectors in space under study. The detector proposals under study have arm length ranging from 1000 km to 1.3×10^9 km (8.6AU) including (a) Solar orbiting detectors and (b) Earth orbiting detectors.

Ho Jung Paik (U. Maryland): “Superconducting Tensor Gravitational-Wave Detector and Mitigation of Newtonian Noise”

Detection of gravitational waves (GWs) from binary black holes (BHs) by Advanced LIGO has opened a new window of astronomical observation. Many conceivable sources such as intermediate-mass BH binaries and white dwarf binaries, as well as stellar-mass BH inspiral,

would emit GWs below 10 Hz. It is highly desirable to open a new window for GW astronomy in the infrasound frequency band. A low-frequency tensor detector could be constructed by combining six magnetically levitated superconducting test masses. Such a detector would be equally sensitive to GWs coming from anywhere in the sky, and would be capable of resolving the source direction and wave polarization. I will present a design concept of a new terrestrial GW detector, named SOGRO, which could reach a strain sensitivity of 10^{-19} - 10^{-21} Hz^{-1/2} at 0.1-10 Hz. Seismic and Newtonian gravity noises are serious obstacles in constructing terrestrial GW detectors at frequencies below 10 Hz. I will explain how these noises are rejected in SOGRO. I will also discuss the possibility of mitigating the Newtonian noise for advanced laser interferometers by directly detecting and removing it with mini-SOGROs collocated with the interferometer test masses.

P3: Astrophysics - Relativistic astrophysics, Observation, Cosmic rays, GRB, etc.

Medeu Abishev (Al Farabi Kazakh Nat'l U.): “The orbital stability of a test particle motion in the field of two massive rotating bodies”

We investigate a motion of the test body in the restricted three body problem, where two massive bodies have their own rotation. We consider the problem of orbital stability of circular motion of a test body, where disturbances to motion of the test body (in the plane of motion of the second body) from the circular orbital motion of the second body in the field of central body are in order of relativistic corrections to the motion of a test body from the central body.

In the work [1], the orbital stability of the motion of a test body in the restricted three body problem in mechanics of general relativity (GR) is investigated (all bodies have no proper rotation). As a result[1], it is shown that the motion of the test body in the plane of the orbit of the two body is stable when orbit of the test body is circular. In this work, we consider the case when massive bodies have their own rotation. We found the evolution equation of motion for the test (third) body, which describes the average change of its orbital momentum. To do that, we'll study the evolutionary equations of motion by the asymptotic adiabatic theory, through the process of averaging of the corresponding equations using the vector elements M (the orbital moment) and A (the Laplace vector).

References

[1] Abishev M.E., Toktarbay S., Zhami B.A. On the Stability of Circular Orbits of a Test Body in the Restricted Three-Body Problem in GR Mechanics. Gravitation and cosmology, 20. (2014)

Giovanni Battista Pisani (Sapienza University of Rome and ICRANet): “The 1st ICRANet Catalog of Binary-driven HyperNovae”

In a series of recent publications, scientists from ICRANet led by Remo Ruffini have reached a novel comprehensive picture of “gamma-ray bursts” (GRBs) thanks to their development of a series of new theoretical approaches. Among those, the “induced gravitational collapse” paradigm explains a class of energetic, long-duration GRBs associated with Ib/c supernovae, recently named “binary-driven hypernovae” (BdHNe). Thanks to this novel theoretical and observational understanding, it was possible for ICRANet scientists to build the 1st BdHNe

catalog, composed by the 344 BdHNe identified up to the end of 2016.

Gregory Vereshchagin (ICRANet): “Cosmic horizon for GeV sources and photon-photon scattering”

Propagation of ultra high energy particles in the Universe is reviewed. Particular emphasis is given to the photon-photon scattering process.

Naser Ahmadinia (Institute for Basic Science): “Master formulas for the dressed scalar propagator in a constant field”

The worldline formalism has previously been used for deriving compact master formulas for the one-loop N-photon amplitudes in both scalar and spinor QED, and in the vacuum as well as in a constant external field. For scalar QED, there is also an analogous master formula for the propagator dressed with N photons in the vacuum. Here, we extend this master formula to include a constant field. The two-photon case is worked out explicitly, yielding an integral representation for the Compton scattering cross section in the field suitable for numerical integration in the full range of electric and magnetic field strengths.

Mehbub Khan (UMass): “Baryonic Force for Accelerated Cosmic Expansion and Generalized Yang-Mills Symmetry”

Based on conserved baryon number (or charge) and the generalized Yang-Mills symmetry, we discuss a new baryonic gauge field and its linear potential for two point-like baryon charges. The force between two baryons is repulsive, extremely weak, but independent of distance. Only in the later stage of cosmic evolution, when two baryonic galaxies are separated by an extremely large distance, the baryonic force can overcome their gravitation attractive force. Thus, this provides a gauge-field-theoretic understanding of the late-time accelerated cosmic expansion. The general forces between two big objects with baryon charges are calculated. The trajectories of two baryonic objects are also numerically calculated and displayed.

Myeong-Gu Park (Kyungpook Nat'l U.): “Accretion onto Black Holes with Outflow”

Recent works on the accretion flow onto black holes show that the accretion rate of the flow can be significantly different from the Bondi mass accretion rate. In addition, hot accretion flows are expected to develop outflows. We discuss the implications of the outflow in terms of the accretion rate and energetics as well as black hole growth.

Sehrish Iftikhar (Lahore College for Women U.): “Particle Dynamics Around a Charged Black Hole”

Black holes are the most important predictions of general relativity, which are the end

product of gravitational collapse. The study of geodesics reveals geometrical properties of such a curved spacetime. A physical particle follows either null or timelike geodesics. We explore the particle motion near a charged black hole. In this context, we study the stability of orbits through effective potential and examine the effect of charge on the motion of particles.

Mohammad Wali Hossain (APCTP): “Quintessential inflation: A unified scenario of inflation and dark energy”

In quintessential inflation, inflation and late time acceleration are described by a single scalar field. Such a scenario will be discussed with canonical and noncanonical scalar fields. The scalar field behaves as a inflaton field during inflation and as a quintessence field during late time. Comparison with recent Planck data will also be done.

Daria Primorac (ICRANet & Sapienza U. Roma): “Analysis of the GRB110731A within the fireshell model”

Long gamma-ray burst GRB 110731A was bright enough to cause Autonomous Repoint Request when it triggered the GBM onboard Fermi spacecraft. Swift Burst Alert Telescope was also triggered and immediately slew into the position. Many more observatories responded with prompt follow-up observation. As a result, provided data ranges from optical to gamma rays, covering few hundred seconds. This gives an unique opportunity to study the burst and identify its properties within the IGC paradigm, using the fireshell model. In the fireshell model, description of the GRB acceleration process invokes the dynamics of an optically-thick e^+e^- plasma, which gradual annihilation causes its expansion and self acceleration. The dynamics of the fireshell up to the transparency point is fully described by the total energy of the plasma E and the baryon load B . We determine these quantities by performing the time-resolved spectral analysis of the GRB 110731A light curve. We proceed with the light curve simulation from which we deduce the CBM density values and its inhomogeneities. Finally, time-integrated spectra of the simulated light curve was compared with the spectra observed by NaI and BGO detectors onboard Fermi spacecraft.

Yongsoo Jho (Yonsei U.): “Search for Sphaleron from the Ultra-High-Energy cosmic rays and neutrinos”

We study the Ultra High Energy Cosmic Rays (UHECR) as a probe of the sphaleron processes. Our focuses are on the high energy proton-proton and neutrino-nucleon collisions for the cosmic ray observatories such as TA and Pierre Auger. With the attenuation and regeneration effects due to generic high-multiplicity processes such as the electroweak sphaleron and the microscopic Black hole, constraints from the neutrino telescopes, IceCube and Super-Kamiokande, are also discussed.

Rahim Moradi (Sapienza U. of Rome and ICRANet): “Charged Cosmological Black holes”

The cosmological black holes are black holes living not in an asymptotically flat universe but

in an expanding spacetime. They have a rich dynamics in particular for their mass and horizon. In this article we perform a natural step in investigating this new type of black hole: we consider the possibility of a charged cosmological black hole. We derive the general equations of motion governing its dynamics and report a new analytic solution for the special case of the charged Lemaitre-Tolman- Bondi equations of motion that describe a charged cosmological black hole. We then study various relevant quantities for the characterization of the black hole such as the C-function, the effect of the charge on the black hole flux and the nature of the singularity. We also perform numerical investigations to strengthen our results.

Julio David Melon Fuksman (Sapienza U. Rome & ICRANet): “Simulation of an electron-positron plasma in the context of the IGC paradigm”

The BdHN model has been introduced in the last years, to explain a subfamily of gamma-ray bursts (GRBs) with energies $E_{\text{iso}} \geq 10^{52}$ erg associated with type Ic supernovae. Such BdHNe have as progenitor a tight binary system composed of a carbon-oxygen core (COcore) and a neutron star (NS) undergoing an induced gravitational collapse (IGC) to a black hole (BH), triggered by the COcore explosion as a supernova (SN). This collapse produces an optically-thick e^+e^- plasma, part of which expands acceleratedly and impacts the SN ejecta at $r \sim 10^{10}$ cm. This process is here considered as a candidate for the production of X-ray flares, which are frequently observed following the prompt emission of GRBs. In this preliminary work we simulate the evolution of the e^+e^- plasma as it interacts with the SN ejecta, and estimate the subsequent photon emission.

P4: Gravitational Waves – Gravitational wave astronomy/astrophysics, Numerical relativity, etc.

Dong-Hoon Kim (Seoul Nat'l U.): “Gravitational waves with effects of radiation reaction”

In General Relativity, it is known that a particle moving in curved spacetime undergoes a force which results from the interaction of the particle with its own field; namely, a self-force or radiation reaction force. In this talk, I discuss the effects of the self-force on the orbital motion of a small object about a black hole: e.g. a test particle orbiting a small black hole (of about a solar mass), a small black hole (of about a solar mass) orbiting a supermassive black hole (of about a million solar masses), etc.. This study can be applied to design accurately the theoretical gravitational waveforms from binary systems consisting of a small black hole and a supermassive black hole (so called extreme-mass-ratio binaries), which are possible target sources of gravitational waves for eLISA detection.

Toshinori Matsui (KIAS): “Gravitational waves from the first order electroweak phase transition in the Z_3 symmetric singlet scalar model”

Among various scenarios of baryon asymmetry of the Universe, electroweak baryogenesis is directly connected with physics of the Higgs sector. We discuss spectra of gravitational

waves which are originated by the strongly first order phase transition at the electroweak symmetry breaking, which is required for a successful scenario of electroweak baryogenesis. In the Z_3 symmetric singlet scalar model in which the dark matter candidate is included, the significant gravitational waves are caused by the multi-step phase transition. We show that the model can be tested at future gravitational wave interferometers such as eLISA and DECIGO. This talk is based on a project collaborated with Zhaofeng Kang and Pyungwon Ko.

Hyung Won Lee (Inje University): “TaylorF2 CBC waveform with eccentricity corrected phase”

We developed eccentric corrected TaylorF2 waveform and performed to check determinability for eccentricity using this waveform.

Luis Gabriel Gómez (Sapienza U. Rome & ICRA Net): “Gravitational wave emission versus dark matter dynamical friction in the evolution of compact star binaries”

The measured orbital period decay of relativistic compact star binaries, with characteristic orbital periods ~ 0.1 days, is explained with very high precision by the gravitational wave (GW) emission of an inspiraling binary in vacuum predicted by general relativity. However, the binary gravitational binding energy is also affected by an usually neglected phenomenon, namely the dark matter dynamical friction (DMDF) produced by the interaction of the binary components with their respective DM gravitational wakes. Therefore, the inclusion of the DMDF might lead to a binary evolution which is different from a purely GW-driven one. The entity of this effect depends on the orbital period and on the local value of the DM density, hence on the position of the binary in the Galaxy. We evaluate the DMDF produced by three different DM profiles: the Navarro-Frenk-White (NFW) profile, the non-singular-isothermal-sphere (NSIS) and the fermionic Ruffini-Argüelles-Rueda (RAR) model. We first show that indeed, due to their Galactic position, the GW emission dominates over the DMDF in the NS-NS, NS-WD and WD-WD binaries for which measurements of the orbital decay exist. Then, we evaluate the conditions (i.e. orbital period and Galactic location) under which the effect of DMDF on the binary evolution becomes comparable to, or overcomes, the one of the GW emission. In the case of NFW profile, we find that this occurs for orbital periods longer than 18 days for $1.3 - 0.2 M_\odot$ NS-WD binaries and around 30 days for both $1.3 - 1.3 M_\odot$ NS-NS binaries and $0.25 - 0.5 M_\odot$ WD-WD binaries, located at distances $0.1 - 1.5$ kpc from the Galactic center. For closer distances to the Galactic center, the DMDF effect increases and the above critical orbital periods become interestingly shorter.

Gihyuk Cho (Seoul Nat’l U.) Theory of Gravitational radiation

To detect GW in high precision we need to have highly accurate waveform of GWs. I pay attention to this problem in analytic method, specially using post-Newtonian theory. I will show some results and ongoing projects.

Jinn-ouk Gong (APCTP): “Induced gravitational waves”

We present the induced gravitational waves during matter dominated epoch sourced by not only the quadratic combinations of the linear scalar-scalar perturbations, but also tensor-tensor and scalar-tensor perturbations that were not known before. These contributions can be significant in certain frequency windows.

Hisaaki Shinkai (Osaka Inst. Tech.): “Gravitational waves from merging intermediate-mass black holes”

Based on a dynamical formation model of a supermassive black hole (SMBH), we estimate the expected observational profile of gravitational waves at ground-based detectors, such as KAGRA or advanced LIGO/ VIRGO. We estimate the number density of galaxies from the halo formation model and estimate the number of BH mergers from the giant molecular cloud model assuming hierarchical growth of merged cores. At the designed KAGRA (and/or advanced LIGO/VIRGO), we find that the BH merger of its total mass $M \sim 60$ Msun is at the peak of the expected mass distribution. With its signal-to-noise ratio $r = 10$ (30), we estimate the event rate $R \sim 200$ (20) per year in the most optimistic case, and we also find that BH mergers in the range $M < 150$ Msun are $R > 1$ per year for $r = 10$. Thus, if we observe a BH with more than 100 Msun in future gravitational-wave observations, our model naturally explains its source. [ApJ 835 (2017)276]

Sunghoon Jung (Invited, Seoul Nat’l U.): “Angular Resolutions of Mid-Frequency Gravitational Wave Detectors”

Opening up the mid-frequency band of $f=0.1-10$ Hz is a next important goal of gravitational-wave physics. In particular, this band has an ideal balance between gravitational-wave lifetime and frequency for sub-degree angular resolution. We demonstrate how well a mid-frequency detector can localize compact binary mergers and discuss this ideal balance. Although we use an atom interferometer as an example detector in this band, any space detectors can generally achieve similar performance. But terrestrial detectors in this band would be swamped by gravity gradient noise.

Gungwon Kang (KISTI): “Structural analysis of the SOGRO platform”

SOGRO is a conceptual design for a superconducting low-frequency gravitational wave telescope. Its platform has three arms whose ends support six superconducting test masses. Among many required properties for the platform to work well as a main part of the detector, vibrational noises should be outside of the frequency bandwidth in interest (e.g., 0.1~10Hz). We report preliminary results of structural analyses in finite element method for several platform configurations including 30m and 50 m arm lengths.

Dawoo Park (Seoul Nat’l U.): “Black Hole Binaries Dynamically Formed in Globular

Clusters”

Globular clusters (GCs) are an ideal environment to form black hole (BH) binaries. BHs in GC quickly segregate into central region through dynamical friction, then BH-BH binaries can form under high density environment. Subsequent interactions of the binaries with other stars or BHs make the binaries tighter. The tightening of binaries means the release of binding energy in the form of kinetic energies of binaries and interacting stars. Eventually binaries can be ejected from the GC. We investigate properties of BH binaries using direct N-body simulations. We considered the GC with various BH mass population, and studied properties of binaries that are ejected from the clusters. Our results show higher mass BHs are more likely to form BH binaries. The mass ratios of dynamically formed binaries are found to be close to one. The rate of BH binary merger rate density is estimated to be about 10 per year per cubic Gpc, which is consistent with the current estimation based on the detected events by LIGO so far. We further note that the progenitor of the latest BH merger event GW170104 may have been a dynamically formed binary system because the at least the spin axis of one BHs appeared to be non-aligned with the angular momentum axis.

HanGil Choi (Seoul Nat’l U.): “Finding Quasi-Spherical Orbit Initial condition of Black Hole Binary using Effective-One-body model”

We are developing a iterative method for eccentricity reduction of compact binary inspiral based on the Effective-One-Body model[M. Pürrer et al. Phys. Rev. D. 85, 124051(2012)]. We improve the original method in using more state-of-the-art version of the EOB model, SEOBNRv4[A. Bohé et al. Phys. Rev. D. 95, 044028(2017)]. To cover spinning, precessing binary black hole configurations by SEOBNRv4, we adopt precessing orthonormal frame when integrating equation of motion of EOB instead of cartesian frame.

P5: Inflation and Dark Matter

Hyun Min Lee (Chung-Ang U): “Flattening the inflaton potential beyond the minimal gravity”

We consider inflation models at large field values, motivated by low energy physics to describe the Higgs phenomena such as the SM Higgs mechanism or the B-L symmetry for generating neutrino masses. We show that non-minimal coupling to gravity and/or modified gravity for large inflaton energy density play a crucial role in flattening the inflaton potential at large field values, being consistent with observed CMB data.

Aditya Aravind (APCTP): “Higgs Portal Inflation with Fermionic Dark Matter”

We discuss an inflationary model involving a gauge singlet scalar field and fermionic dark matter added to the standard model. Either the Higgs boson or the singlet scalar could play the role of the inflaton, and slow roll is realized through its non-minimal coupling to gravity. The effective scalar potential is stabilized by the mixing between the scalars as well as the coupling with the fermionic field. Mixing of the two scalars also provides a portal to dark

matter. Constraints on the model come from collider searches, dark matter relic density and direct detection and impose a constraining relationship on the masses of dark matter and scalar fields. Inflationary predictions are generically consistent with current Planck data.

Echal Chang (Chungnam Nat'l U.): “Toward a more realistic Randall-Sundrum Brane World”

In the original version of Randall-Sundrum Brane World scenario, they demonstrated the gravity localization/graviton trapping on a “Poincare-invariant” 4-dim. Brane world. This is, however, a too much simplification as the “Poincare-invariant” 4-dim. Brane world can only be a cold, empty universe which obviously lacks its realistic, practical nature. We [Hongsu Kim; KASI], therefore, relax this original set-up to a more realistic/practical set-up where the graviton still gets trapped on a “Ricci-flat” 4-dim. Brane world that, now, may allow for realistic structures like black holes or homogeneous, anisotropic cosmology [i.e., expanding universe] which are, particularly, solutions to the vacuum Einstein equation.

Zhu Yi (Huazhong U. Sci. Tech.): “Nonminimal coupling and inflationary attractors

We show explicitly how the T model, E model, and Hilltop inflations are obtained from the general scalar-tensor theory of gravity with arbitrary conformal factors in the strong coupling limit. We argue that ξ attractors can give any observables n_s and r by this method. The existence of attractors imposes a challenge to distinguish different models.

Yongwan Gim (Sogang U.): “On the thermodynamic origin of the initial radiation energy density in warm inflation”

In warm inflation scenarios, radiation always exists, so that the radiation energy density is also assumed to be finite when inflation starts. To find out the origin of the non-vanishing initial radiation energy density, we revisit thermodynamic analysis for a warm inflation model and then derive an effective Stefan-Boltzmann law which is commensurate with the temperature-dependent effective potential by taking into account the non-vanishing trace of the total energy-momentum tensors. The effective Stefan-Boltzmann law shows that the zero energy density for radiation at the Grand Unification epoch increases until the inflation starts and it becomes eventually finite at the initial stage of warm inflation. By using the above effective Stefan-Boltzmann law, we also study the cosmological scalar perturbation, and obtain the sufficient radiation energy density in order for GUT baryogenesis at the end of inflation.

Dong Woo Kang (Yonsei U.): “Electroweak Kaluza-Klein Dark Matter”

In models with universal extra dimensions (UED), the lightest Kaluza-Klein excitation of neutral electroweak gauge bosons is a stable, weakly interacting massive particle and thus is a candidate for dark matter thanks to Kaluza-Klein parity. We examine concrete model realizations of such dark matter in the context of non-minimal UED extensions. The

boundary localized kinetic terms for the electroweak gauge bosons lead to a non-trivial mixing among the first Kaluza-Klein excitations of the $SU(2)_W$ and $U(1)_Y$ gauge bosons and the resultant low energy phenomenology is rich. We investigate implications of various experiments including low energy electroweak precision measurements, direct and indirect detection of dark matter particles and direct collider searches at the LHC. Notably, we show that the electroweak Kaluza-Klein dark matter can be as heavy as 2.4 TeV, which is significantly higher than 1.3 TeV as is indicated as an upper bound in the minimal UED model.

Jae-Weon Lee (Jungwon U.): “Brief History of Ultra-light Scalar Dark Matter Models”

I review the brief history of the scalar field dark matter model also known as fuzzy dark matter, BEC dark matter, wave dark matter, or ultra-light axion. In this model ultra-light scalar dark matter particles with mass $m = O(10^{-22})\text{eV}$ condense in a single Bose-Einstein condensate state and behave collectively like a classical wave. Galactic dark matter halos can be described as a self-gravitating coherent scalar field configuration called boson stars. At the scale larger than galaxies the dark matter acts like cold dark matter, while below the scale quantum pressure from the uncertainty suppresses the smaller structure formation so that it can resolve the problems of the conventional cold dark matter model.

Sichun Sun (National Taiwan U.): “New views on dark matter from modified gravity”

We discussed a scenario that the dark matter emerge from higher dimensional embedding of the 4-dimensional spacetime, such that the dark matter density can be determined by the Hubble constant, local gravity and the visible matter content. Our approach may give a new viewpoint for Verlinde’s emergent gravity from higher dimensions. We also comment on the some phenomenological implications of this type of models, including gravitational wave solutions and MOND limit.

Yasuhiro Yamamoto (Yonsei U.): “Protophobic Light Vector Boson as a Mediator to the Dark Sector”

The observation of a protophobic 16.7 MeV vector boson has been reported by a ^8Be nuclear transition experiment. Such a new particle could mediate between the Standard Model and a dark sector, which includes the dark matter. In this paper, we show some simple models of the dark matter which satisfy the thermal relic abundance under the current experimental bounds from the direct and the indirect detections. In a model, it is found that an appropriate self-scattering cross section to solve the small scale structure puzzles can be achieved.

Seodong Shin (Yonsei U.): “Non-minimal dark matter search in dark matter colliders”

I will discuss the relativistic collisions of dark matter in non-minimal dark sector with the targets in current and future neutrino detectors such as Super/Hyper Kamiokande and DUNE,

which induces cascade signals in a scenario like inelastic boosted dark matter.

Soo Min Choi (Chung-Ang U): “SIMP dark matter and its cosmic abundances”

Thermal production of light dark matter with sub-GeV scale mass can be attributed to $3 \rightarrow 2$ self-annihilation processes. We consider the thermal average for annihilation cross sections of dark matter at $3 \rightarrow 2$ and general higher-order interactions. A correct thermal average for initial dark matter particles is important, in particular, for annihilation cross sections with overall velocity dependence and/or resonance poles. We apply our general results to benchmark models for SIMP dark matter and discuss the effects of the resonance pole in determining the relic density.

Yoo-Jin Kang (Chung-Ang U): “Forbidden Channels and SIMP Dark Matter”

We consider a thermal production of self-interacting dark matter in models with gauged Z_3 symmetry. In particular, the 2-to-2 forbidden channels in the dark sector assist producing a SIMP dark matter from thermal freeze-out and extend the parameter space for a correct relic density. We show that dark photon and/or dark Higgs should be relatively light for unitarity and for forbidden channels to work. We identify the constraints on the parameter space of dark matter self-interaction and mass in the case that forbidden channels are important in determining the relic density.

5 July, Wednesday

Plenary Presentations

Bum-Hoon Lee (Sogang U.): “Higher Curvature Gravity”

We consider the properties of the gravity theories with higher curvature term, especially the Gauss-Bonnet term. The black holes carry the scalar charge, which is determined by the mass. There also exists the minimum mass for the existence of the black hole. We also study the cosmological implication by studying the role of the Gauss-Bonnet term during the inflation.

Jun'ichi Yokoyama (U. Tokyo): “Creation of the inflationary universe from a black hole?”

First I revisit the derivation of the Hawking-Moss transition rate between two de Sitter spacetimes. Using the static coordinates I show that the Euclidean action is entirely determined by the contribution of de Sitter entropy. I then discuss creation of a new inflationary universe from an evaporating black hole which produces high energy radiation around it due to the Hawking radiation. A thin wall bubble created around a black hole may tunnel to produce another universe.

Il Hung Park (Sungkyunkwan U.): “Status and Perspectives in GRB observations”

We present the status of and a few selected topics of GRB observations in space and ground are presented. The important issues for future observations will be discussed as well.

Kei-ichi Maeda (Waseda U.): “Inflation and Disformal Transformation”

The accelerating expansion of the Universe is a big mystery in modern cosmology. To solve it, modified gravity theories have been proposed. In this talk, we show that a disformal transformation is useful to analyze such complicated models, especially a slow-roll inflationary scenario. We present some examples, i.e., three Higgs inflationary models (the original Higgs inflation, the new Higgs inflation and the hybrid Higgs inflation).

Jorge Armando Rueda (ICRANet): “On the rate and on the gravitational wave emission of short and long GRBs”

GRBs, traditionally classified as "long" and "short", have been often assumed, till recently, to originate from a single black hole (BH) with an ultrarelativistic jetted emission. There is evidence that both long and short bursts have as progenitors merging and/or accreting binaries, each composed by a different combination of carbon-oxygen cores (CO core), neutron stars (NSs), BHs and white dwarfs (WDs). Consequently, the traditional long bursts have been sub-classified as (I) X-ray flashes (XRFs), (II) binary-driven hypernovae (BdHNe), and (III) BH-supernovae (BH-SNe). They are framed within the induced gravitational collapse (IGC) paradigm which envisages as progenitor a tight binary composed of a CO core and a NS or BH companion. The SN explosion of the CO core, originating a new NS (ν NS), triggers a hypercritical accretion process onto the companion NS or BH. If the accretion is not sufficient for the NS to reach its critical mass, an XRF occurs, leading to a ν NS-NS system. Instead, when the BH is already present or formed by the hypercritical accretion, a BdHN occurs, leading to a ν NS-BH system. Similarly, the traditional short bursts, originating in NS-NS mergers, are sub-classified as (IV) short gamma-ray flashes (S-GRFs) and (V) short GRBs (S-GRBs), respectively when the merging process does not lead or leads to BH formation. Two additional families are (VI) ultra-short GRBs (U-GRBs) and (VII) gamma-ray flashes (GRFs), respectively formed in ν NS-BH and NS-WD mergers. We use the estimated occurrence rate of the above sub-classes to assess the gravitational wave emission in the merging process and its detectability by Advanced LIGO, Advanced Virgo, eLISA, and resonant bars.

6 July, Thursday

Plenary Presentations

Yaakov (Yasha) Neiman (Perimeter Institute): “Towards a working model of causal-patch physics in dS/CFT”

Quantum gravity with de Sitter (dS) asymptotics is a major open question, both conceptually and technically. One possible avenue is to adapt the holographic framework of AdS/CFT to

the de Sitter setup. Working models of dS/CFT are hard to come by, but one such model has been found in 4 dimensions - a duality between higher-spin gravity in the bulk and a free vector model on the boundary. I will describe my attempts, within this model, to bridge the gap between the CFT at future de Sitter infinity and physics in the causal patch of a bulk observer. In the process, I will present some new results on the relationship between holography and twistor theory.

Rong-Gen Cai (Chinese Academy of Science): “Standard sirens and dark sector with Gaussian process”

Gravitational wave from a binary system is a standard siren to probe cosmological evolution history. In this talk, I will first show how to the reconstruction of dark matter and dark energy by using the SIna union 2.1 data, as an application of the Gaussian process. Then I will apply the method to reconstruct the interaction between dark matter and dark energy from mock data from Lisa and to show the constraint ability on the cosmological parameters with the mock data from Einstein Telescope.

Daniel Grumiller (Vienna U. of Technology): “Soft Heisenberg Hair”

Soft hair"" refers to zero energy excitations in the near horizon region of black holes or cosmologies, advocated by Hawking, Perry and Strominger. I review recent results on soft hair in 3 spacetime dimensions. The near horizon symmetry algebra is surprisingly simple, namely infinite copies of the Heisenberg algebra. The results are fairly universal and allow a semi-classical construction of microstates for BTZ black holes, whose degeneracy correctly accounts for their Bekenstein-Hawking entropy.

Jeong-Hyuck Park (Sogang U.): “Stringy Gravity & solution to dark matter problem”

Recent development in string theory has led to the extension of General Relativity, i.e. Stringy Gravity. It postulates the entire closed string massless sector to be geometric and thus gravitational. I will first introduce the mathematical foundation and then discuss a solution to dark matter/energy problems. In terms of $R/(MG)$, i.e. the dimensionless radial variable normalized by mass, Stringy Gravity agrees with General Relativity near infinity, but modifies it at short distance. At far short distance, gravitational force can be even repulsive. These may solve the dark matter and energy problems, as they essentially arise from small $R/(MG)$ observations: far distance divided by much heavier mass.

Chiang-Mei Chen (Nat'l Central U.): “Pair Production of Scalar Dyons in Kerr-Newman Black Holes”

We study the spontaneous pair production of scalar dyons in the near extremal dyonic Kerr-Newman (KN) black hole, which contains a warped AdS_3 structure in the near horizon region. The leading term contribution of the pair production rate and the absorption cross section ratio are also calculated using the Hamilton-Jacobi approach and the thermal

interpretation is given. In addition, the holographic dual conformal field theories (CFTs) descriptions of the pair production rate and absorption cross section ratios are analyzed both in the $\mathcal{J}\mathcal{S}$ -, $\mathcal{Q}\mathcal{S}$ - and $\mathcal{P}\mathcal{S}$ -pictures respectively based on the threefold dyonic KN/CFTs dualities.

P3: Astrophysics - Relativistic astrophysics, Observation, Cosmic rays, GRB, etc.

Anna Pollmann (Invited, U. Wuppertal): “Searches for magnetic monopoles with IceCube”

Particles that carry a single magnetic charge are proposed by various theories which go beyond the Standard Model of particle physics. The expected mass of the magnetic monopoles varies depending on the theory describing its origin, but generally the monopole mass exceeds those possible by direct creation in accelerators by far. In large scale magnetic fields, magnetic monopoles can gain kinetic energy up to relativistic velocities. IceCube is a high energy neutrino detector using the clear ice close to the South Pole as the detection medium. Relativistic magnetic monopoles induce Cherenkov or luminescence light production while passing through the ice. Depending on the monopole kinetic energy, light can also be induced by secondary particles which result from ionization or the proposed catalysis of nucleon decay by magnetic monopoles. A review of possible detection methods and the limits for the monopole flux over a broad parameter range are described for the IceCube Neutrino Observatory, the most sensitive detector available for magnetic monopole searches.

Insik Hahn (Ewha Womans U.): “Nuclear astrophysics experiments related to the rp-process using rare isotope beams”

Nuclear astrophysics experiments using radio isotope beams have been very successful to understand some of the important reactions related to explosive hydrogen burning process. Some reactions such as $^{14}\text{O}(\text{a,p})^{17}\text{F}$, $^{15}\text{O}(\text{a,g})^{19}\text{Ne}$, $^{18}\text{F}(\text{p,a})^{15}\text{O}$ are important for studying the breakout mechanism from the HCNO cycle to the rp process. The above reactions were investigated using radioactive ion beams at the Center for Nuclear Study in RIKEN. We plan to study the structures of neutron-deficient ^{66}Se and ^{56}Zn relevant to the rp-process at RIKEN. Korea will build the radioactive ion beam accelerator facility called RAON. This new facility is expected to carry out nuclear astrophysics experiments for understanding explosive nuclear synthesis in stellar sites such as X-ray bursts and novae as well as the origin of proton-rich elements in the rp-process. Current activities and prospects of nuclear astrophysics in Korea will be discussed.

Myung-Ki Cheoun (Invited, Soongsil U.): “Modified Gravity in Nuclear Astrophysics and Big Bang Nucleosynthesis”

We discuss roles of gravitation in the compact cosmological objects like neutron star because equations of state turn out to be so sensitive on the gravity and the modified gravity. In this

talk, we also make a brief summary about the equations of state which is now widely and intensively discussed in the nuclear astrophysics. Finally, the Big-Bang nucleosynthesis will be shown to be a useful test of the gravitation as well as the new physics beyond the standard model.

Chang-Hwan Lee (Pusan Nat'l U.): “Strangeness in Neutron Star Cooling”

In this talk, I will review our recent work on the thermal evolution of neutron stars in the presence of hyperons or kaons in the core. Our results indicate that the nucleon and hyperon direct Urca processes play crucial roles for macroscopic cooling behavior of neutron stars. There are possibilities that the neutron star equation of states with hyperons and kaons are consistent with both mass and temperature observations. However, requirement of the fine-tuning of the parameters to explain the observations is still an open problem.

Hyun Kyu Lee (Hanyang U.): “Hadronic matter with emergent symmetries at high density”

The neutron stars with high core density have been considered among the most relevant objects for the formation of GRB centers and gravitational radiations. It is expected that the detection of GRBs and gravitational radiations provide us the opportunity of constraining the EoS of extreme high dense hadronic matter at the core of neutron stars. The possibility of emergent scale symmetry along with local flavor symmetry will be discussed in relation to EoS with GRB and gravitational wave detections.

Hongjun An (*Invited*, Chungbuk Nat'l U.): “Studying intrabinary shock emission in pulsar binaries”

We present our studies of intrabinary emission of the gamma-ray binary 1FGL J1018.6-5856. We measure the light curve and phase-resolved spectra, and model them using an intrabinary shock emission model. The model assumes a slow and a fast population of particles accelerated in the shock, and computes the high-energy emission spectra produced by synchrotron and self-Compton processes of the high-energy particles in the shock. Fitting the data with the model allows us to constrain the binary geometry, most importantly the inclination angle. This model can be used for other pulsar binaries and help to determine the inclination angle of the binary hence the mass of the neutron star.

Dong-Hoon Kim (Seoul Nat'l U.): “Pulsar radiation with general relativistic effects”

We consider a magnetic dipole model of a pulsar and investigate general relativistic effects on electromagnetic radiation from the pulsar. The general relativistic modifications should be found applicable to many well-known issues in pulsar astronomy. Among other things, the modifications of Goldreich-Julian model and subpulse drift would be challenging issues of significant interest. The electromagnetic fields in the pulsar magnetosphere are computed by solving Maxwell's equations defined in the strongly curved spacetime around the pulsar, hence containing the properties of the strong gravitational effect. In combination with this

effect, the effects from rotation and obliqueness of the pulsar are investigated so that we work out general-relativistic extensions of Goldreich-Julian model and subpulse drift.

Alexander Yushchenko (Sejong University): “Velocity distribution in the clusters of galaxies”

Using SLOAN survey we analyzed the distribution of galaxy redshift in five hundred clusters of galaxies. The mean profiles were constructed for different redshift intervals. It was found that rich clusters have members with discordant redshifts. The possible interpretations are discussed.

Hisaaki Shinkai (Osaka Inst. Tech.): “Nonlinear dynamics in Gauss-Bonnet gravity”

We numerically investigated how the dynamics depends on the dimensionality and how the higher-order curvature terms affect to singularity formation in two models: (i) perturbed wormhole in spherically symmetric space-time, and (ii) colliding scalar pulses in planar space-time. Our numerical code uses dual-null formulation, and we compare the dynamics in 5, 6 and 7-dimensional General Relativity and Gauss-Bonnet (GB) gravity. Both results suggest that GB correction works for avoiding singularity formation in their dynamics. We also found that the existence of the trapped surface in GB gravity does not directly indicates formation of a black hole.

Andreas Krut (ICRANet): “Dark matter and galactic structures”

A self-gravitating system composed of massive fermions in spherical symmetry is considered. We solve the Einstein equation for a thermal and semi-degenerate fermionic gas considered as a perfect fluid in hydrostatic equilibrium. No additional interaction is assumed for the fermions besides their fulfilling of quantum statistics and the relativistic gravitational equation. Within this more general approach a new family of density profiles arises which explains DM halo constraints of the Galaxy and provides at the same time an alternative to the central black hole scenario. Further, we show predictions of that model for galactic structures from dwarf spheroidals to big ellipticals in agreement with observations.

P6: Gravity in String Theory

Jae-Hyuk Oh (Hanyang U.): “Phase transition in anisotropic holographic superfluids with arbitrary z and α ”

Einstein-dilaton- $U(2)$ gauge field theory is considered in a spacetime characterised by α and z , which are the hyperscaling violation factor and the dynamical critical exponent respectively. We obtain the critical values of chemical potential μ_c that is defined on its boundary dual fluid and derives phase transition from spatially isotropic to anisotropic phase for the various values of the α and z . To do so, we first apply Sturm-Liouville theory and estimate the upper

bounds of the critical values of the chemical potential. We also employ a numerical method in the ranges of $1 \leq z \leq 4$ and $0 \leq \alpha \leq 4$ to check if the Sturm-Liouville method correctly estimates the critical values of the chemical potential. It turns out that the two methods are agreed within 10 percent error ranges. Finally, we compute free energy density of the dual fluid by using its gravity dual and check if the system shows phase transition at the critical values of the chemical potential μ_c for the given parameter region of α and z . Interestingly, it is observed that the anisotropic phase is more favoured than the isotropic phase for small values of z and α . However, for large values of z and α , the anisotropic phase is not favoured.

Run-Qiu Yang (KIAS): “Strong energy condition and complexity growth bound in holography”

In this talk, I will discuss a result about strong energy condition and action growth bound in holographic complexity. I will prove that if eternal neutral black holes satisfy some general conditions and matter fields only appear in the outside of the Killing horizon, the strong energy condition is a sufficient condition to insure that the vacuum Schwarzschild black hole has the fastest action growth of the same total energy. This result is consistent with the bound of computational complexity growth rate and gives a strong evidence for the holographic complexity-action conjecture.

Yun-Long Zhang (APCTP): “Bell inequality from holographic gravity”

We show that the manifestation of quantum entanglement in Bell inequality can be reproduced from the gravitational theory in the bulk, and the CHSH formula of Bell inequality can be related with the holographic Schwinger-Keldysh correlator from AdS gravity.

Sunyoung Shin (CQUeST): “Walls of massive Kähler sigma models on $SO(2N)/U(N)$ in three dimensions”

We construct walls of massive Kähler sigma models on $SO(2N)/U(N)$ in three dimensions by using moduli matrices. We discuss the operators generating walls and the root vectors.

Chanju Kim (Ewha Womans U.): “Holographic micro state deformations of BTZ black holes”

We find general deformations of BTZ spacetime and identify the corresponding thermofield initial states of the dual CFT. We deform the geometry by introducing bulk fields dual to primary operators and find the back-reacted gravity solutions to the quadratic order of the deformation parameter.

O-Kab Kwon (Sungkyunkwan U.): “Exact holography of massive M2-brane theories and entanglement entropy”

We obtain an exact holographic relation for the vacuum expectation values of the chiral primary operator with conformal dimension 1 in the large N limit in mass-deformed ABJM theory. Our results involve infinite number of exact dual relations for all possible supersymmetric Higgs vacua and so provide a nontrivial test of gauge/gravity duality away from the conformal fixed point in the large N limit. Using the Ryu-Takayanagi conjecture to obtain the entanglement entropy in gravity side, we calculate the holographic entanglement entropy (HEE) in the reduced 4-dimensional gravity theory. We also obtain constraints for the HEE, which is the counterpart of the perturbed Einstein equations.

Kyung Kiu Kim (Sejong U.): “Thermodynamic volume in AdS/CFT”

The cosmological constant in AdS space can be interpreted as a pressure of the bulk. If the variation of the cosmological constant is allowed, the pressure has a dual thermodynamic volume. We study on the physical meaning of the variation and related quantities through the standard AdS/CFT dictionary.

Taejin Lee (Kangwon Nat'l U.): “Gravitational Scattering Amplitudes and Closed String Field Theory in the Proper-Time Gauge”

We construct a closed string field theory in the proper-time gauge which is the closed analog of the deformed cubic open string field theory and define the general closed string scattering amplitudes. Taking the zero-slope limit, we explicitly evaluate the three-graviton scattering amplitudes and the four-graviton scattering amplitudes. We discuss in the framework of the closed string field theory, the Kawai-Lewellen-Tye (KLT) relations, which relate the tree level closed string scattering amplitudes to those of open string.

Hongsu Kim (KASI): “3rd Quantization of Taub Universe”

In the present work, we address the issue of Quantum Field Theory of Taub Cosmology. To be more concrete, we describe this issue in more detail one at a time: “Taub Cosmology model [A.H. Taub, Am. Math. 53,472 (1951)] can be thought of as a special limit of the Bianchi-type IX (Mixmaster) cosmology. Namely, it is a homogeneous but anisotropic cosmology model. Next, in a physical system consisting of matter and gravity(spacetime), we 1st[quantum mechanics] and 2nd[quantum field theory] quantize the matter fields to begin with. Then we turn to gravity and 1st[universe wave function as a solution to the Wheeler-DeWitt eq.] and 2nd[promote the universe wave function to a field operator a. la. Hosoya-Morikawa] quantize the spacetime. Now the name, “3rd quantization” manifests itself as the gravity is 2nd quantized only after the matter in it gets 2nd quantized beforehand!, Lastly, in order to work it out, the Bogoliubov transformation comes into play...

That is, the choice of mode functions to span the universe field operator is NOT unique as each set of mode functions is separately complete, orthonormal (in the Hilbert space). This is because the physical state of the system (subject to the mode expansions) keeps changing during its (time) evolution. As a result, the Bogoliubov transformations come into play and

result in non-trivial Mode (or, frequency) mixing that, in turn, leads to the notion of vacuum and creation, annihilation of universe(quantum) in its Hilbert space...

To summarize, even the universe itself can be treated as quantum that undergo "birth and destroy".

Hongsu Kim (KASI): "Callan-Rubakov Effect could answer the baryon asymmetry puzzle"

Back in 1982, Callan and Rubakov, independently, pointed out that the 't'Hooft-Polyakov magnetic monopole", a topological soliton solution in Yang-Mills-Higgs theory with SSB in WGS standard model for the electroweak interaction could "catalyze" the proton decay. This is obviously an academic speculation which has NOT been motivated by any precision observational evidence at the time as the proton is known to be definitely stable & secure with its lifetime being as long as the age of the universe itself! As such, we find, after 30 years, that this effect is not just a purely academic speculation, but also a severely wrong-motivated set-up, as now we know the matter-antimatter(or baryon) asymmetry in our present universe... That is, in the present universe, we have severe matter-antimatter(or baryon) asymmetry in which, the number of proton is overwhelmingly greater than that of antiproton... This reality teaches us the lesson that after all, it is "anti proton" rather than proton that should(spontaneously) decay and disappear! To summarize, the age-old Callan-Rubakov Effect has to be modified to its opposite objective; "monopole-catalyzed antiproton decay"!

In the present work, therefore, we briefly revisit and review the original version of the Callan-Rubakov effect and discuss how it should be modified and reorganized for our new perspective and new objective: "monopole-catalyzed antiproton decay"

7 July, Friday

Plenary Presentations

Jong-Ping Hsu (UMass): "Experiments on the CMB Spectrum and Their Implications for the Missing Half of the Universe"

Based on the concept of Lorentz-Poincaré invariance and its limiting continuation, we propose an alternative formulation of the generalized Planck distribution that leads to a new physical interpretation of the observed anisotropy of the Cosmic Microwave Background (CMB). We also discuss how data from satellite experiments might be used to search and discover the missing half of the universe, i.e., an extremely distant 'antimatter-blackbody,' through accurate measurements of the CMB spectra towards and away from the constellation Leo.

Dieter Rudolf Brill (U. Maryland): "The revival of General Relativity at Princeton."

After General Relativity was established in essentially its present form in 1915 it was celebrated as a great success of mathematical physics. But the initial hopes for this theory as a basis for all of physics began to fade in the next several decades, as General Relativity was relegated to the margins of theoretical physics. Its fate began to rise in the 1950's in a revival of interest and research that over time made gravitational physics one of the hottest research

topics it is today. One center of this renaissance was Princeton, where two relative newcomers explored new and different approaches to gravitational physics. Robert Dicke showed that gravity is not as inaccessible to experiment as was thought, and John Wheeler propelled it into the mainstream by proposing highly original and imaginative consequences of Einstein's theory. We will concentrate on these ideas that, in his characteristically intriguing style, Wheeler called "Daring Conservatism" -- a term well known to his associates, but one he never mentioned in print. With the aid of unpublished manuscripts and notes we will explore Daring Conservatism's origin and motivation, its successes and failures, and the legacy it left behind. In passing we will encounter a small footnote to the geon problem.

Yong-Seon Song (KASI): "Cosmological Implications of RSD"

The mapping of dark matter clustering from real space to redshift space introduces the anisotropic property to the measured density power spectrum in redshift space, known as the redshift space distortion effect. The mapping formula is intrinsically non-linear, which is complicated by the higher order polynomials due to indefinite cross correlations between the density and velocity fields, and the Finger-of-God effect due to the randomness of the peculiar velocity field. Whilst the full higher order polynomials remain unknown, the other systematics can be controlled consistently within the same order truncation in the expansion of the mapping formula, as shown in this paper. The systematic due to the unknown non-linear density and velocity fields is removed by separately measuring all terms in the expansion directly using simulations. The uncertainty caused by the velocity randomness is controlled by splitting the FoG term into two pieces, 1) the "one-point" FoG term being independent of the separation vector between two different points, and 2) the "correlated" FoG term appearing as an indefinite polynomials which is expanded in the same order as all other perturbative polynomials. Using 100 realizations of simulations, we find that the Gaussian FoG function with only one scale-independent free parameter works quite well, and that our new mapping formulation accurately reproduces the observed 2-dimensional density power spectrum in redshift space at the smallest scales by far, up to $k \sim 0.2 \text{ h Mpc}^{-1}$, considering the resolution of future experiments.

Eunil Won (Korea U.): "Status of the GroundBIRD experiment"

The GroundBIRD experiment, a ground-based telescope for the detection of the B-mode of the CMB polarization down to the tensor to scalar ratio of 0.01 is under construction at KEK in Japan. The observation site is Tenerife Island in Spain and the telescope is planned to be moved to the site in early 2018. We discuss present construction details and prospects for the future observation.

Marco Muccino (ICRANet) "What can we learn from gamma-ray bursts?"

Gamma-ray bursts (GRBs) are powerful transient sources spanning a wide range in their energy release, duration and redshift distributions. These properties makes GRBs perfect candidates for studying their rates and the possible progenitor systems.

On behalf of a large collaboration, I review the major results obtained in the past two years: 1) the classification of GRBs into seven different sub-classes, each one characterized by distinct set of observational features, different astrophysical systems as progenitors and occurrence rates; 2) the assessment of the gravitational wave emission for some of the above sub-classes and its detectability by Advanced LIGO, Advanced Virgo, eLISA, and resonant bars.

P7: Cosmology – Cosmology, CMB, Perturbations, Structure formation, Quantum effect, etc.

Seokcheon Lee (Gyeongsang Nat'l U.): “Conformal equality”

It is well known that cosmological observables (like Primordial curvature perturbation and Hubble parameters) are frame independent (under conformal transformation) at early Universe. However, late time cosmological observables are frame dependent and issues for physical frame are open. We discuss these issues both in classical level and in quantum one.

Dong-han Yeom (Nat'l Taiwan U.): “Hartle-Hawking wave function and large-scale power suppression of CMB”

In this talk, I will first describe the Hartle-Hawking wave function in the Euclidean path integral approach. After we introduce perturbations to the background instanton solution, following the formalism developed by Halliwell-Hawking and Laflamme, one can obtain the scale-invariant power spectrum for small-scales. We further emphasize that the Hartle-Hawking wave function can explain the large-scale power suppression by choosing suitable potential parameters, where this will be a possible window to confirm or falsify models of quantum cosmology. Finally, we further comment on possible variations of background solutions, e.g., Euclidean wormholes, which can result in distinct signatures to the power spectrum.

Mu-In Park (Sogang U.): “On Gauge Invariant Cosmological Perturbations in UV-modified Horava Gravity”

We revisit gauge invariant cosmological perturbations in UV-modified, $z = 3$ Horava gravity with one scalar matter field, which has been proposed as a renormalizable gravity theory without the ghost problem in four dimensions.

Tae Hoon Lee (Invited, Soongsil U.): “Quintessence in low-energy effective theory”

Considering a theory of scalar-tensor gravity with non-renormalizable couplings of heavy fields, we derive the low-energy effective theory action in the universe of temperature much lower than the heavy field mass. An effective potential of the scalar field is induced through the heavy field interactions in the late-time universe and we find a de Sitter cosmological solution with the potential of the scalar field. We also investigate stability properties of the solution.

Ki-Young Choi (Chonnam Nat'l U.): “Lower-Bound on the reheating temperature with dark matter”

We suggest new lower-bound on the reheating temperature from the cosmological evolution of the dark matter.

Kyungjin Ahn (Chosun U.): “Small-scale structure formation under the large-scale density and CDM-baryon drift velocity environment

The cosmological structure formation, if in the mildly nonlinear regime, cannot be well estimated by the linear approximation. Even in the regime that used to be believed to be linear, Tseliakhovich and Hirata have shown that small-scale structure formation can be affected by the large-scale, CDM-baryon drift velocity environment and thus the linear approximation is invalid. We show that an even stronger effect comes from the large-scale density environment (ApJ 830:68). Therefore, how small-scale structure evolves is determined by the competition between the density environment and the CDM-baryon drift-velocity environment. In terms of the nonlinear objects, minihalos whose mass is about 10^8 solar mass or below, are the ones that are strongly affected. This may also affect the formation of more massive halos that are usually used for galaxy surveys through suppressed merger, so cosmology from galaxy surveys may have to be examined more carefully. We also present BCCOMICS, a cosmological initial condition generator for numerical simulations, which includes this effect and thus surpasses the accuracy of the linear Boltzmann solver such as CAMB.

Sungwook E Hong (KASI): “Small-scale Features of Thermal Inflation: CMB Distortion and Substructure Abundance”

Thermal inflation is an additional inflationary mechanism before the big bang nucleosynthesis, which solves the moduli problem and naturally provides a plausible dark matter candidate. Thermal inflation leaves a slight enhancement followed by huge suppression of a factor of ~ 50 in the curvature and matter power spectrum, which can be expressed in terms of a single characteristic scale $k_{\rm b}$. Here we describe the observability of the small-scale features of thermal inflation from various observations, such as CMB distortion, satellite galaxy abundance in the Milky-Way-sized galaxies, and 21-cm power spectrum before the epoch of reionization.

Maurice H van Putten (Invited, Sejong U.): “Fast evolution of the deceleration parameter in surveys of $H(z)$ ”

Redshift evolution $Q(z)=dq/dz$ of the deceleration parameter $q(z)$ is shown to satisfy $Q(z) \gtrsim 2.8$ in recent heterogeneous data on $H(z)$ over $0 < z < 2$. This observation rules out $Q(z) \lesssim 1$ in Λ CDM at a level of confidence of 4.36σ .

Muhammad Sharif (U. Punjab): “Stability Analysis of Bulk Viscous Cosmology”

This paper explores the non-equilibrium behavior of thermodynamics at the apparent horizon of isotropic and homogeneous universe model in $f(G,T)$ gravity (G and T represent the Gauss-Bonnet invariant and trace of the energy-momentum tensor, respectively). We construct the corresponding field equations and analyze the first as well as generalized second law of thermodynamics in this scenario. It is found that an auxiliary term corresponding to entropy production appears due to the non-equilibrium picture of thermodynamics in first law. The universal condition for the validity of generalized second law of thermodynamics is also obtained. Finally, we check the validity of generalized second law of thermodynamics for the reconstructed $f(G,T)$ models (de Sitter and power-law solutions). We conclude that this law holds for suitable choices of free parameters.

P8: Black Holes – Black holes, Wormholes, etc

Masakatsu Kenmoku (Nara Sci. Academy): “Superradiant Phenomena for Spinor Fields in Rotating Black Hole Geometry”

We derive the results (i) non-existence of zero modes and (ii) the completeness relation for spinor fields in rotating black hole geometry. From these results, we show the superradiant phenomena for spinor fields should be type 2: positive momentum on the horizon ($p_H > 0$) and negative frequency at infinity ($\omega < 0$).

Khalid Saifullah (Quaid-i-Azam U.): “Thermodynamics of rotating non-Kerr black holes”

Some rotating black holes, other than the famous Kerr solution, have attracted a lot of attention in the literature. In this talk the thermodynamical properties of some of these non-Kerr black holes are discussed. First slow rotation and then full rotation has been studied. The relationship between the Hawking temperature and the radius of the black holes is investigated and their physical interpretations discussed. This analysis gives rise to some interesting features of these objects.

Bogeun Gwak (Invited, Sejong U.): “Upper Limit of Radiation from Coalescence of Rotating Hayward Black Holes”

We have studied the spin interaction and the gravitational radiation thermally allowed in a head-on collision of two rotating Hayward black holes. The Hayward black hole is a regular black hole in the modified Einstein equation. The potential of the spin interaction can be analytically obtained. For the collision of massive black holes, the gravitational radiation is numerically obtained as the upper bound using the laws of thermodynamics. The effect of the Hayward black hole tends to increase the radiation energy, but we can limit the effect by comparing it with the gravitational waves.

Sung-Won Kim (Ewha Womans U.): “Wormhole cosmological model”

As the McVittie derived the black hole solution in a cosmological model, we derive the

cosmological model with a wormhole at the origin of the "cosmical" coordinate system by solving the Einstein's equation with proper matter distribution. We also find the apparent cosmological horizon from the redefined metric and derive the Hawking temperature by using the conventional methods.

Jin Young Kim (Kunsan Nat'l U.): "Wormholes in Einstein-Born-Infeld Gravity"

We study a new approach for the wormhole construction in Einstein-Born-Infeld theory with a cosmological constant, which does not require exotic matters in the Einstein equation. We study the relation of the newly introduced conditions with the usual continuity for the energy-momentum tensor and the gravitational Bianchi identity. We find that there is no violation of energy conditions for the Born-Infeld fields contrary to the usual approaches. The exoticity of energy-momentum tensor is not essential for sustaining the wormholes.

Kimitake Hayasaki (Invited, Chungbuk Nat'l U.): "Detection of gravitational wave emission by supermassive black hole binaries through tidal disruption flare"

Galaxy mergers produce binaries of supermassive black holes, which emit gravitational waves prior to their coalescence. We perform the hydrodynamic simulations to study the tidal disruption of stars by such a binary in the final centuries of its life. We find that the gas stream of the stellar debris moves chaotically in the binary potential and forms accretion disks around both black holes. The accretion light curve is modulated over the binary orbital period owing to relativistic beaming. This periodic signal allows to detect the decay of the binary orbit due to gravitational wave emission by observing two tidal disruption events that are separated by more than a decade.

Medeu Abishev (Al Farabi Kazakh Nat'l U.): "Dilatonic dyon black hole solutions in the model with two Abelian gauge fields"

Dilatonic black hole dyon solutions in the gravitational 4d model with a scalar field, two 2-forms, two dilatonic coupling constants $\lambda_i \neq 0$, $i = 1, 2$, obeying $\lambda_1 \neq -\lambda_2$ and sign parameter $\varepsilon = \pm 1$ for scalar field kinetic term are considered. Here $\varepsilon = -1$ corresponds to ghost scalar field. These solutions are defined up to solutions of two master equations for two moduli functions, when $\lambda_{2i} \neq 1/2$ for $\varepsilon = -1$. Some physical parameters of the solutions: gravitational mass, scalar charge, Hawking temperature, black hole area entropy and parametrized post-Newtonian (PPN) parameters β and γ are obtained. PPN parameters do not depend on couplings λ_i and ε . A set of bounds on gravitational mass and scalar charge are found by using a certain conjecture on parameters of solutions, when $1 + 2\lambda_{2i}\varepsilon > 0$, $i = 1, 2$. The composite dyon solution with $\lambda_1 = \lambda_2$ was considered in ref. [1]. References [1] M.E. Abishev, K.A. Boshkayev, V.D. Dzhusushaliev and V.D. Ivashchuk, Dilatonic dyon black hole solutions, Class. Quantum Grav. 32, No. 16, 165010 (2015).

Seung Hun Oh (Konkuk U.) “Poisson algebra of gauge-invariant quasilocal angular momentum and its asymptotic limit”

In this talk, we will discuss the previously proposed quasilocal angular momentum of gravitational field in the absence of isometries in detail, and find the condition in which it is gauge-invariant. The gauge-invariant angular momentum has the following attractive properties; (i) it follows from one of the Einstein's constraint equations, (ii) it satisfies the Poisson algebra $\{L(\xi), L(\eta)\}_{\text{P.B.}} = L([\xi, \eta]_{\text{L}})$, up to a constant normalizing factor, (iii) its Poisson algebra reduces to the standard $SO(3)$ algebra of angular momentum at null infinity, and (iv) it reproduces the standard value for Kerr spacetime at null infinity. It will be argued that our angular momentum is a quasilocal and canonical generalization of A. Rizzi's geometric definition.

Deniz Olgu Devecioglu (Sogang U.): “Lifshitz black holes in Einstein-Yang-Mills theory”

We find that the four-dimensional cosmological Einstein-Yang-Mills theory with $SU(2)$ gauge group admits Lifshitz spacetime as a base solution for the dynamical exponent $z > 1$. Motivated by this, we next demonstrate numerically that the field equations admit black hole solutions which behave regularly on the horizon and at spatial infinity for different horizon topologies. The solutions depend on one parameter, the strength of the gauge field at the horizon, which is fine-tuned to capture the Lifshitz asymptotics at infinity. We also discuss the behavior of solutions and the change in Hawking temperature for black holes that are large or small with respect to the length scale L , which is itself fixed by the value of the cosmological constant.

Lunchakorn Tannukij (Hanyang U.): “Black holes in dRGT Massive Gravity”

Massive gravity is a gravity theory in which the gravitational force is described through a concept of having massive graviton as a force carrier. One of the successful massive gravity theory is known as the dRGT massive gravity in which mass is given to the graviton in a special way so that there is no theoretical pathologies in the theory. By computing its solution, we can obviously see differences between massive gravity and general relativity in an astronomical aspect. In this talk, we present both a spherically symmetric solution and a cylindrically symmetric solution to the dRGT theory. Metric functions of those solutions appear to incorporate a characteristic which can be interpreted as an effective cosmological constant while they also contain a linear term which cannot be obtained from the general relativity. Moreover, some thermodynamical properties like temperatures and heat capacities of those solutions will be mentioned.

Awards for Best Student Presentations

*** Best student presentations:**

- **Daria Primorac** (ICRANet & Sapienza U. Roma) for “*Analysis of the GRB110731A within the fireshell model*”
- **Zhu Yi** (Huazhong U. Sci. Tech.) for “*Nonminimal coupling and inflationary attractors*”
- **Gihyuk Cho** (Seoul Nat’l U.) for “*Theory of Gravitational Radiation*”
- **Rahim Moradi** (Sapienza U. of Rome and ICRANet) for “*Charged Cosmological Black holes*”
- **Yongwan Gim** (Sogang U.) for “*On the thermodynamic origin of the initial radiation energy density in warm inflation*”

*** Selection committee:**

Gungwon Kang (KISTI, Chair), Gregory Vereshchagin (ICRANet), Hideki Maeda (Hokkai-Gakuen U.), Muhammad Sharif (U. of Punjab), Jae-Weon Lee (Jungwon U.) and Yungui Gong (Huazhong U. of Sci. Tech.)

The selection was truly based on the excellence of research work and presentation. Five presentations were selected out of 18 in total. A certificate and 100,000KRWs have been awarded to each student.

Conference Poster (Credit: IK15 Web <http://www.icranet.org/ik15>)

XIII International Conference on Gravitation, Astrophysics and Cosmology
15th Italian- Korean Symposium on Relativistic Astrophysics
A joint meeting

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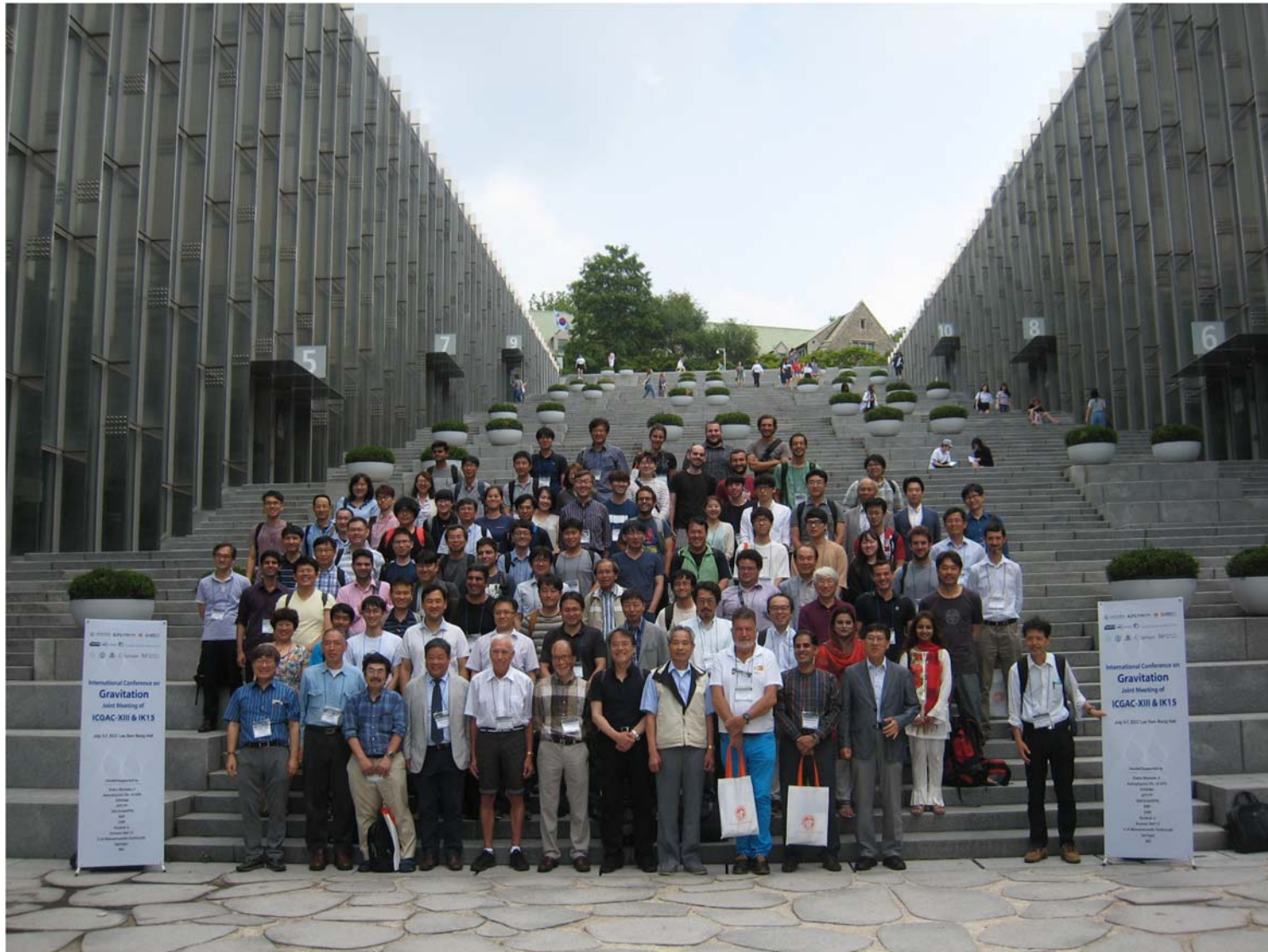
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Image: Cluster of stars 47 Tucanae over Ewha University Campus - Credit: ESO/M-R. ContVISTA Magellanic Cloud survey - Acknowledgment: Cambridge Astronomical Survey Unit

Group Picture



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