INDO-SOUTH AFRICA WORKSHOP ON ASTROPHYSICS

SEPTEMBER 29, 2023 – 9.30am -5.30pm

ABSTRACT BOOKLET

CENTRE FOR THEORETICAL PHYSICS + ICARD

JAMIA MILLIA ISLAMIA, NEW DELHI

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INDO-SOUTH AFRICA WORKSHOP ON ASTROPHYSICS
SEPTEMBER 29, 2023 – 9.30am -5.30pm

WORKSHOP - PROGRAM

09:30 AM - 10:15 AM: Registration + Inaugural

10:15 AM - 11:00 AM: Prof Sunil Maharaj, UKZN, RSA

10:00 AM - 11:15 AM: Tea

11:15 AM - 12:00 PM: Dr. Mayukh Raj Gangopadhyay, SGT University, Gurugram

12:00 PM - 12:40 PM: Dr. Dibya Chatterjee, Ashoka University, Sonipat

12:40 PM - 01:10 PM: Dr. Misba Afrin, CTP, JMI

01:10 PM - 2:00 PM: Lunch

02:00 PM - 02:30 PM: Prof Kesh Govender, UKZN, RSA

02:30 PM - 03:00 PM: Dr. Sayantan, SGT, Gurugram

03:00 PM - 03:30 PM: Dr. Jitendra Kumar, CTP, JMI

03:30 PM - 03:45 PM: Tea

03:45 PM - 04:05 PM: Dr. Yogesh, SGT University

04:05 PM - 04:25 PM: Dr. Vijay Singh, DU

04:25 PM - 04:45 PM: Dr. Byron Brassal, UKZN, RSA

04:45 PM - 05:05 PM: Dr. Dharam Veer, GLA Mathura

05:05 PM - 05:25 PM: Dr. Arun Kumar, CTP, JMI

1 NAME: **Sunil Maharaj**

University of KwaZulu-Natal

TITLE: Dimension and gravity

ABSTRACT: We consider the role of spacetime dimension and the connection to gravity. The effect on kinematical quantities, physical variables and the dynamics of the gravitational field are investigated. We consider general relativity and modified gravity theories. Some examples are analysed which highlight the role of dimension.

2 NAME: **Mayukh Raj Gangopadhyay**

CCSP, SGT University

TITLE: Gravitational Waves & Primordial Black Holes: Next Frontiers of 'Precision' Cosmology

ABSTRACT: In recent years the study of stochastic Gravitational Waves(GW) and Primordial Black Holes(PBHs has become a very active field of research in Cosmology. Mainly due to the advancement in the observational cosmology, lack of evidence of the particle dark matter, the mass of the Black Holes merger producing GW signals detected by LIGO and VIRGO collaboration, recent report by PTA consortium, ignited the urge to under stand the formation mechanism of GW and PBHs in the primordial Universe. In this talk, I will give an overview of formation of GWs and PBHs in the early Universe and the observational impact of such events.

3 NAME: **Dibya Chakraborty**

Ashoka University

TITLE: The Conspiracy of dS Space in String Theory (?)

ABSTRACT: In this talk, I will discuss various string-loop, warping, and curvature corrections, which are expected to appear in type IIB moduli stabilization scenarios. It has recently been a topic of active debate whether these corrections can be consistently as well as simultaneously ignored for concrete de Sitter constructions. We study this question in the presence of a new weakly-warped LVS de Sitter vacua, which represents a distinctive branch in the parameter space, featuring small conifold fluxes. We have found that the warping corrections are less problematic and few corrections help us to land in this regime of parameter space. I will end my talk with a detailed description of how to avoid these corrections, if at all possible, in order to not destroy the consistency of the weakly-warped LVS de Sitter solution.

4 NAME: **Misba Afrin**

Jamia Millia Islamia

TITLE: Astrophysical signatures of dark matter from black hole shadows

ABSTRACT: We consider Kerr black holes surrounded by perfect dark fluid matter (PFDM), namely the rotating PFDM BHs. We analyse the photon orbits around PFDM BHs and naked singularities (NSs) and emphasize the effect of PFDM on photon boomerangs. Unlike in the Kerr NSs, photon boomerangs can form around rotating PFDM NSs. We use the Event Horizon Telescope (EHT) results for M87* and Sgr A* to constrain the PFDM parameter, which thus hints at the possibility of obtaining astrophysical signatures of dark matter through black hole shadow observations.

6 NAME: **Dr. Sayantan Choudhury**

CCSP, SGT University, Gurugram, Delhi-NCR

TITLE: Quantum Field Theory Primer of PBH formation: An ultimate roadmap for Cosmology

ABSTRACT: We present a detailed exposition on the prospects of formation of Primordial Black Holes (PBHs) during Slow Roll (SR) to Ultra Slow Roll (USR) transitions in the framework of single-field inflation. We use effective field theory (EFT) approach in order to keep the analysis model-independent and applicable to both the canonical and non-canonical cases. We show in detail how renormalizing the power spectrum to one loop order in $P(X,\phi)$ theories severely limits the prospects for PBH formation in a single-field inflationary framework. We demonstrate that for the allowed range of effective sound speed, $1<c_s<1.17$, the consistency of one-loop corrected power spectrum leaves a small window for black hole masses, $M_{\rm PBH}\sim \mathcal{O}(10^2-10^3)$gm to have sufficient e-foldings, $\Delta {\cal N}_{\rm Total}\sim {\cal O}(54-59)$ for inflation. We confirm that adding a SR regime after USR before the end of inflation, does not significantly alter our conclusions. Our findings strictly rule out the possibility of generating large masses of PBHs from all possible models of single field inflation (canonical and non-canonical) and mature into a "no-go theorem" for the class of mentioned theories. In the end, we consider Galileon inflation in the Effective Field Theory (EFT) framework and examine the possibility for PBH formation during slow roll (SR) to ultra slow roll (USR) transitions. We show that loop corrections to the power spectrum for Galileon inflation, in this case, do not impose additional constraints on the masses of PBHs produced, which means that the imposed strong "no-go theorem" can be fully evaded in this context. We indicate that the remarkable non-renormalization property of Galileon due to generalized shift symmetry is responsible for protecting PBH formation from quantum loop corrections which give rise to Scalar Induced Gravity Waves (SIGW) consistent with recent NANOGrav 15 data and can also accommodate large negative non-Gaussinaity in the USR phase using which we address the PBH overproduction issue. Last but not the least we try to solve this PBH loop effects controversy with the help of Multiple Sharp Transition (MSTs) using which we generate SIGW which successfully explain the recent NANOGrav 15 data.

7 NAME: **Jitendra Kumar**

Centre for Theoretical Physics, Jamia Millia Islamia

TITLE: Strong gravitational lensing by regular black holes and no-horizon spacetimes

ABSTRACT: We compare and contrast gravitational lensing, in the strong field limit, by the photon sphere in spherically symmetric regular electrically charged (REC) black holes ($0 < b \leq bE$) and with those by corresponding REC no-horizon spacetimes ($b > bE$). Here, b is an additional parameter due to the charge and the value $b = bE \approx 0.226$ corresponds to an extremal black hole with degenerate horizons. Interestingly, the spacetime admits a photon sphere for $0 < b \leq bP \approx 0.247$ and an anti-photon sphere only for $bE < b \leq bP$. With no-horizon spacetime, images by lensing from the inside of the photon sphere ($u < ups$) can also appear. Interestingly, for the case of $u < ups$ the deflection angle αD increases with u. We analyse the lensing observables by modeling compact objects Sgr A*, M87*, NGC 4649, and NGC 1332 as black holes and no-horizon spacetimes. The angular position $\theta\infty$ and photon sphere radius xps decrease with increasing parameter b. Our findings suggest that the angular separations (s) and magnification (r) of relativistic images inside the photon sphere may be higher than those outside. Moreover, the time delay for Sgr A* and M87* can reach $\sim$ 8.8809 and $\sim$ 12701.8 minutes, respectively, at $b = 0.2$, deviating from Schwarzschild black holes by $\sim$ 2.615 and $\sim$ 4677 minutes. These deviations are insignificant for Sgr A* because it is too small, but they are sufficient for astronomical observation of M87* and some other black holes. With EHT bounds on the θsh of Sgr A* and M87*, within the 1σ region, placing bounds on the parameter b, our analysis concludes that the REC black holes agree with the EHT results in finite space, whereas the corresponding REC no-horizon spacetimes are completely ruled out.

8 NAME: **Yogesh**

Centre For Cosmology and Science Popularization (CCSP), SGT University, Haryana-122505, India

TITLE: Is NANOGRAV signals pointing towards resonant particle creation during inflation?

ABSTRACT: In this work, we show that the observed cosmic gravitational wave background by the NANOGrav 15-year collaboration may be the result of resonant particle creation during inflation. For the appropriate amplitude and particle mass, an enhancement of the primordial scalar power spectrum could induce Secondary Induced Gravitational Waves (SIGW), which will appear on a scale corresponding to the frequency of the NANOGrav detection. Since the resonant creation will have an effect comparable to that of a delta function increment as studied by the NANOGrav 15-year collaboration, our study indicates that the low-frequency Pulsar Timing Array (PTA) data could reveal the aspects of the physics during inflation through the detection of a cosmic background of Gravitational Waves (GW).

9 NAME: **Vijay Singh**

Kirori Mal College, University of Delhi, Delhi

TITLE: Can 5th dimension slow down the expansion of the universe?

ABSTRACT: A generalization of the standard class of exact solutions in Kaluza–Klein (4 + 1) gravity are obtained for a homogeneous cosmological model filled with vacuum energy. The models which describe transition from a decelerated to an accelerated phase are in the line of observational outcomes and of physical interest. The standard three-space expands indefinitely. Extra dimensions exhibit contraction as well as expansion with suitable values of the parameters. The model rejects the hypothesis of manifesting matter from extra dimensions. However, extra dimensions generate some attractive forces similar to gravity during the early evolution. Consequently, extra dimensions can be responsible for the past deceleration of the universe. The model seems to suggest an alternative mechanism pointing to a smooth transition from a decelerated phase to accelerated phase where the extra dimensions cause the transition.

10 NAME: **Byron Brassel**

Durban University of Technology

TITLE: Charged gravitational collapse in Einstein-Gauss-Bonnet gravity

ABSTRACT: We generalise the continual gravitational collapse of a spherically symmetric radiation shell of matter in five dimensional Einstein–Gauss–Bonnet gravity to include the electromagnetic field. The presence of charge has a significant effect in the collapse dynamics.We note that there exists a maximal charge contribution for which the metric functions in Einstein–Gauss–Bonnet gravity remain real, which is not the case in general relativity. Beyond this maximal charge the spacetime metric is complex. With the presence of an electromagnetic field, collapse terminates with the emergence of a branch singularity separating the physical spacetime from the complex region. We show that this marked difference in singularity formation is only prevalent in five dimensions.

11 NAME: **Dharm Veer Singh**

Department of Physics, GLA University, Mathura

TITLE: Thermodynamical phase transition of black holes in modified gravity

ABSTRACT: In this talk we will discuss the new exact black hole solutions in the presence modified gravity coupled with nonlinear electrodynamics. Based on horizon thermodynamics, we study the thermodynamic properties of the obtained solution (e.g., mass, temperature, and entropy). Furthermore, the stability of the obtained black hole solution using the nature of heat capacity and free energy will also be the part of discussion. Within context, we find that the phase transition exists at the point where the heat capacity diverges and, incidentally, the temperature attains the maximum value. Moreover, we also discuss the extended thermodynamics of the black hole when cosmological constant treated as the thermodynamics pressure.

12 NAME: **Amnish Vachher**

Jamia Millia Islamia

TITLE: Strong Gravitational Lensing around supermassive object

ABSTRACT: Investigating the behaviour of delfection angle in case of strong gravitational lensing around a supermassive black hole. Also we study the behaviour of various gravitational lensing observables.

13 NAME: **Mohd Rehan**

Jamia Millia Islamia

TITLE: Extended Phase Space Thermodynamics of Regular-AdS Black Hole

ABSTRACT: We construct a regular black hole solution by solving the Einstein field equations coupled with nonlinear electrodynamics. We then study the thermodynamic stability and phase transition of the regular black hole in the extended Anti-de Sitter (AdS) phase space

14 NAME: **Mohammed Osman Ebrahim Ismail**

University of KwaZulu-Natal

TITLE: The Chini equation and Einstein-Gauss-Bonnet gravity

ABSTRACT: We consider the Einstein-Gauss-Bonnet field equations for a charged perfect fluid. The condition of pressure isotropy is an Abel differential equation of the second kind. A systematic approach to integrate this equation is to relate it to the Chini differential equation. New solutions are found in explicit and implicit form. Previously obtained exact solutions are regained.

15 NAME: **Arun Kumar**

Jamia Millia Islamia

TITLE: Hayward-Letelier Black Holes in AdS spacetime

ABSTRACT: We analyze Hayward black holes (BHs) with a negative cosmological constant surrounded by a cloud of strings, called Hayward-Letelier AdS BHs. These solutions can be obtained by coupling the Einstein equations with nonlinear electrodynamics and the energy-momentum tensor of clouds of strings. We show these solutions are no longer regular and have a curvature singularity at the centre. In turn, we analyze the thermodynamics associated with these BHs by establishing the form of the Smarr formula and the first law of thermodynamics. We derive the expressions for the thermodynamic quantities such as pressure, temperature, heat capacity, Gibbs free energy, and isothermal compressibility. We explore the phase structure of these solutions by analyzing the behaviour of the heat capacity and Gibbs free energy. These solutions exhibit a first-order phase transition, similar to van der Waals fluid. We also check the behaviour of the thermodynamic quantities near the critical points and calculate the values of the critical exponents. This illustrates a robust analogy between our solutions and van der Waals fluids.

16 NAME: **Shavani Naicker**

University of KwaZulu-Natal

TITLE: Dust models in Einstein-Gauss-Bonnet gravity

ABSTRACT: We investigate the influence of the higher order curvature terms on the static configuration of a charged dust distribution in EGB gravity. The governing equation can be written as an Abel differential equation of the second kind, or a second order linear differential equation. Exact solutions are found to these equations in terms of special functions, series and polynomials. New families of solutions are found which are shown to be physically well behaved.