IV WORKSHOP ON FIELD THEORY, GRAVITY AND COSMOLOGY

Virtual meeting

IF-BUAP, Puebla, October 25-26, 2021

Invited talks

- **Pritam Banerjee** *(Indian Institute of Technology Kanpur, India)*
- **Ezequiel F. Boero Serra** *(IATE-UNC, Argentina)*
- **Roberto de Arcia Solís** *(DI-UGTO, Mexico)*
- **Manuel de la Cruz López** *(IF-BUAP, Mexico)*
- **Gabriela García Arroyo** *(DI-UGTO, Mexico)*
- **Jhony A. Herrera Mendoza** *(IF-BUAP, Mexico)*
- **Daniel F. Higuita Borja** *(IF-BUAP, Mexico)*
- **Francisco X. Linares Cedeño** *(DI-UGTO, Mexico)*
- **Raúl A. Lizardo Castro** *(ICN-UNAM, Mexico)*
- **Julio A. Méndez Zavaleta** *(Max Planck Institute, Germany)*
- **Mehrab Momennia** *(Shiraz University, Iran)*
- **Gustavo Niz Quevedo** *(DCI-UGTO, Mexico)*
- **Uriel Noriega Cornelio** *(FCFM-BUAP, Mexico)*
- **Carlos E. Romero Figueroa** *(IF-BUAP, Mexico)*
- **Víctor A. Zavala Pérez** *(IF-BUAP, Mexico)*

To attend the event,
please send an email to: **TallerIFUAPTCGC@gmail.com**

Link to the event:

October 25 - meet.google.com/qse-jsiz-spm

October 26 - meet.google.com/dsp-nqbx-ggv

Organizing Committee

Roberto Cartas Fuentevilla
Alberto Escalante Hernández
Alfredo Herrera Aguilar
Ulises Nucamendi Gómez
Israel Quiros Rodríguez
Ricardo García Salcedo
Instituto Avanzado de Cosmología

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More Info: www.ifuap.buap.mx/eventos/2021/1ra_Circular_4o_Taller_TCGC_2021.pdf

4th Workshop on Field Theory, Gravity and Cosmology
(virtual meeting)

Monday and Tuesday 25-26/10/21

From 13:30 till 18:30 UTC (Coordinated Universal Time)

From 8:30 am till 13:30 MTC (Mexican Central Time)

Organizing Institutions: IF-BUAP, IFM-UMSNH, DI-UGTO, CICATA-IPN, IAC.

Organizing Committee: Roberto Cartas-Fuentevilla, Alberto Escalante-Hernández, Alfredo Herrera-Aguilar, Ulises Nucamendi Gómez, Israel Quiros Rodríguez, Ricardo García Salcedo, Instituto Avanzado de Cosmología.

Registration - Please send an email to: **TallerIFUAPTCGC@gmail.com**

Link for October 25 - meet.google.com/qse-jsiz-spm

Link for October 26 - meet.google.com/dsp-nqbx-ggv

Invited speakers – PhD students and postdoctoral researchers:

Pritam Banerjee (IIT Kanpur, India)
Ezequiel Boero (IATE-UNC, Argentina)
Roberto de Arcia Solís (DI-UGTO, Mexico)
Manuel de la Cruz-López (IF-BUAP, Mexico)
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Date	Monday 25/10	Tuesday 26/10	
Chairman	A. Herrera Aguilar	U. Nucamendi Gómez	
13:30 – 14:10 UTC	**M. Momennia**	**P. Banerjee**	08:30 – 09:10 CMT
14:10 – 14:50 UTC	**J. A. Méndez Zavaleta**	**E. F. Boero Serra**	09:10 – 09:50 CMT
14:50 – 15:30 UTC	**D. F. Higuita Borja**	**R. A. Lizardo Castro**	09:50 – 10:30 CMT
15:30 – 15:50 UTC	**break**	**break**	10:30 – 10:50 CMT
15:50 – 16:30 UTC	**M. de la Cruz López**	**G. Niz Quevedo**	10:50 – 11:30 CMT
16:30 – 17:10 UTC	**J. A. Herrera Mendoza**	**G. García Arroyo**	11:30 – 12:10 CMT
17:10 – 17:50 UTC	**U. Noriega Cornelio**	**F. X. Linares Cedeño**	12:10 – 12: 50 CMT
17:50 – 18:30 UTC	**C. E. Romero Figueroa**	**R. de Arcia Solís**	12:50 – 13:30 CMT
18:30 – 19:10 UTC	**V. A. Zavala Pérez**	**Discussion session**	13:30 – 14:10 CMT

Abstracts

Pritam Banerjee (IIT Kanpur, India)

Title: Parametric constraints on modified gravity theories using Roche lobe formation in cataclysmic variables

Abstract: When a star approaches near a black hole or any other compact object, it experiences a tidal force due to the inhomogeneity of gravity. Tidal forces can be strong enough to disrupt a star and give rise to observable astrophysical phenomena. When the tidal force is equal to the self-gravity of the star at its surface, it is maximally deformed. It is known as the tidal disruption limit or the Roche limit. This critical limit is used to study various properties of the deformed star and the central object.

In the talk, I shall begin with tidal effects on self-gravitating Newtonian stars in general relativistic spacetime background, namely the GR effects coming from orbital properties and compare tidal effects around black holes and wormholes. We compare the peak fallback rates of tidal debris and the tidal disruption event rates in these backgrounds. Thereafter, I'll talk about a novel methodology to find parametric constraints in beyond-Horndeski gravity using Roche lobe filling secondary stars in cataclysmic variables. We numerically model the Roche lobe filling secondary stars incorporating the modified Poisson's equation that appear in this theory. The numerical results are contrasted with existing observational data yielding the desired constraints in beyond-Horndeski theories. A similar method is used to constrain Eddington-inspired Born-Infeld gravity, which is an important modification of Einstein's general relativity and can give rise to non-singular cosmologies at the classical level, and avoid the end-stage singularity in a gravitational collapse process. By using our methodology, we are able to constrain these theories within 5 sigma confidence level.

Ezequiel Boero (IATE-UNC, Argentina)

Title: Timelike and null geodesic out of the ecliptic plane of black holes and the parameter estimates of orbits around SgrA∗

Abstract: In this talk we will present a work in progress in collaboration with Dr. Alfredo Herrera-Aguilar and Dr. Ulises Nucamendi intended to study the strong gravitational effects of supermassive black holes on the orbits of compact emitters having passages at small distances from the event horizon, in particular to the well monitored stellar objects around SgrA∗. We will comment on a fully relativistic approach that generalizes the common post-Newtonian treatments employed in the analysis of data. We will show general expressions for the observable redshift of emitters in general bounded geodesic motion around black holes

Roberto de Arcia Solís (DI-UGTO, Mexico)

Title: Global asymptotic dynamics of the cubic galileon interacting with the dark matter

Abstract: A dynamical systems analysis of the cubic galileon model non-minimally coupled to the dark matter is performed for two well-known classes of interacting models: Q_1=3 \alpha H\rho_m and Q_2=3\beta\rho_m\dot{\phi}, respectively. We are able to show the global asymptotic dynamics of the model for the exponential potential in a homogeneous and isotropic background. The cosmological implications of the proposed scenarios are explored and it is found that, although there are no new solutions in addition to the equilibrium configurations that arise in the non-interacting cubic galileon model and in the interacting quintessence, there is a significant impact of the non-minimal coupling through modification of the stability properties of the critical points.

Manuel de la Cruz-López (IF-BUAP, Mexico)

Title: Pandora metrics: holographic superconductivity input-output machine

Abstract: If all physics can be stored in a black hole geometry box, as assert the gauge/gravity duality, it could be nice to open it!. Nowadays, 15000 pandora papers of these holographic ideas have been exposed and some are related to superconductivity. In this talk, we present the pioneer paper obtained in this pandora's box that creates an algorithm capable to explore phenomenological quantities of the superconducting state. The IFBUAP workgroup of Fields, Gravity, and Cosmology is interested, among other things, in obtaining new black hole solutions from general Einstein-Hilbert (+...) actions so, this algorithm can be useful to explore holographic interpretations of the workgroup research, especially the so-called Lifshitz geometries.

Gabriela García-Arroyo (DI-UGTO, Mexico)

Title: Extensions of LCDM

Abstract: As is well known the Cosmological Standard Model, LCDM, assumes General Relativity as gravity theory, a cosmological constant to explain the accelerated expansion of the universe, cold dark matter, baryons, photons and neutrinos as matter components. However, each one of these assumptions could be different, in this talk I will show three extensions of the model that are phenomenologically viable, one of these promotes the cosmological constant to an exotic dark energy fluid with a barotropic equation of state, the second extension is also in the aim to achieve an accelerated expansion of the universe but instead of dark energy the responsible will be a modified gravity theory, f(R), for example. And the third extension that I will cover is around the neutrino's sector that in this talk could have non-standard self-interactions. All of these extensions are capable to fit the current cosmological observations.

Jhony A. Herrera-Mendoza (IF-BUAP, Mexico)

Title: Lifshitz black holes in generalized Einstein-Maxwell-dilaton theories

Abstract: Nowadays, it is well-known the importance of Lifshitz spacetimes within the non-relativistic context of the holographic correspondence. Lifshitz spacetimes could serve as gravity duals of certain condensed matter systems. In this talk, we show some results concerning Lifshitz black holes within the framework of an Einstein-Maxwell-dilaton theory supplemented with a self-interacting potential. These black holes incorporate either planar, spherical, or hyperbolical horizon topologies. We show that some configurations accommodate extremal solutions under some election of parameters. Finally, we discuss some thermodynamic properties and show that the first law is plausibly fulfilled.

Daniel F. Higuita-Borja (IF-BUAP, Mexico)

Title: Rotating Spacetimes generalizing Lifshitz Black Holes

Abstract: We present a spinning black hole solution in d dimensions with a maximal number of rotation parameters in the context of the Eistein-Maxwell-Dilaton theory. An interesting feature of such a solution is that it accommodates Lifshitz black holes when the rotation parameters are set to zero. We verify the rotating nature of the black hole solution by performing the quasi-local analysis of conserved charges and defining the corresponding angular momenta. In addition, we perform the thermodynamical analysis of the black hole configuration, show that the first law of thermodynamics is completely consistent, and obtain a Smarr-like formula. We further study the thermodynamic stability of the constructed solution from a local viewpoint, by computing the associated specific heats, and a global perspective, by using the so-called new thermodynamic geometry. We finally make some comments related to a pathology found in the causal structure of the obtained rotating black hole spacetime.

Francisco X. Linares Cedeño (DI-UGTO, Mexico)

Title: Unimodular gravity and diffusion processes in the dark sector: a possible solution to the H0 tension.

Abstract: In this talk, we review some phenomenological models of diffusion in the context of Unimodular Gravity. We will show that, by considering non-gravitational interactions between dark matter and an effective cosmological constant, it is possible to address one of the problems of modern cosmology: the H0 tension. Finally, we will impose constraints on the parameters of the diffusion models, and thus, study the viability of these models. We will show that these diffusion models within the context of Unimodular Gravity seem to alleviate the H0 tension. Some current progress as well as some perspective will be given.

Raúl A. Lizardo-Castro (ICN-UNAM, Mexico)

Title: Towards the gravitational redshift detection in NGC 4258 and the estimation of its black hole mass-to-distance ratio

Abstract: We construct from first principles a general relativistic approach to study Schwarzschild black hole (BH) rotation curves and estimate the mass-to-distance ratio of the Active Galactic Nucleus (AGN) of NGC 4258 in terms of astrophysical observable quantities. The presented method allows one to clearly distinguish and quantify the general and special relativistic contributions to the total redshift expression. The total relativistic redshift/blueshift comprises three components: the gravitational redshift due to the spacetime curvature generated by the mass of the BH in its vicinity, the kinematic shift, originated by the photons' local Doppler effect, and the redshift due to a special relativistic boost that describes the motion of a galaxy from a distant observer. We apply our method to the largest data set of highly redshifted water megamaser measurements on the accretion disk of the NGC 4258 active galaxy and use this general relativistic method to estimate its BH mass-to-distance ratio: $M/D = (0.5326 \pm 0.00022) \times 10^7 M_{Sun}/Mpc$.

Julio A. Méndez-Zavaleta (Max Planck Institute, Germany)

Title: Scalarization-like mechanism through spacetime anisotropic scaling symmetry

Abstract: We present a new family of exact black hole configurations, which is a solution to a generalized Einstein-Maxwell-Dilaton setup in arbitrary dimension. These solutions are asymptotically Lifshitz for any dynamical critical exponent $z \geq 1$. It turns out that the existence of a nontrivial scalar field is a direct consequence of breaking the spacetime isotropic scaling symmetry. This black hole family accepts various interesting limits that link it to well-known solutions in both the isotropic and anisotropic cases. We study the thermodynamics of these field configurations showing that the first law is satisfied and providing the corresponding Smarr formula, both of these relations account for an electric contribution. Furthermore, we show that for a certain parameter region, the anisotropic field

configuration with a nonzero scalar field is thermodynamically preferred. This observation, together with a direct verification of the so-called scalarization conditions, suggest that the emergence of the dilaton field is due to a mechanism similar to spontaneous scalarization.

Mehrab Momennia (Shiraz University, Iran)

Title: Reentrant Phase Transition of Asymptotically Reissner–Nordström Black Holes

Abstract: By considering a small correction to the Maxwell field, we show that the resultant asymptotically Reissner–Nordström black hole solutions undergo the reentrant phase transition and can have a novel phase behavior. We also find that such a small nonlinear correction of the Reissner–Nordström black holes has high effects on the phase structure of the solutions. It leads to a new classification in the canonical ensemble of extended phase space providing the values of the nonlinearity parameter α. Interestingly, we find that there is the reentrant phase transition for $\alpha < 4q^2/7$, and for the case of $\alpha = 4q^2/7$, there is no phase transition below (at) the critical point.

Gustavo Niz Quevedo (DCI-UGTO & Advanced Cosmology Institute)

Title: Testing gravity using DESI and LSST

Abstract: We will first introduce the parameter space of some modified gravity theories, and then describe how these modifications to GR can produce departures in the formation and evolution of the large scale structure in the Universe. Finally, we will show how the new stage IV galaxy surveys experiments, such as DESI and LSST, can shed light on the observational evidence of alternatives to Einstein's theory.

Uriel Noriega Cornelio (FCFM-BUAP, Mexico)

Title: Lifshitz black holes solutions in scalar-tensor theories

Abstract: We present new exact asymptotically Lifshitz black hole solutions of two-dimensional gravity non-minimally coupled to two scalar fields. We compute some geometrical invariant quantities for these space-times and carry out the analysis of their thermodynamical ones. We introduce Kruskal-like coordinates in order to extend the metric inside the event horizon and investigate the causal structure for these solutions. Furthermore, we study the behaviour of the scalar fields on these backgrounds.

Carlos E. Romero Figueroa (IF-BUAP, Mexico)

Title: Hyperscaling violating Schrödinger black holes

Abstract: In this talk two different families of asymptotically Schrödinger hyperscaling violating black holes with a generic dynamical critical exponent *z* and an arbitrary number of spacetime dimensions are presented. These black holes families represent solutions within the Einstein-Maxwell-scalar setup with a self-interaction scalar potential where the Maxwell field is coupled to the scalar field. Furthermore, within the framework of the Gravity/Condensed Matter Theory correspondence the above mentioned solutions are gravitational candidates to describe field theories with hyperscaling violating Schrödinger symmetry at finite temperature.

Víctor A. Zavala-Pérez (IF-BUAP, Mexico)

Title: Methodology for analyzing higher-order canonical gravitational theories

Abstract: Higher-order theories are of great interest in theoretical physics, from generalizations of electrodynamics to string theory and dark energy physics; there is no shortage of applications. Notably, the interest of higher order gravitational Lagrangians lies in the fact that these become renormalizable when they contain higher-order derivatives. Their analysis can be performed by the Güller-HJ and the Gitman-Lyakhovich-Tyutin (GLT) frameworks, both of which introduce new dynamical variables to the Lagrangian in order to reduce the order of the time derivatives, leaving these theories ready for a Hamiltonian analysis. However, by doing this one must introduce constraints to these theories and ensure that they are held through the dynamics. In this presentation, we describe these two frameworks and then proceed to analyze a system known as the higher-order Maxwell–Chern–Simons gauge theory in 2 + 1 dimensions.