7th Gulf Coast Gravity Meeting – Conference Program

Each talk is 15+5 minutes; students (marked by a *) are eligible for the Blue Apple Award

FRIDAY, APRIL 19 – (Venue: Student Union Ballroom)

8:30am–9:00am:
Welcome *from the organizers and Department Chair Lucien Cremaldi*

9:00am–10:40am
Emanuele Berti *(University of Mississippi)*
Resonant-plane locking and spin alignment in stellar-mass black-hole binaries: a diagnostic of compact-binary formation
Saeed Mirshekari* *(University of Florida)*
Compact Binary Systems in Scalar-Tensor Gravity: Equations of Motion to 2.5 Post-Newtonian Order
Michael Horbatsch *(University of Mississippi)*
Gravitational Radiation in Massive Scalar-Tensor Gravity
Sergei M. Kopeikin *(University of Missouri, Columbia)*
Equations of Motion in an Expanding Universe
Clifford M. Will [with Pierre Fromholz] *(University of Florida)*
The Schwarzschild Metric: It's the Coordinates, Stupid!

11:10am–12:30am
Ulrich Sperhake *(DAMTP, Cambridge, UK)*
Universality and wave absorption in high-energy collisions of spinning black holes
Miguel Megevand *(Louisiana State University)*
Scalar wigs and galactic dark matter halos
Shawn Wilder* *(Florida Atlantic University)*
Stability of approximate Killing fields and black hole spin
Edward L. Green *(North Georgia College & State University)*
Theory of General Conservation: Spherically Symmetric Solutions

2:00pm–3:20pm
Peter L. Biermann [with Benjamin C. Harms] *(University of Alabama)*
Testing a quantitative model for dark energy
Al Stern *(University of Alabama)*
Possible Evidence of Thermodynamic Activity in Dark Matter Haloes
Laleh Sadeghian* [with Francesc Ferrer, Clifford M. Will] *(University of Florida)*
Dark matter distributions around massive black holes: A fully general relativistic approach
William Duhe* *(Loyola University)*
A comprehensive investigation of a multiple big bang scenario

3:50pm–5:10pm
Shaoqi Hou* *(University of Alabama)*
Searching for Microscopic Black Holes at the LHC
Caixia Sky Gao* *(University of Mississippi)*
Non-singular spherical symmetric solution in extended massive gravity
Anton Joe* *(Louisiana State University)*
Characteristics of Kantowski-Sachs space-time in effective theory of Loop Quantum Cosmology
Brajesh Gupt* *(Louisiana State University)*
Quantum gravitational Kasner transitions in Bianchi-I spacetime

SATURDAY, APRIL 20 – (Venue: Student Union Ballroom)

8:30am–10:30am
Marco Cavaglia *(University of Mississippi)*
On the road to Advanced LIGO
Linqing Wen *(University of Western Australia)*
Low Latency Search for Gravitational Waves from Compact Binary Coalescences
Yuri Bonder *(Indiana University)*
Lorentz violations and gravity: The Newtonian limit
Ryan Everett* **[with James Overduin]** *(Towson University)*
Gravity Probe B constraints on higher-dimensional extensions of general relativity
Zoey Warecki* **[with James Overduin]** *(Towson University)*
Planets and Moons as Probes of Physics Beyond the Standard Model
Justin C. Feng* *(University of Texas, Austin)*
Rigid Surfaces in General Relativity

11:00am–12:20pm
Steven Detweiler *(University of Florida)*
Introduction to Self-force calculations
Jonathan Thompson* *(University of Florida)*
Second Order Self-force Calculations
Peter Diener *(Louisiana State University)*
Self-consistent Evolution of a Scalar Point Charge Around a Schwarzschild Black Hole
V H Satheeshkumar* *(Baylor University)*
Theoretical Limits on the (Non-)Existence of Lorentz Frame Near Black Hole Singularity

LUNCH; BLUE APPLE AWARD DECISION

2:00pm–3:30pm

BLUE APPLE AWARD ANNOUNCEMENT

Gary White *(National Science Foundation)*
Spandex models for gravity wells: folklore, facts, and fun
Luca Bombelli *(University of Mississippi)*
Lorentzian manifolds and causal sets as partially ordered measure spaces
Parampreet Singh *(Louisiana State University)*
A quantum gravitational inflationary scenario in Bianchi-I spacetime
Sergio Fabi *(University of Alabama)*
The theory of gravity on a Lie Algebroid

4:00am–5:20pm
Benjamin C. Harms *(University of Alabama)*
Time Jitter Due to Gravitational Solitons
Octavian Micu *(Institute of Space Science, Bucharest, Romania)*
Possible searches for the non-thermal micro black holes back-to-back decay signature
Stanislav Fisenko *(Rusthermosyntesis)*
Gravitational radiation of the relativistic theory of gravitation
Alexey Golovanov *(M.V. Lomonosov Moscow State University, Moscow, Russia)*
New Relativity

ABSTRACTS

Emanuele Berti

Resonant-plane locking and spin alignment in stellar-mass black-hole binaries: a diagnostic of compact-binary formation

This talk will focus on the influence of astrophysical formation scenarios on the precessional dynamics of spinning black-hole binaries by the time they enter the observational window of second- and third-generation gravitational-wave detectors, such as Advanced LIGO/Virgo, LIGO-India, KAGRA and the Einstein Telescope. Under the plausible assumption that tidal interactions are efficient at aligning the spins of few-solar mass black-hole progenitors with the orbital angular momentum, black-hole spins should be expected to preferentially lie in a plane when they become detectable by gravitational-wave interferometers. This "resonant plane" is identified by the conditions $\Delta\Phi = 0^\circ$ *or* $\Delta\Phi = \pm 180^\circ$*, where* $\Delta\Phi$ *is the angle between the components of the black-hole spins in the plane orthogonal to the orbital angular momentum. If the angles* $\Delta\Phi$ *can be accurately measured for a large sample of gravitational-wave detections, their distribution will constrain models of compact binary formation. In particular, it will tell us whether tidal interactions are efficient, and whether mass transfer between the binary members is strong enough to produce mass-ratio reversal (so that the heavier black hole is produced by the initially lighter stellar progenitor). This offers a concrete observational link between gravitational-wave measurements and astrophysics.*

Peter L. Biermann [with Benjamin C. Harms]

Testing a quantitative model for dark energy

Dark energy is considered to be the most challenging problem for modern physics. Dark energy drives the universe apart with acceleration. We propose to develop quantitative tests of a concept for dark energy, and to evolve it further to a full theory. The concept is that dark energy is the ensemble of soliton-like gravitational waves originally produced when the first generation of super-massive back holes were formed. These solitons keep up their energy density throughout the evolution of the universe by stimulating emission from a background. Key tests involve pulsar timing, clock jitter, the radio-, X-ray, gamma- and neutrino-background, and the early formation of pure-disk galaxies. First steps are in arXiv:1205.4016, and in arXiv:1302.0040 (Biermann & Harms).

Luca Bombelli

Lorentzian manifolds and causal sets as partially ordered measure spaces

Causal set theory is a minimalist approach to quantum spacetime and quantum gravity, in which the only fundamental variable representing spacetime and gravity is a partial order, interpreted as causal relations, among elements of a discrete set. I will give an overview of the main parts of the theory, mention briefly some approaches that have been proposed for its dynamics, and then discuss in some more detail causal set kinematics, the part of the theory that studies mostly the relationship between discrete sets with partial orders and continuum spacetime geometries. After summarizing what is known about the kinematics, I will describe a recent idea about how to include Lorentzian manifolds and causal sets into a common, larger class of objects. This provides a new way of addressing questions about when two spacetimes are close to each other and when a discrete spacetime approximates a continuum Lorentzian geometry, as well as a new framework in which to include other possible generalizations of Lorentzian geometries as spacetime structures.

Yuri Bonder

Lorentz violations and gravity: The Newtonian limit

The Standard Model Extension (SME) is a framework that parametrizes all possible violations of (local) Lorentz invariance within the context of field theory. Studying Lorentz violating matter fields in a general spacetime has proven to be extremely difficult. As a first step in this direction, we present a method that allows to investigate how a Lorentz violating test spinor behaves in a uniform Newtonian gravitational potential. In order to do so, we take the one particle Hamiltonian of the SME fermionic sector in the Rindler spacetime and compute the nonrelativistic Hamiltonian through a series of Foldy-Wouthuysen transformations. The obtained Hamiltonian can be used to shed light into the way gravity affects Lorentz violating spinors and to reinterpret some of the bounds on the coefficients that control Lorentz violations.

Marco Cavaglia

On the road to Advanced LIGO

In 1916 Albert Einstein demonstrated that the theory of general relativity allows for wave-like solutions. Although there is indirect proof of the existence of gravitational waves, their direct detection is still lacking almost one hundred years after Einstein's seminal result. The Laser Interferometer Gravitational-wave Observatory (LIGO) is the world's leading scientific experiment for the detection of astrophysical gravitational waves. The LIGO detectors are currently undergoing a major upgrade. The new Advanced LIGO interferometers will soon be the world's largest precision optical instruments and the most sensitive gravitational wave detectors ever built. In this talk I will present an overview of the LIGO science, and challenges and prospects of experiments with Advanced LIGO detectors.

Steven Detweiler

Introduction to self-force calculations

In General Relativity small objects move along geodesics of spacetime. This elementary fact implies that even the effect of what might be called "gravitational radiation reaction" on a small black hole m *orbiting a large black hole, with metric* g_{ab}*, results in geodesic motion for* m*—but the worldline is not a geodesic of* g_{ab}*! The retarded metric perturbation* h^{ret}_{ab} *is determined using standard linear perturbation analysis. In the neighborhood of the small mass this may be decomposed into two parts* $h^{ret}_{ab} = h^{S}_{ab} + h^{R}_{ab}$ *where the "singular source"* h^{S}_{ab}*, with local coordinates, appears as the part of the Schwarzschild metric which is linear in* m *along with some other terms that reflect the tidal distortion of the small black hole. The "regular remainder"* h^{R}_{ab} *also scales as* m*. The effect of radiation reaction then requires that* m *move along a geodesic of* $g_{ab} + h^{R}_{ab}$*, which is a source free solution to the Einstein equations in a neighborhood of* m*.*

Peter Diener

Self-consistent Evolution of a Scalar Point Charge Around a Schwarzschild Black Hole

The prediction of gravitational waveforms from a small compact object in orbit around a super-massive black hole is very difficult using standard numerical relativity techniques due to the large range of length and time scales. Instead, perturbation techniques, where the small object can be treated as a point particle perturbing the background spacetime of the large black hole, have to be employed. A new approach to this problem (the effective source approach) has recently been developed and applied to a simpler toy problem (the scalar field case), resulting in the first fully self-consistent evolution of a scalar charge in orbit around a Schwarzschild black hole. I will describe the method and present these new results.

William Duhe

A comprehensive investigation of a multiple big bang scenario

In this article we will be giving a brief overview of the scope cyclic-inflation model in its relation to the broader context of cosmology. The particular focus of the paper will be an attempt to quantify the physical properties that the early universe would exhibit if it were to behave in a cyclic manner.. This would allow for the development of a cosmological paradigm containing a negative cosmological constant, an appetizing notion for string theorists, as well eliminate the need for a singularity at the moment of our last big bang.

Ryan Everett [with James Overduin]

Gravity Probe B constraints on higher-dimensional extensions of general relativity

Using measurements of geodetic precession around the Earth from Gravity Probe B, we constrain departures from Einsteins General Relativity for a spinning test body in Kaluza-Klein gravity with one additional space dimension. We consider two of three known time-independent, spherically symmetric solutions of the 5D field equations and obtain new constraints on the values of the free parameters associated with each metric.

Sergio Fabi

The theory of gravity on an Lie Algebroid

We present the geometric formulation of gravity based on the math- ematical structure of a Lie Algebroid. In this framework we are able to address various issues about the gauge properties of the gravitational interaction and propose a new framework for quantization.

Justin C. Feng

Rigid Surfaces in General Relativity

A Rigid Surface is defined as a 2+1 timelike surface, isometrically embedded in a 3+1 spacetime, which admits a coordinate system with a time-independent spatial metric and a unit time vector. These surfaces are called Rigid Surfaces because they provide a notion of intrinsic rigidity for 2-surfaces moving in curved spacetime. Given an initial 2-surface embedded in a generic spacetime, one can extend it so that it forms a Rigid Surface. Using the thin-shell formalism, one can construct a definition of quasilocal energy for a Rigid Surface. In particular, one can define a notion of energy by considering a timelike Rigid Surface spatially encloses a region of spacetime, and calculating the amount of negative mass that one must place on a thin shell coincident with the Rigid Surface in order to make spacetime flat outside. Furthermore, if the Rigid surface posesses a unit timelike Killing vector, this notion of quasilocal energy is conserved.

Stanislav Fisenko

Gravitational radiation of the relativistic theory of gravitation

The concept of gravitational radiation as a radiation of one level with the electromagnetic radiation is based on theoretically proved and experimentally confirmed fact of existence of electrons stationary states in own gravitational field, characterized by gravitational constant $K = 10^{42}G$ *(G – Newtonian gravitational constant) and by irremovable space-time curvature. The received results strictly correspond to principles of the relativistic theory of gravitation and the quantum mechanics.*

Caixia Sky Gao
Non-singular spherical symmetric solution in extended massive gravity

We investigate non-singular spherical symmetric solution in a universe governed by the extended non-linear massive gravity, in which the graviton mass is promoted to a scalar-field potential. By following some ansatz for the potential and metric factors, we can find the distribution of graviton mass and the corresponding scalar field.

Alexey Golovanov
New Relativity

We suggest new theoretical model for gravitation. In this model we justify the existence of new inertial field with induction nature, like the magnetic field for gravitation. We obtain set of differential Maxwell type equations, which eliminates the shortcomings of classical Newtonian mechanics and General Relativity. In Galilean frames of references formulas for coordinates transformation is equal to corresponding formulas from STR. We solved problem of non-inertial frames of reference. Full relativity is obtained in all frames due to inertia in our approach caused by massive moving bodies of the Universe. This approach can explain many earlier unexplained phenomena and predicts new. It explains flat rotation of celestial bodies, planet disks, many dark matter effects. Existence of black holes becomes a question. All that things is due to action of inertial field. Also light can be strongly curved in spirals. Both Doppler and Einsteins effects become indistinguishable for terrestrial observer. We obtain opportunity how to use inertial field for support-free motion. In our approach axial force appears for fast rotating bodies in the non-uniform inertial field.

Edward L. Green
Theory of General Conservation: Spherically Symmetric Solutions

A unified field theory has been developed which extends the geometrical structure of a real four-dimensional space-time via a field of orthonormal tetrads with an enlarged transformation group. This new transformation group, called the conservation group, contains the group of diffeomorphisms as a proper subgroup and is the foundation of the theory of general conservation. Field equations were obtained from a variational principle which is invariant under the conservation group. The theory is further extended by development of a suitable Lagrangian for a field with sources. Spherically symmetric solutions for both the free field and the field with sources are given. The theory implies that the external stress-energy tensor has non-compact support and hence may give the geometrical foundation for dark matter. The resulting models are compared to the internal and external Schwarzschild models. The theory may explain the Pioneer anomaly and the corona heating problem.

Brajesh Gupt

Quantum gravitational Kasner transitions in Bianchi-I spacetime

Loop quantum cosmology (LQC) resolves all physical singularities in Bianchi- I spacetime and replaces the big-bang singularity by big-bounce. Due to the anisotropic nature of Bianchi-I spacetime, there is a rich structure of approach to singularity in the classical theory giving rise to a Kasner like universe near singularity. In LQC, due to the bounce, there will be Kasner transitions across the bounce. Now, several questions arise - are these transitions completely random or there is an order to them? can one predict the type of transition given the anisotropy in the current universe? are certain transitions ruled out/favored depending on the state of the current universe? We explore these questions in Bianchi-I spacetime filled with perfect fluids with constant equation of state. Our analysis show that the answers to these questions are in affirmative. We find that depending on the total anisotropic shear there are transitions which are more favored than the others. Our results show that LQC allows transition from one Kasner era to the other is Bianchi-I spacetime, a feature which is absent in the classical theory for vanishing spatial curvature.

Benjamin C. Harms [with Peter L. Biermann]

Time Jitter Due to Gravitational Solitons

In a recent paper (arXiv:1205.4016) we proposed that gravitational solitons interacting with a strong-gravity brane a Planck length away in the fifth dimension is the source of the phenomenon known as dark energy. The passage of these solitons, which are created by the stimulated emission of gravitational waves as described in the paper, through spacetime causes time-dependent deviations from the Minkowski metric. The passage of each soliton requires about 1000 seconds to pass a given point in space. There are on average 50 such solitons passing through the given point in the 1000 second time interval. Thus there is one new soliton every 20 seconds passing through the point. In this talk we present the mathematical descriptions of a metric which describes the energy transferred from the strong-gravity brane to the solitons propagating on our weak-gravity brane and of the local, time-dependent metric which describes the net effect of the solitons. We also propose experimental tests, which can be performed in the near future, of the validity of our model.

Michael Horbatsch

Gravitational Radiation in Massive Scalar-Tensor Gravity

We consider scalar-tensor theories where the scalar has non-zero mass (or finite range), and calculate the gravitational radiation emitted by an eccentric binary system of compact objects. These results are applied to binary pulsars in order to constrain scalar masses and scalar-matter couplings.

Shaoqi Hou

Searching for Microscopic Black Holes at the LHC

The Standard Model of elementary particles can be used to explain most of the phenomena in the universe, but it suffers from problems. One of the distinctive problems is called Hierarchy Problem, which states that there is a great gap between the electroweak scale $E_{EW} \sim 1$ *TeV and the Planck scale* $E_G \sim 10^{16}$ *TeV. One possible solution is to introduce large spatial compactified extra dimensions (ADD scenario). Because of the existence of the extra dimensions, gravity is diluted such that the Planck scale is lowered to around the electroweak scale. This result has significant consequences and predicts the production of black holes in particle colliders. Compact Muon Solenoid (CMS) collided two protons at TeV scale and promises to generate a lot of microscopic black holes. With the help of CATFISH, a Fortran Monte Carlo generator to simulate black hole events, we can compare the experimental data and the simulation to tell whether black holes are produced so that determine the existence of extra dimensions. In this presentation, I will briefly review the basic idea of ADD scenario, introduce you to CATFISH and show some primitive simulation results.*

Anton Joe

Characteristics of Kantowski-Sachs space-time in effective theory of Loop Quantum Cosmology

Singularity theorems have shown that general relativistic space-times have singularities which make them incomplete. It is hoped that a quantum theory of gravity will be devoid of these singularities. The Kantowski-Sachs cosmology has been studied in the effective theory of loop quantum cosmology for both vacuum and massless scalar field as matter. In both cases it is seen that the space-time is non-singular. It is now known that all the strong singularities are resolved in effective loop quantum cosmology models of FLRW and Bianchi-I cosmologies for generic matter. We aim to address the same question for Kantowski-Sachs space-time. As a first step we study if the energy density is always bounded in this model.

Sergei M. Kopeikin
Equations of Motion in an Expanding Universe

Post-Newtonian theory of motion of celestial bodies and propagation of light is instrumental in conducting the critical experimental tests of general relativity and in building the astronomical ephemerides of celestial bodies in the solar system with an unparalleled precision. The cornerstone of the theory is the postulate that the solar system is gravitationally isolated from the rest of the universe and the background spacetime is asymptotically flat. We extend this theoretical concept and formulates the principles of celestial dynamics of particles and light moving in gravitational field of a localized astronomical system embedded to the expanding Friedmann-Lematre-Robertson-Walker (FLRW) universe. We formulate the precise mathematical concept of the Newtonian limit of Einstein's field equations in the conformally-flat FLRW spacetime and analyze the geodesic motion of massive particles and light in this limit. We prove that by doing conformal spacetime transformations, one can reduce the equations of motion of particles and light to the classical form of the Newtonian theory. However, the time arguments in the equations of motion of particles and light differ from each other in terms being proportional to the Hubble constant H. This leads to the important conclusion that equations of light propagation used currently by Space Navigation Centers for fitting the range and Doppler-tracking observations of celestial bodies are missing some terms of the cosmological origin that are proportional to the Hubble constant H. We also analyze the effect of the cosmological expansion on motion of electrons in atoms. We prove that the Hubble expansion does not affect the atomic frequencies and, hence, does not affect the atomic time scale used in creation of astronomical ephemerides. We derive the cosmological correction to the light travel time equation and argue that their measurement opens a fascinating opportunity to determine the local value of the Hubble constant in the solar system independently of cosmological observations.

Miguel Megevand
Scalar wigs and galactic dark matter halos

Scalar fields have been proposed as possible candidates to describe the dark matter component of the universe. Since supermassive black holes seem to exist at the center of almost every galaxy, scalar field configurations can be viable as dark matter halos only if they can be stable enough in the presence of a central black hole. After some analytical considerations, we study numerically the evolution of different scalar field configurations surrounding a black hole. We see that, for a range of parameters consistent with supermassive black holes and galactic halos, some quasi-stationary solutions can last for cosmological timescales in a region surrounding the black hole.

Octavian Micu
Possible searches for the non-thermal micro black holes back-to-back decay signature

The possibility for cosmic ray experiments or neutrino observatories to discover non-thermal small black holes with masses in the TeV range will be discussed. These black holes would result due to the impact between ultra high energy cosmic rays or neutrinos with nuclei (from the upper atmosphere, respectively in water or ice for the case of neutrinos) and decay instantaneously. As their masses are close to the Planck scale, these holes would typically decay into two particles emitted back-to-back. The resulting spatially separated but simultaneous showers could be measured by the detectors.

Saeed Mirshekari

Compact Binary Systems in Scalar-Tensor Gravity: Equations of Motion to 2.5 Post-Newtonian Order

We calculate the explicit equations of motion for non-spinning compact objects to 2.5 post-Newtonian order, or $O(v/c)^5$ beyond Newtonian gravity, in a general class of scalar-tensor theories of gravity. We use the formalism of the Direct Integration of the Relaxed Einstein Equations (DIRE), adapted to scalar-tensor theory, coupled with an approach pioneered by Eardley for incorporating the internal gravity of compact, self-gravitating bodies. For the conservative part of the motion, we obtain the two-body Lagrangian and conserved energy and momentum through second post-Newtonian order. We find the 1.5 post-Newtonian and 2.5 post-Newtonian contributions to gravitational radiation reaction, the former corresponding to the effects of dipole gravitational radiation, and verify that the resulting energy loss agrees with earlier calculations of the energy flux. For binary black holes we show that the motion through 2.5 post-Newtonian order is observationally identical to that predicted by general relativity. For mixed black-hole neutron-star binary systems, the motion is identical to that in general relativity through the first post-Newtonian order, but deviates from general relativity beginning at 1.5 post-Newtonian order, in part through the onset of dipole gravitational radiation. But through 2.5 post-Newtonian order, those deviations in the motion of a mixed system are governed by a single parameter dependent only upon the scalar-tensor coupling constant and the structure of the neutron star, and are formally the same for a general class of scalar-tensor theories as they are for pure Brans-Dicke theory.[1]

Laleh Sadeghian [with Francesc Ferrer, Clifford M. Will]

Dark matter distributions around massive black holes: A fully general relativistic approach

The cold dark matter at the center of a galaxy will be redistributed by the presence of a massive black hole. The redistribution may be determined by beginning with a model distribution function for the dark matter, and "growing the black hole adiabatically, holding the adiabatic invariants of the motion constant. Unlike previous approaches, which adopted Newtonian theory together with ad hoc correction factors to mimic general relativistic effects, we carry out the calculation fully relativistically, using the exact Schwarzschild geometry of the black hole. We consider a range of initial distribution functions, including "cuspy profiles, and find that the density spike very close to the black hole is significantly higher than that found previously by Newtonian analyses. The potential implications for detection of signals from galactic center dark matter will be discussed.

V H Satheeshkumar

Theoretical Limits on the (Non-)Existence of Lorentz Frame Near Black Hole Singularity

General Relativity (GR) is known to break down at singularities. However, from the order-of-magnitude argument, it is expected that quantum corrections become important when the curvature is of the order of Planck scale. In this talk we prove this rigorously. By calculating the effect of tidal forces of a black hole on a freely falling local inertial frame and assuming the least possible size of the frame to be of the Planck length, we show that the Lorentz frames cease to exist at a finite distance from the singularity. This contradicts the strong Equivalence Principle. Within that characteristic radius, one cannot use General Relativity or Quantum Field Theory as we know today. As a bonus, this result sheds some light on the symmetries in the theories of Quantum Gravity.

Parampreet Singh

A quantum gravitational inflationary scenario in Bianchi-I spacetime

An important issue for inflationary paradigms is to understand the way anisotropy in the initial state of the universe affects the onset of inflation. Since in the classical theory, the past evolution is singular, this problem can only be addressed properly in a non-singular model of inflation in anisotropic spacetime based on quantum gravity. In this talk, we will discuss the way loop quantum gravity effects modify the physics of the early universe in a Bianchi-I spacetime to yield a non-singular inflationary model. We explore the effects of the anisotropic shear and initial conditions on the amount of inflation and compare in detail the the attractor behavior in loop quantum cosmology with the classical theory. We discuss some key differences in the attractor behavior and point out some avenues where the new physics of anisotropies in loop quantum cosmology may lead to potential observational effects.

Ulrich Sperhake

Universality and wave absorption in high-energy collisions of spinning black holes

We present numerical simulations of grazing collisions of spinning black holes with speeds up to $> 90\%$ *of the speed of light. We demonstrate that the dynamics become increasingly unaffected by the individual holes' spins. We furthermore show that absorption of graviational energy by the black holes puts an upper limit of the total amount of energy lost in gravitational waves. Black holes formed in high-energy collisions should therefore be expected to have a mass given up to a factor* $\lesssim 1$ *by the center-of-mass energy of the collision.*

Al Stern

Possible Evidence of Thermodynamic Activity in Dark Matter Haloes

We show that the dark matter density decreases exponentially with the gravitational potential in substantial regions of several galactic haloes. This could indicate that a simple Boltzmann description of dark matter haloes is possible.

Jonathan Thompson

Second Order Self-force Calculations

General advancement in perturbation theory usually involves pushing the perturbative analysis to higher orders. When examining the geodesic motion of a point particle in a background geometry, the full spacetime metric is expanded in powers of the particle's mass, m. *Adhering to the standard formalism for self-force perturbations, one finds that by solving the first-order problem the particle no longer travels along a geodesic of the background metric, but rather a geodesic of the background plus an order* $O(m)$ *correction to the metric, typically written* $g_{\mu\nu} + h^{1\mathrm{R}}_{\mu\nu}$. *The field* $h^{1\mathrm{R}}_{\mu\nu}$ *is called the regular field. In pushing the perturbation to second-order, one must first calculate the first-order regular field, so as to account for the shift in the particle's worldline. This talk focuses on the benefits achieved from moving to second-order, as well as the practical concerns involved in calculating the second-order metric perturbation.*

Zoey Warecki [with James Overduin]

Planets and Moons as Probes of Physics Beyond the Standard Model

We use observational data on the positions, masses and compositions of solar-system bodies to constrain violations of the equivalence principle like those predicted by extensions of the Standard Model of particle physics. Violations can be quantified by X, the amount by which the ratio of gravitational mass to inertial mass differs from unity for a given test body. Using appropriate combinations of observational upper limits on violations of Keplers third law, migration of stable Lagrange points, and orbital polarization (Nordtvedt effect) we obtain new constraints on X for many planets (and some moons), and combine these with composition data to set qualitatively new limits on violations of the equivalence principle by individual elements.

Linqing Wen

Low Latency Search for Gravitational Waves from Compact Binary Coalescences

For advanced gravitational-wave detectors, signals from coalescing binaries of neutron stars and stellar-mass black holes could be detected before or near their merger. I will discuss the astrophysical motivation for an early detection of such signals and present a recently developed time-domain search technique aiming at extremely low-latency search. The status of an online pipeline including this technique and the application of GPU acceleration will also be presented.

Gary White

Spandex models for gravity wells: folklore, facts, and fun

*Many sources tout the use of taut rubber sheets with heavy spheres on top as a useful way to visualize aspects of gravity wells. In this talk, after summarizing some results regarding the shape of stretched spandex when attached to a circular boundary with a heavy mass suspended from the center, I'll indicate how this shape dictates what kinds of orbits will be observed when viewing marbles rolling on the surface**. *After discussing the limitations of this Spandex model in modelling Newtonian gravity, I'll move to discuss the mass distribution that produces a similar well in general relativity, exploring in a semi-quantitative way Wheeler's oft-cited quote: "Matter tells space how to curve. Space tells matter how to move."*

**While rolling marbles on stretched Spandex is a great way to engage students in the subtleties of celestial orbital phenomena, everything from precession to escape velocity to the Roche limit to tides to planetary rings, many in the blogosphere point out the perils of conflating gravity wells and embedding diagrams—linguistic caution is warranted. See "The shape of The Spandex and orbits upon its surface," Gary D. White and Michael Walker, Am. J. of Phys., 70 (1) January, 2002, pp. 48-52, and the comment by Don S. Lemons and T. C. Lipscombe, Am. J. of Phys., 70 (10) October, 2002, pp. 1056-1058.*

Shawn Wilder

Stability of approximate Killing fields and black hole spin

In relativistic physics, a precise definition of a black hole's angular momentum is possible only when its horizon possesses an axial symmetry. Unfortunately most black hole horizons have no such symmetry. However, it is possible to pose an eigenvalue problem that has solutions corresponding to any manifold's "approximate Killing fields." This allows one to generalize formulae requiring symmetry to cases where no symmetry is present and thus define, for example, the spin of an arbitrary black hole. This talk will discuss work using perturbation theory of a horizon to quantify the stability of quantities generalized in this way. We will present precise conditions for the stability of solutions to the eigenvalue problem, and discuss potential applications to numerical relativity.

Clifford M. Will [with Pierre Fromholz]

The Schwarzschild Metric: It's the Coordinates, Stupid!

Textbook derivations of the vacuum Schwarzschild metric are rather simple: write down the trial metric in "Schwarzschild coordinates, derive the Riemann, Ricci and Einstein tensors and solve the trivial first-order differential equations. While the spacetime is known to be unique, the coordinates are arbitrary, and can be changed to isotropic, Eddington-Finklestein, or harmonic coordinates, to name just a few popular choices. Einsteins equations can also be formulated as a flat-spacetime wave equation whose source in vacuum contains the famous Landau-Lifshitz pseudotensor. In this talk we will describe how to find the Schwarzschild solution from this approach, using harmonic gauge a priori. It turns out to be much more complicated. We will also discuss the curious fact that a strange constant of integration appears in the calculation (not the mass). If the constant is zero, we obtain the Schwarzschild metric in harmonic coordinates; if it is non-zero, the resulting 2nd order, non-linear differential equation has no obvious solution. This illustrates the maxim that, while coordinates have no physical significance, the right choice of coordinates up front can make the relativists life infinitely simpler.