Tenth Canadian Conference on General Relativity and Relativistic Astrophysics
Invited and Contributed Talks

May 16, 2003

Invited talks (Morning sessions)

Thomas Baumgarte: Numerical Simulations of Compact Binaries

Recent advances in numerical relativity have led to significant progress in the simulation of compact binaries. I will briefly review some of these developments, and will then discuss the current status of both initial value and evolution calculations for both neutron star and black hole binaries.

Kayll Lake: Directions in computer algebra for gr-qc and hep-th

Computer algebra applied to general relativity is now a mature and widely used tool. In this review I focus on some recent developments including interactive databases of exact solutions and the problem of visualization.

Hugh Couchman: Numerical Simulations of Cosmic Structure: Where are we now?

From the first credible cosmic structure simulations over 20 years ago, numerical models have made sustained improvements in realism and have proved an essential tool to investigate the formation, evolution and properties of cosmic structure. I will review the progress of these efforts and plot the future directions and challenges for numerical studies in this field.

Gabriela Gonzalez: Gravitational Wave Detectors: new eyes for physics and astronomy

Several interferometric gravitational wave detectors around the world are now starting to achieve better sensitivity to gravitational waves than ever before. I will describe the exciting prospects these detectors offer for physics and astronomy and review the rapid progress and present status of the detectors' sensitivities. I will also report on the progress made by the LIGO Science Collaboration in analyzing data produced by the LIGO and GEO detectors during the First Scientific Run.

Ramesh Naryan: Black Holes in Astrophysics

Astrophysicists have discovered many excellent black hole candidates, both in X-ray binaries and in the centers of galaxies. The masses of the candidates have been reliably measured by means of a variety of dynamical methods. Astrophysical black holes are often extremely luminous as they convert a fraction of the rest mass energy of accreting gas to radiation. Much of the radiation comes out in X-rays, which indicates that the radiating gas is very hot. Relativistic velocities have been observed both in the orbiting gas and in jets of ejected material. Also, very short time scale variability has been seen in some systems, indicating a very small linear size. All of these observations confirm the presence of a compact massive object with a deep gravitational potential. In addition, there is some evidence that black hole candidates do have event horizons.

Mike Turner: Understanding the Absurd Universe

The recent results of WMAP have made clear that as crazy as they seem, we have determined the basic features of the Universe: spatially flat and accelerating; comprised of 4% baryons, 29% nonbaryonic dark matter (including between 0.1% and 5% neutrinos), and 67% dark energy; with density perturbations characteristic of quantum fluctuations in a free scalar field. The challenge is to make sense of this. A better understanding of gravity may result from doing so (or may be crucial to doing so). These are exciting times in cosmology.

Valeri Frolov: Black Holes in a Spacetime with Large Extra Dimensions

After a brief review of known black hole solutions in a spacetime with large extra dimensions we discuss some aspects of black hole physics in ADD models. This discussion covers the following problems: Does a black hole emit radiation mainly into the brane? Can a black hole leave the brane as a result of the recoil effect during its Hawking evaporation? Particle motion and field propagation in a spacetime of a 5-dimensional rotating black hole; Bulk-black-hole–brane interaction in a spacetime with large extra dimensions.

Don Marolf: On the Status of Highly Entropic Objects

A subject of longstanding debate and interest is whether the consistency of black hole thermodynamics requires fundamental constraints on the equation of state of ordinary matter (e.g., "entropy bounds"). If true, this idea provides strong motivation for the so-called 'holographic principle.' However, arguments for such constraints remain controversial. This talk greatly expands one loophole in such arguments and provides related comments on the status of highly entropic objects.

Rob Myers: Quantum Gravity Phenomenology

Recent discussions have raised the question as to whether manifestations of quantum gravity may be experimentally accessible in the present day or in the near future. One suggestion is that the existence of a fundamental scale, such as the Planck scale in quantum gravity, may lead to modifications of the dispersion relations for particles at high energies. We apply effective field theory to this problem and identify dimension 5 operators that lead to cubic modifications of dispersion relations for scalars, fermions, and vector particles. Further we show that, for electrons, photons and light quarks, clock comparison experiments bound these operators at $10^{-5}/M_{\rm planck}$.

Ingrid Stairs: Pulsar Tests of General Relativity: Status and Prospects

Radio pulsars make possible several different tests of relativistic gravity. This talk will review pulsar timing and discuss both tests of equivalence principle violations and the experiments in which predicted strong-field effects are compared directly with observations. Results from various recent and on-going pulsar surveys will also be summarized, highlighting new pulsars that hold promise for the next generation of tests.

Mathematical relativity (Afternoon session 1A)

Richard Woodard: Plane Waves in A General Robertson-Walker Background

I present an exact solution for the plane wave mode functions of a massless, minimally coupled scalar propagating in an arbitrary homogeneous, isotropic and spatially flat geometry. The solution encompasses all previous solvable cases such as de Sitter and power law expansion. Moreover, it can generate the mode functions for gravitons. I discuss some of the many applications that are now possible.

Tina Harriott and Jeff Williams: Kink Spacetime with a Scalar Field Source

A kink solution in 2+1 dimensions is extended to 3+1 and used to develop a rotating spacetime, which has a scalar field source. The spacetime has constant curvature, closed timelike curves and a kink.

It is shown that the inclusion of a pressureless fluid (dust) allows the usual energy conditions to be satisfied.

Ryan Kerner: Dynamical N-body Equilibrium in Circular Dilaton Gravity

We obtain a new exact equilibrium solution to the N-body problem in a one-dimensional relativistic self-gravitating system. It corresponds to an expanding/contracting spacetime of a circle with N bodies at equal proper separations from one another around the circle.

Norbert Van den Bergh: Purely magnetic vacuum solutions

A review is presented of the recently obtained results for vacuum solutions of the Einstein field equations for which the electric part of the Weyl tensor is identically zero.

Edward Glass: A Spacetime in Toroidal Coordinates

We have constructed an exact solution of Einstein's field equations in toroidal coordinates. The solution has three regions: an interior with a string equation of state; an Israel boundary layer; an exterior with constant isotropic pressure and constant density, locally isometric to anti-de Sitter spacetime. The exterior can be a cosmological vacuum with negative cosmological constant. The size and mass of the toroidal loop depend on the size of the cosmological constant.

Ivan Booth: Canonical Phase Space Formulation of Quasilocal General Relativity

I will discuss a Hamiltonian formulation of quasilocal general relativity on an extended phase space that includes boundary coordinates as configuration variables. With this formulation, Hamiltonian techniques may be used to derive an expression for the energy of a non-isolated region of space-time that interacts with its neighbourhood. Connections to the Brown-York quasilocal energy and applications to black hole mechanics will be discussed.

Sanjeev Seahra: Embedding theorems and higher-dimensional physics

We review some classical embedding theorems from differential geometry and discuss their application to current higher-dimensional theories in physics, such as braneworld scenarios. Special attention is paid to the (generalized) Campbell-Magaard theorem, which states that an n-manifold with arbitrary intrinsic geometry can be locally embedded in an (n+1)-manifold sourced by a cosmological constant.

Bob Wood: Critical phenomena on curved manifolds

The unusual properties of physical systems near their critical points suggest that critical phenomena offer a rich arena to probe some novel aspects of nature. One striking feature that emerges as a system approaches a critical point is the onset of scale invariance. This feature is considered within a gravitational context of conformal metric fluctuations of the metric.

David Garfinkle: Critical collapse of a massive vector field

We perform numerical simulations of the critical gravitational collapse of a massive vector field. The result is that there are two critical solutions. One is equivalent to the Choptuik critical solution for a massless scalar field. The other is periodic.

Classical cosmology (Afternoon session 1A)

Mustapha Ishak: From an Inverse Problem in General Relativity to a Possible Solution for the Acceleration problems

I will describe an inverse problem that can be stated as follows: Given a spacetime M, what kind of fluid, if any, could generate M via the Einstein's equations? This question is addressed for non-conducting fluids and a class of space-times that includes many cases of interest. It is shown that the velocity field is uniquely determined from the condition of zero-flux. Invariant necessary conditions for perfect fluid sources are derived. In some cases these conditions are also sufficient (Ishak and Lake 2003). I will follow with interesting links to the acceleration problems: What is driving the acceleration of the Universe? Why is it happening during the present epoch of the cosmic evolution? It is shown that if we relax the "perfect fluid" assumption about the nature of Dark Matter, in a way that is compatible with the cosmological principle, an explanation for the acceleration problem of the Universe is possible (Ishak 2003). This possibility is compatible with Supernovae and CMB observations.

Jonas Mureika: The Packed Swiss Cheese Cosmology and Multifractal Large-Scale Structure in the Universe

The notion that large-scale galaxy clustering is not homogeneous has its origins in the hierarchical clumping of Charlier. Recent analyses of deep redshift surveys confirm that at least locally galaxies seem to exhibit preferential clustering behavior. This "fractal" structure is in strict violation of the Cosmological Principle and associated Friedmann-Robertson-Walker solutions to Einstein's Equations, which demand homogeneity and isotropy throughout. A resolution of this contradictory stance is found in the Packed Swiss Cheese (PSC) Cosmology, which represents an exact solution to the field equations at all points and exhibits both local inhomogeneity with global homogeneity. This talk will present results of multifractal structure analyses of various instances of PSC clustering in open, closed, and flat spacetimes. These are compared to both redshift data and simulated models of large scale galaxy clustering, to assess the viability of the PSC cosmology as a formation candidate for the observed structure. The use of multifractal analysis as a test for global curvature will also be discussed, in light of these results.

Woei Chet Lim: Asymptotic isotropization in inhomogeneous cosmology

It is part of the folklore of relativistic cosmology that, roughly speaking, all ever-expanding cosmological models with a positive cosmological constant asymptotically approach the de Sitter solution. In this paper, we define the notion of a cosmological model being future asymptotic to de Sitter and then derive asymptotic expansions for the key physical and geometrical quantities for this class of models. We show that the asymptotic expansions contain eight arbitrary functions, implying that this class forms a general family of cosmological models. Our results thus provide support for the cosmic no-hair conjecture.

Conrad Hewitt: The Exceptional Bianchi Cosmologies

We consider the asymptotic states at early, late and intermediate times of the so-called exceptional class of orthogonal Bianchi cosmologies. We provide strong evidence for an oscillatory initial singularity. Since these models are generic amongst the Bianchi cosmologies admitting a G2, their analysis provides insight into the evolution of both G2 cosmologies, and cosmological models with even less symmetry.

Quantum black holes (Afternoon session 1B)

Gabor Kunstatter: d-Dimensional Black Hole Area Spectrum from Quasi-normal Modes

Starting from recent observations about quasinormal modes, we use semi-classical arguments to derive the area spectrum of d-dimensional spherically symmetric black holes. We find the area spectrum to be equally spaced. By requiring the Bekenstein-Hawking entropy of the corresponding black hole states to have a statistical mechanical entropy one can predict the general form of the large damping quasinormal modes of d-dimensional black holes. This prediction has recently been confirmed by explicit analytic calculations.

Saurya Das: Varying Fine Structure Constant and Black Hole Physics

Recent astrophysical observations suggest that the fine structure constant $\alpha = e^2/\hbar c$ may be slowly increasing with time. This may be due to an increase of e or a decrease of c, or both. In this article, we argue from model independent considerations that this variation should be considered adiabatic. Then, we examine in detail the consequences of such an adiabatic variation in the context of a specific model of quantized charged black holes. We find that the second law of black hole thermodynamics is obeyed, regardless of the origin of the variation, and that interesting constraints arise on the charge and mass of black holes. Finally, we estimate the work done on a black hole of mass M due to the α variation.

Olaf Dreyer: Black Hole Entropy from Near Horizon Symmetries

We shed some new light on an attempt to count the microstates of a black hole by looking at symmetries of the classical space time in the near horizon region. A natural way to obtain these symmetries is shown and the required pahse space methods are developed.

Jorma Louko: Geons, spinors, and thermality

Several derivations of the Hawking-Unruh effect on maximally extended nonextremal black hole spacetimes rely on the existence of two exterior regions separated by a bifurcate Killing horizon. We discuss quantum field theory on geon-type, single-exterior black holes in which the exterior regions have been identified by a suitable isometry. Previous scalar field analyses have shown that thermal effects are present only in a suitable asymptotic sense at early or late times, and the non-thermal correlations carry information about the spacetime region behind the horizons. We show that similar conclusions hold for fermions, and the non-thermal correlations then also contain information about the spin structure. Similar phenomena arise for fermions on topologically analogous versions of the Rindler spacetime. [Based on joint work with Paul Langlois.]

Holography (Afternoon session 1B)

Sergey Solodukhin: Horizon and Holography

I will discuss a holographic correspondence between a Conformal Field Theory living on horizon and space-time physics. The elements of the correspondence include: revealing an asymptotic conformal symmetry at horizon; computation of conformal weights and 2-point functions for scalar perturbations; reconstruction of the scalar field and the metric from the data given on horizon. Applications to de Sitter space will be discussed in some detail.

Wenfeng Chen: N=2 Four-dimensional Conformal Supergravity from N=4 Five-dimensional Gauged Supergravity and the Holographic Supercurrent Anomaly

N=4 gauged supergravity in five dimensions admits an AdS_5 classical solution that preserves the full N=4 supersymmetry. We show explicitly that near such a vacuum configuration, the on-shell N=4 gauged five-dimensional supergravity multiplet reduces to the off-shell N=2 conformal supergravity multiplet on the four-dimensional AdS_5 boundary. Correspondingly, The N=4 supersymmetric transformation of the five-dimensional gauged supergravity near AdS_5 vacuum converts into the one for the N=2 conformal supergravity in four dimensions. Further, we consider the Maldacena's AdS/CFT correspondence conjecture, and believe that there should exist a correspondence between the AdS_5 gauged supergravity and the large-n limit of a four-dimensional N=2 supersymmetric SU(n) gauge theory at the fixed point of its renormalization flow. Based on this consideration, we reproduce the γ-trace anomaly of the supersymmetry current of N=2 supersymmetric SU(n) gauge theory in four dimensions from the five-dimensional N=4 gauged supergravity, which shares a superconformal anomaly multiplet with the chiral R-symmetry anomaly and the trace anomaly. All these results provide a test and support to the AdS/CFT conjecture at the low-energy level and in the large-n limit.

Robert Mann: Nutty Black Holes and the (A)dS/CFT Correspondence

The corresponendence conjecture relating conformal field theories and (anti) de Sitter spacetimes has led to some intriguing conjectures in gravitational theory, including the proposal that de Sitter spacetimes have maximal mass and entropy. I examine the proposal for Nut-charged de Sitter Black holes, computing the action, entropy and conserved mass associated with such spacetimes. In certain instances the mass and entropy can exceed that of pure de Sitter spacetime, in violation of recent suggestive conjectures to the contrary.

Amir Masoud Ghezelbash: Mass and N-bound conjectures violation

We apply a recent proposal for defining conserved mass in asymtotically de Sitter spacetimes to the class of Taub-Bolt-dS spacetimes. We compute the action, entropy and conserved mass of these spacetimes, and find that in certain instances the mass and entropy can exceed that of pure ds sitter spacetimes, in violation of suggestive conjectures to the contrary.

Cristian Stelea: Nuttier Bubbles

We construct new nutty bubble spacetimes that are time-dependent solutions of the vacuum Einstein field equations with cosmological constant. These solutions describe spacetimes with non-trivial topology that are analytic continuations of higher dimensional topological NUT-charged spacetimes. We also construct the nutty bubbles corresponding to NUT charged spacetimes in odd dimensions and we explicitly construct such spaces in 5, 7 and 9 dimensions. The existence of such spacetimes with non-trivial topology is closely related to the existence of the cosmological constant.

Eric Woolgar: The Anti-de Sitter soliton and string-inspired problems in relativity

The anti-de Sitter soliton is a globally static vacuum spacetime with negative cosmological constant and toroidal Penrose conformal boundary. Remarkably, it has negative mass (in a certain reasonable sense). Reasoning from the AdS/CFT correspondence, Horowitz and Myers conjectured a new "positive" mass theorem that the soliton has least mass in its asymptotic class. I review recent work with my collaborators Galloway and Surya, wherein we prove a weaker conjecture, that AdS solitons are the unique static, non-nakedly singular, negative mass Einstein spacetimes with toroidal Penrose boundary and negative mass (obeying a certain asymptotic condition). For fixed mass, there is in fact an infinity of AdS solitons, determined by choice of flat structure on the toroidal Penrose boundary and the selection of a distinguished closed curve there. This non-uniqueness has a physical consequence discovered by Page: it leads to zero temperature phase transitions in the CFT. Time permitting, I will discuss some other open conjectures in relativity that are motivated by the AdS/CFT correspondence conjecture.

Brane worlds (Afternoon session 1B)

Dejan Stojkovic: Black hole as a point radiator and recoil effect in the brane world models

A small black hole attached to a brane in a higher dimensional space emitting quanta into the bulk may leave the brane as a result of a recoil. We construct a field theory model in which such a black hole is described as a massive scalar particle with internal degrees of freedom. In this model, the probability of transition between the different internal levels followed by emission of massless quanta is identical to the probability of thermal emission calculated for the Schwarzschild black hole. The discussed recoil effect implies that the thermal emission of the black holes, which might be created by interaction of high energy particles in colliders, could be terminated and the energy non-conservation can be observed in the brane experiments.

Martin Snajdr: Interaction of a Brane with a Moving Black Hole

We study the interaction of an n-dimensional topological defect (n-brane) described by the Nambu-Goto action with a higher-dimensional Schwarzschild black hole moving in the bulk spacetime. We derive the general form of the perturbation equations for an n-brane in the weak field approximation and solve them analytically in the most interesting cases. We specially analyze applications to brane world models. We calculate the induced geometry on the brane generated by a moving black hole. From the point of view of a brane observer, this geometry can be obtained by solving $(n+1)$-dimensional Einstein's equations with a non-vanishing right hand side. We calculate the effective stress-energy tensor corresponding to this 'shadow-matter'. We explicitly show that there exist regions on the brane where a brane observer sees an apparent violation of energy conditions. We also study the deflection of light propagating in the region of influence of this 'shadow matter'.

Quantum cosmology (Afternoon session 2A)

Koray Karaca: A Physical Model for Dimensional Reduction and Its Effects on the Observable Parameters of the Universe.

In this work, we investigate the possibility of describing the universe in higher dimensions during inflationary pre-matter phase of the universe by adopting the Gliner and Markov picture of Planck limits to physical quantities and assume that the universe exits from inflation when the temperature reaches Planck temperature T_{pl}.

David Craig: Generalized Quantum Theory of Homogeneous Cosmologies

A sum-over-histories generalized quantum theory is developed for homogeneous, minisuperspace, type A Bianchi cosmological models, focussing on the particular example of the classically closed Bianchi IX universe. It is shown how the probabilities of decoherent sets of alternative, coarse-grained histories of these model universes may be calculated. The decoherence functional for such universes is exhibited, and evaluated explicitly for the closed FRW cosmology for certain coarse grainings and specific choices of initial state.

Amjad Ashoorioon: Search for a Fingerprint of Planck-Scale Physics in the CMB

In most inflationary models, the successful predictions for the CMB spectrum come at the price of assuming the validity of conventional QFT down to distances on the order of the Planck length. This raises the question whether and to what extent Planck scale physics may have left an imprint in the CMB. I report on work which investigates the case of string inspired uncertainty relations. In particular, we study their effect on a solid prediction of inflation, namely, the consistency relation between the scalar/tenser ratio and the spectral index.

Andrei Frolov: Inflation and de Sitter Thermodynamics

We consider the quasi-de Sitter geometry of the inflationary universe. We calculate the energy flux of the slowly rolling background scalar field through the quasi-de Sitter apparent horizon and set it equal to the change of the entropy (1/4 of the area) multiplied by the temperature, $dE = TdS$. Remarkably, this thermodynamic law reproduces the Friedmann equation for the rolling scalar field. Next we add inflaton fluctuations which generate scalar metric perturbations. Metric perturbations result in a variation of the area entropy. Again, the equation $dE = TdS$ with fluctuations reproduces the linearized Einstein equations. In this picture as long as the Einstein equations hold, holography does not put limits on the quantum field theory during inflation.

Quantum gravity (Afternoon session 2A)

Frederic Leblond: SD-branes and rolling tachyons

I will describe recent progress in our understanding of SD-branes in string theory from the perspective of supergravity.

Oliver Winkler: Modified dispersion relations due to quantum gravity: will they be observable?

The idea that we might be able to observe quantum gravity effects in the propagation of cosmic rays, in particular gamma ray bursts, has caused great excitement in the quantum gravity community, and justifiably so. As a result, many proposals for the possible form of these modified dispersion relations have been proposed. We think, however, that it is also necessary to carefully investigate whether other physical effects could blur or mask these quantum gravity effects.In this talk we will discuss a first step in that direction, that is modified dispersion relations due to classical gravitational scattering.

Stephen Fairhurst: Modeling the Low Energy Limit of Loop Quantum Gravity: Shadow States and Quantum Mechanics

Analyzing the low energy limit of loop quantum gravity poses several conceptual difficulties. We illustrate these problems and their solutions in a simple toy model, by constructing a new quantum theory of the non-relativistic point particle that mimics the 'polymer representation' of quantum geometry. Though inequivalent to the standard Schrdinger theory, it agrees with the latter in the regime of validity of non-relativistic quantum mechanics. In particular, we show that for this model it is possible to identify semi-classical states and we show that the expectation values of interesting observables are peaked around their classical values with small fluctuations in these semi-classical states. Furthermore, we show that one may define a Hamiltonian and demonstrate that its eigenstates and eigenvalues are close to the corresponding eigenstates and eigenvalues in the Schrdinger representation, in the low energy limit. Even in this simple model some subtleties are encountered and we remark on these as well.

Achim Kempf: Aspects of Information Theory on Curved Space

If there is a natural ultraviolet cutoff in nature, does it constitute a bound on the density of information? I propose to address this question by using a branch of information theory called sampling theory. Sampling theory is the theory of special classes of functions: functions which if known merely at arbitrary discrete points can be reconstructed everywhere, assuming the samples' spacing is small enough. The maximum spacing for the reconstructibility of physical fields could be around the Planck length.

Herbert Lee: Noncommutative probability, matrix models, and quantum orbifold spacetimes

Inspired by the intimate relationship between Voiculescu's noncommutative probability theory (of type A) and large-N matrix models in physics, we look for physical models related to noncommutative probability theory of type B. These turn out to be fermionic matrix-vector models at the double large-N limit. They describe different quantum orbifold spacetimes with boundaries. Their critical exponents coincide with that of ordinary quantum spacetime, but their renormalised tree-level one-boundary amplitudes differ.

Astrophysical relativity (Afternoon session 2B)

Bojan Losic: Backreaction effects in cosmological perturbation theory

We examine aspects of higher order perturbation theory about deSitter spacetime.

Steven Detweiler: Radiation Reaction and the Principle of Equivalence

A charged particle in free-fall near the Earth accelerates and, consequently, must radiate and lose energy. However, the principle of equivalence implies that an observer falling with the particle sees no acceleration, no radiation and, therefore, no energy loss. Recent analysis shines new light on this old apparent paradox.

Etienne Racine: A surface integral derivation of post-1-Newtonian equations of motion for systems of N arbitrarily structured bodies

We discuss a matched asymptotic expansion / surface integral derivation of post-1-Newtonian equations of motion for a system of arbitrarily structured bodie admitting a post-Newtonian expansion of its metric in the region far from each body. These equations have previously been obtained by Damour, Soffel and Xu for weakly self-gravitating bodies by integrating the conservation law of the stress energy tensor over a given body. The approach we present makes use of their powerful formalism and has the advantage of extending the validity of their equations to a large class of strongly self-gravitating compact objects. It als has the advantage of using far field quantities only, i.e. no integrals over quantities with non-compact support are needed. Applications of the present work are likely to be found in consistency checks of numerical codes evolving binary inspirals of compact objects in the regime where they are widely seperated.

Patrick Sutton: Swift Pointing and the Association Between Gamma-Ray Bursts and Gravitational-Wave Bursts

The currently accepted model for gamma-ray burst phenomena involves the violent formation of a rapidly rotating solar mass black hole. Gravitational waves should be associated with the black-hole formation, and their detection would permit this model to be tested, the black hole progenitor (e.g., coalescing binary or collapsing stellar core) identified, and the origin of the gamma rays (within the expanding relativistic fireball or at the point of impact on the interstellar medium) located. Even upper limits on the gravitational-wave strength associated with gamma-ray bursts could constrain the gamma-ray burst model. To do any of these requires joint observations of gamma-ray burst events with gravitational and gamma-ray detectors. Here we examine how the quality of an upper limit on the gravitational-wave strength associated with gamma-ray burst observations depends on the relative orientation of the gamma-ray-burst and gravitational-wave detectors, and apply our results to the particular case of the Swift Burst-Alert Telescope (BAT) and the LIGO gravitational-wave detectors. A result of this investigation is a science-based "figure of merit" that can be used, together with other mission constraints, to optimize the pointing of the Swift telescope for the detection of gravitational waves associated with gamma-ray bursts.

Warren Anderson: Looking for Merging Black holes wih LIGO

LIGO (the Laser Interferometer Gravitational wave Observatory) is a USA funded facility to observe gravitational waves (one of a network of such detectors being built around the world). The merger of black holes in a binary black hole system is one of the most promising sources for first detection of these waves, which were predicted to exist as early as 1916 by Einstein, but still have not been directly observed. I will describe the way in which gravitational waves from such systems are currently searched for, and work in progress to design improved detection algorithms.

Laszlo Gergely: Gravitational radiation reaction in compact binary systems: Quadrupole - monopole and magnetic dipole - magnetic dipole contributions

We study the gravitational radiation reaction in compact binary systems composed of neutron stars with spin and huge magnetic dipole moments. Both the spins and the magnetic dipole moments undergo precessional motions about the angular momentum and the spin directions, respectively. The quadrupole - monopole contribution is of second post-Newtonian order. At sufficiently high values of the magnetic dipole moments, the magnetic dipole - magnetic dipole interaction also generates second post-Newtonian order contributions both to the equations of motion and to the gravitational radiation escaping the system. We parametrize the radial motion and average over a radial period in order to find the secular contributions to the energy and magnitude of the orbital angular momentum losses, in the generic case of eccentric orbits. We deduce the secular evolution of the relative orientations of the orbital angular momentum and spins due to both type of effects. These equations, supplemented by the evolution equations for the angles characterizing the orientation of the dipole moments form a first order differential system, which is closed. The circular orbit limit of the energy loss agrees with the corresponding earlier results of Poisson and Ioka-Taniguchi, respectively.

Sheldon Campbell: Photon Propogation Near Rapidly Rotating Neutron Stars

In general relativity, strong gravitational fields and rapid rotation generate a number of observable effects, including gravitational lensing and frame dragging. I will present new results of a code which traces the paths of photons that are emitted from a rapidly rotating neutron star and detected by an observer at infinity. Phenomenologically, the spacetime about an isolated rapidly rotating neutron star is that generated by a stationary rigidly rotating perfect fluid whose stress-energy tensor is dependant on the equation of state for the stellar matter. Assuming black body emission, the results include dependance of the signal's flux on the star's luminosity, mass, spin, and equation of state. These results have the potential to introduce new constraints on equations of state if the thermal spectrum of a rapidly rotating neutron star is observed.

Vahid Rezania: On the angular momentum conservation of bursting shell during the Type I X-ray bursts

We study the spin-down of a neutron star atmosphere during the Type I X-ray burst in low mass X-ray binaries. Using polar cap acceleration models, we show that the resulting stellar "wind" torque on the burning shell due to the flowing charged particles (electrons, protons and ions) from the star's polar caps may change the shell's angular momentum during the burst. We conclude that the net change in the angular momentum of the star's atmosphere can account for rather large frequency drifts observed during Type I X-ray burst.

Coire Cadeau: On Type I X-ray bursts and angular momentum conservation

Type I X-ray bursts are thermonuclear flashes occurring on the surface of accreting neutron stars in low mass X-ray binaries. Type I X-ray bursts generally exhibit oscillatory brightness, at a frequency thought to be largely determined by the angular velocity of the underlying star and angular momentum conservation; in particular, an expected increase in frequency as the burning matter falls back to the underlying star has been observed from a variety of sources (see Strohmayer and Bildsten, 2003 for a review). If correct, this model also predicts a latitude dependence on the frequency of burst oscillations. We present an analysis of some public data from NASA's Rossi X-ray Timing Explorer satellite examining whether such an effect is observable.

David Hobill: Gravitational lensing in compact binaries

Gravitational lensing is analyzed for binary pulsar systems in "eclipsing binary orbits". While image resolution can be considered to be nearly impossible, Shapiro delays, path length differences, image formation times, and lens magnifications are capable of producing measurable changes in pulse shape profiles. Given that a high resolution radio source mapping of the Galaxy is now underway, it is likely that many more pulsars will be discovered. Templates of expected pulse profiles for compact binaries should provide a means for discovering new and interesting systems.

Sharon Morsink: Nonlinear saturation of neutron star r-modes

Rotating neutron stars have oscillation modes which can be driven unstable by gravitational radiation. The effect of the instability is for the star's rotational kinetic energy to be radiated away by gravitational radiation until some critical slowest rotation speed is reached when the instability turns off. The main problem with this picture is that the predictions are made using linear perturbation theory. However, the physical system is nonlinear. As a result, the original linearized theory can't make any predictions about the maximum size that the perturbations can grow to. In this talk, I will discuss recent calculations in the weakly nonlinear regime which shed some light on the processes that cause the instability to saturate.