Titles and Abstracts

Robert Bartnik

Title: Mass-Minimizing Metrics and Critical Points of the Energy Functional

Abstract: This talk will describe a Hilbert structure on the space of asymptotically flat 3-metrics, with respect to which the total energy and the constraint sets are smooth submanifolds. A fundamental formula relates the constraints and the preferred Hamiltonian, extended "off-shell", to constrained variations of the total energy. Constrained Critical points correspond to static and stationary metrics, assuming some natural but challenging conjectures.

Hubert Bray

Title: On Dark Matter, Spiral Galaxies, and the Axioms of General Relativity

Abstract: In this talk we will discuss geometric axioms for general relativity with a cosmological constant (dark energy) and a real valued scalar field satisfying the Klein-Gordon equation. We will discuss the possibility considered by some astrophysicists that similar scalar fields may describe dark matter, which is thought by many to compose most of the mass of galaxies. We will then compute the galactic potentials which result from some approximate solutions to the Einstein-Klein-Gordon equations with angular momentum, which are roughly rotating potentials with ellipsoidal level sets. We will then discuss the possibility that rotating ellipsoidal galactic potentials may be connected to spiral patterns observed in galaxies.

Mihalis Dafermos

Title: The Black Hole Stability Problem

Michael Douglas

Title: Effective Potentials for Kaluza-Klein Theories

Abstract: String theory and M theory are formulated in 10 and 11 dimensional space-time, so to describe our 4 dimensional universe the extra dimensions must form a small compact manifold X. Most work on this follows the Kaluza-Klein approach, and works with supergravity, with a few important modifications due to string/M theory.

After a brief overview, we formulate and solve the problem of defining an effective potential, a function on the space of metrics and other fields on X, whose critical points are solutions of the higher dimensional Einstein-generalized Maxwell or supergravity equations. We conjecture that this effective potential is bounded below, a problem which mathematically is a close relative of the Yamabe problem and the positive energy conjectures.

Michael Eichmair

Title: Some Results on Scalar Curvature Rigidity

Abstract: I will explain two results that characterize $\mathbb{S}^3$ and $\mathbb{RP}^3$ among manifolds whose scalar curvature is bounded below by 6 by the area of their isoperimetric surfaces. The work on $\mathbb{RP}^3$ is joint with H. Bray, S. Brendle, and A. Neves. I will also describe some recent work with P. Miao and X. Wang on the extension of a result by Y. Shi and L. Tam that is closely related to the scalar curvature rigidity of $\mathbb{R}^n$ and the positive mass theorem.

Greg Galloway

Title: Marginally Trapped Surfaces in 2+1 and Higher Dimensional Gravity

Abstract: Marginally outer trapped surfaces (MOTSs) have long been associated with the development of singularities in spacetime and the existence of black holes. In recent years a number of mathematically rigorous properties of MOTSs have been established. We will discuss some of these properties in connection with the existence of black holes in 2+1 dimensions, as well as the topology of black holes in higher dimensions. The work in 2+1 dimensions is joint with Kristin Schleich and Don Witt.

Gary Gibbons

Title: Antimatter in the Looking Glass

Gary Horowitz

Title: Uniqueness of Extremal Kerr and Kerr-Newman Black Holes

Abstract: The original proofs of the uniqueness of Kerr and Kerr-Newman black holes only applied to nondegenerate horizons. I will show how Mazur's proof of uniqueness can be extended to extremal black holes as well. This is now possible using a couple of recent results in the theory of black holes.

Gerhard Huisken

Title: Monotonicity and Rigidity Estimates for the Evolution of Hypersurfaces

Abstract: The evolution of hypersurfaces by their mean curvature or their inverse mean curvature leads to monotonicity formulae and sharp inequalities between geometric quantities. The lecture explains several examples of this phenomenon and relations to General Relativity.

James Isenberg

Title: Gluing at Asymptopia and the Relativistic N-body Problem

Abstract: In gluing together distinct initial data sets which correspond to astrophysical systems like black holes or stars, one would like the resulting glued solution to have a single connected asymptotic region. The standard gluing methods for the Einstein constraint equations do not generally do this. Here, we discuss two new gluing approaches which do:
A) In work with Jack Lee and Iva Stavrov, we show that one can glue collections of (constant mean curvature) asymptotically hyperbolic (AH) initial data sets in neighborhoods of points on the conformal boundaries of those sets, thereby obtaining an AH solution with a single connected conformal boundary.
B) In work with Piotr Chrusciel and Justin Corvino, we show that, given a collection of asymptotically Euclidean (AE) solutions of the constraints and a choice of an interior region in each, one can construct a new single AE solution which contains copies of each of those regions, placed in an array of one's choice (up to scale), with chosen initial relative velocities.

Sergiu Klainerman

Title: Formation of Trapped Surfaces I

Hans Lindblad

Title: The Weak Null Condition and the Asymptotic Behavior of Solutions to Einstein's Equations

Igor Rodnianski

Title: Formation of Trapped Surfaces II

Richard Schoen

Title: On the High Dimensional Positive Mass Theorem

Abstract: We will describe a method for extending the minimal hypersurface proof of the positive mass theorem to high dimensions (greater than 7). The approach involves extending the existence and partial regularity theory for volume minimizing hypersurfaces to a setting in which the hypersurface is constrained to lie in a singular submanifold of a smooth manifold.

Yuguang Shi

Title: Geometric Problems Related with Quasilocal Mass In General Relativity

Abstract: Quasilocal mass is an important notion in General Relativity. On the other side, it is also an interesting geometric quantity in view point of differential geometry. In this talk we will discuss positivity of Brown-York mass and its generalizations. Some related geometric problems will also be discussed.

Avy Soffer

Title: Price Law for All Angular Momentum

Abstract: I will describe a proof of Price Law for general Schwarzschild geometry, for initial data with a fixed angular momentum, as predicted by the original works of Price. I then show how to get an estimate for general initial data: this involves controlling the large l (angular momentum) estimates, uniformly in l. This is established by a combination of WKB analysis and a new a-priori estimate using the Mourre estimate and semi classical propagation estimates. This last part is used to control energies which are equal to the "top of the barrier" potential, coming from the photon-sphere.

Robert Wald

Title: Derivation of Gravitational Self-Force

Abstract: We analyze the issue of "particle motion" in general relativity by considering a one-parameter family of metrics, $g_{ab}(\lambda)$, corresponding to having a body (or black hole) that is "scaled down" to zero size and mass in an appropriate manner. We prove that the limiting worldline of such a one-parameter family must be a geodesic of the background metric, $g_{ab}(\lambda = 0)$. Gravitational self-force–as well as the force due to coupling of the spin of the body to curvature–then arises as a first-order perturbative correction in λ to this worldline. No assumptions are made in our analysis apart from the smoothness and limit properties of the one-parameter family of metrics.

Mu-Tao Wang

Title: Limit of Quasilocal Energy-Momentum at Infinity

Abstract: I shall first review the recent definition of quasilocal energy-momentum by Yau and myself. The definition is derived from the Hamiltonian formulation of GR where isometric embeddings into the Minkowski space are used as references. A canonical gauge choice (by requiring equal expansions) is used to identify frames along the physical and reference surfaces and Killing fields are transplanted through this identification. The quasilocal mass satisfies the important positivity and rigidity properties, but is nevertheless rather nonlinear. We show that at infinity of an asymptotically flat spacetime, the quasilocal energy gets linearized and regains the Lorentzian symmetry. In particular, it recovers the ADM energy-momentum and Bondi energy-momentum at spatial infinity and null infinity, respectively.