Title : "Wave extraction using Weyl scalars, a numerical application"

Abstract:

Weyl scalars are an important tool for wave extraction on simulation of numerical space-times, the key features of such a methodology being gauge independence. However, in order to get meaningful results they need to be calculated in the right tetrad, the so called quasi-Kinnersley tetrad.
We present a numerical study concerning the evolution of a non-linearly perturbed black hole described by the Bondi-Sachs metric.
So far such a system has been extensively studied and several results about the gravitational wave signal emitted have been produced. Unfortunately, the techniques used are limited to this framework and cannot be extended to other formulations like, for example, ADM. Here we compare the results obtained in the Bondi framework with our new results using Weyl scalars. Such approach has the advantage of being extendible to any formulation of Einstein's equations.
We show that the two approaches give in this particular case results which are in very good agreement.

Preserving the Constraints in Numerical Relativity

Lee Lindblom, Theoretical Astrophysics, Caltech

The exponential growth of constraint violations is one of the most urgent problems facing the numerical relativity community today. These constraint violations cause most numerical solutions of the Einstein evolution equations quickly to become unphysical and large (and then to crash the code). I will describe several recent advances by the Caltech numerical relativity group in controlling the growth of these constraints, including the results of some 3D non-linear numerical tests of these ideas for dynamical black-hole spacetimes. These new constraint control ideas include constraint preserving boundary conditions, optimal constraint projection, and some new constraint suppressing forms of the evolution equations.

Initial data forms the starting point of any evolution. For simulations of binary black hole coalescence, the initial data should resemble as closely as possible a snapshot of a "true" inspiraling binary black hole. The quasi-equilibrium method combined with inner boundary conditions based on isolated horizons, provides a promising approach toward astrophysical initial data. In this talk, I describe this method and present numerical results. Furthermore, I report recent results about non-unique solutions of the Einstein constraint equations.

Title: Coherent network analysis of Gravitational Wave Burst signals
Abstract:
Gravitational wave (GW) burst signals, from sources such as a Supernova core collapse or Binary Black Hole mergers, have either unpredictable or unreliably known waveforms. Hence, the detection and reconstruction of the sky position and GW polarization waveforms of a burst signal is not amenable to matched filtering as used for binary inspiral or other well modeled sources. Algebraically, given a sufficient number of misaligned GW detectors, it is possible to reconstruct the sky direction and the two GW polarization waveforms of such a GW burst. The question is, how best to achieve this in the presence of instrumental noise. There have been many different attempts at solving this so called inversion problem. In this talk, I will give a brief review of the topic and present the details of a new approach that I and collaborators have developed (gr-qc/0508068).

Speaker : Dr. Teviet Creighton (JPL)
Title : Measuring properties of pulsar populations using LIGO

Abstract:

Gravitational waves provide a direct probe of the structure of spinning neutron stars. LIGO data has already been used to set constraints on the non-axisymmetric mass distribution of individual known pulsars, using Bayesian methods. In this talk, I present recent work in using such methods to constrain or measure aggregate properties of pulsar populations. This offers the possibility of placing tighter constraints than are achieved using only individual pulsars, as well as yielding information of more general astrophysical interest.

Galaxies are not static, spherical structures. In this talk, we will explore the surprising consequences of building dynamical models with more realistic galaxy shapes.

First, we'll discuss the interplay between supermassive black holes and triaxial galaxies. Most elliptical galaxies are triaxial in shape, and therefore contain many more plunging and chaotic orbits than an isotropic spherical galaxy. We have modelled the gravitational capture and inspiral rate in an N-body generated triaxial model, and find the capture rate is several orders of magnitude higher than the canonical estimate. We will discuss the peculiar stellar dynamics found in triaxial galaxies and what this implies for the problem of loss cone refilling.

Next, we'll discuss barred galaxies. A stellar bar changes not only the galaxy's disk, but the dark matter halo that surrounds the galaxy, as well. We'll discuss the controversial results of recent state-of-the-art N-body simulations that clearly show that the central density of a dark matter halo flattens as the bar torques it. This may provide a clue to the riddle of the dark matter halo cusp/core paradox. This evolution is mediated by resonant interactions between orbits in the halo and the bar pattern speed, as predicted by a 'new' theory of galaxy dynamics called linear perturbation theory. We'll review this theory, and discuss its implications and limitations.

TITLE: "Accurate Time-domain simulations of Extreme-Mass-Ratio Binaries"

ABSTRACT:
The description of Extreme-Mass-Ratio Binary systems (EMRBs) is a challenging problem in gravitational wave physics with significant relevance for the planned laser interferometric space antenna (LISA).
The main difficulty lies in the evaluation of the effects of the small body's gravitational field on its trajectory. To that end, an accurate computation of the perturbations produced by the small body with respect the background geometry of the large object, a massive black hole, is required. In this talk I present a new time-domain computational method based on the Finite Element Method that produces accurate simulations and at the same time provides smooth waveforms. We discuss the relevance of this method for achieving accurate descriptions of EMRBs.