Classical and Quantum Gravity

iopscience.org/cqg

Highlights

A selection of highly interesting articles chosen by the Editorial Board
Articles published in 2012 by subject area

- black holes 14%
- cosmology 16%
- experimental studies of gravity 13%
- general relativity 29%
- higher-dimensional gravity and other theories of gravity 3%
- numerical relativity (and other approximation methods) 5%
- quantum fields in a curved spacetime 4%
- quantum gravity 8%
- string theory and supergravity 8%

CQG Impact Factor

CQG’s Impact Factor has risen steadily for several years. The most recent Impact Factor of **3.320** puts the journal at an all-time high.

Papers accepted for CQG by quality rating

- 2008
- 2009
- 2010
- 2011
- 2012

- 2008
- 2009
- 2010
- 2011
- 2012

- high quality
- good quality
- borderline quality
Welcome

Clifford M Will
Editor-in-Chief

2012 was a great year for Classical and Quantum Gravity (CQG). Along with the award of yet another record Impact Factor (3.320), the journal recorded a clear improvement in the quality of accepted articles (shown opposite).

This rise in quality is partly due to continued improvement of CQG’s peer review, enabled by the journal’s extensive Advisory Panel of senior referees (see p7). Further improvements in quality have come from CQG’s focus issues, which are summarized throughout this brochure, and from topical reviews (p11).

In 2012, I was very pleased to learn that winners were selected for both of the thesis prizes sponsored by CQG. In this brochure, you can read interviews with the prize winners: Dr Aron C Wall (p15) and Dr John Miller (p22).

I hope that you enjoy reading the CQG Highlights: the Editorial Board’s selection of some of the most interesting articles published between mid-2011 and mid-2012. I would like to thank all of the journal’s authors, referees and board members for their contribution to the ongoing success of CQG.

From the Publisher

Adam Day
Publisher

I am delighted to bring you this overview of the latest CQG Highlights.

Throughout 2012, we implemented a number of innovations to improve the functionality of CQG’s content. The enhanced HTML article format continues to offer new features and the recent semantic enrichment of IOPscience already enables accurate linking of relevant papers on IOPscience. Watch CQG for more novel features in the coming months.

I hope that you will enjoy reading this brochure and I invite you to publish your next paper with CQG.
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Journal scope

Published twice monthly (24 issues per year), *Classical and Quantum Gravity* publishes original research articles on the subjects of gravitational physics and the theory of spacetime. The readership comprises theorists and experimentalists in physics, mathematics and cosmology.

Papers are published in the following areas.

- Classical general relativity
- Applications of relativity
- Experimental gravitation
- Cosmology and the early universe
- Quantum gravity
- Supergravity, superstrings and supersymmetry
- Mathematical physics relevant to gravitation

The journal publishes the following types of articles.

- **Research papers.** Reports of novel and interesting research work; not normally more than 8500 words (14 journal pages).
- **Fast Track Communications.** Short, timely papers presenting important new developments. Fast Track Communications (FTCs) have a strict length limit of eight journal pages (5000 words). FTCs are given prime importance in the journal. Authors submitting an FTC should accompany their manuscript with a short statement outlining why they believe the work merits high-priority publication.
- **Special issue articles.** Invited papers of high interest, which are included in special issues of the journal.
- **Topical reviews.** Comprehensive review articles commissioned by the Editorial Board.
- **Brief reviews.** Short review articles reviewing rapid, recent progress commissioned by the Editorial Board.
- **Comments.** Brief articles that comment on a previously published *Classical and Quantum Gravity* article. The authors of the criticized paper may be invited to submit a Reply in response. Comments and Replies are not normally longer than 2500 words each.
- **Notes.** Brief articles that make a short, interesting point, which would not normally merit publication as a full paper but still make a useful and novel addition to the literature. They may highlight an interesting point, clarify a common misunderstanding or confusion, or present a short new result. Unlike Comments, they do not relate to a specific published article. Notes are not normally longer than 2500 words.

More information on each of these areas can be found at [iopscience.org/cqg](http://iopscience.org/cqg).
Editorial Board

The international Editorial Board oversees the scientific strategy of the journal and provides expert advice on the CQG peer review. The Editor-in-Chief is the final arbiter of the content and quality of the journal.

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Advisory Panel

The CQG Advisory Panel (AP) includes some of the best referees in gravitational physics. Members are invited to the panel after showing excellent judgment as regular referees for CQG. The AP provides quick and authoritative advice, which adds enormous value to the CQG peer review process.

| Name            | Institution                                      |
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Cosmology

INVITED ARTICLE

Inhomogeneity effects in cosmology

George F R Ellis

2011 Class. Quantum Grav. 28 164001

This article looks at how inhomogeneous spacetime models may be significant for cosmology. First it looks at how the averaging process may affect large scale dynamics, with backreaction effects leading to effective contributions to the averaged energy-momentum tensor. Secondly it considers how local inhomogeneities may affect cosmological observations in cosmology, possibly significantly affecting the concordance model parameters. Thirdly it presents the possibility that the universe is spatially inhomogeneous on Hubble scales, with a violation of the Copernican principle leading to an apparent acceleration of the universe. This could perhaps even remove the need for the postulate of dark energy.

“A comprehensive overview of the averaging problem and inhomogeneous models in cosmology.”

Comment from Editorial Board

Linearization of homogeneous, nearly-isotropic cosmological models

Andrew Pontzen and Anthony Challinor

2011 Class. Quantum Grav. 28 185007

The observational evidence that our universe is statistically isotropic is strong, but can never preclude a sufficiently small residual anisotropy. This work re-examines the ‘Bianchi’ models, a class of homogeneous but potentially anisotropic universes which include the normal, isotropic ‘Friedmann–Robertson–Walker’ models as a subset. We give a novel derivation of the Bianchi universes’ geometrical properties by enumerating ways to break the isotropy of maximally symmetric spaces. Then we find a systematic way to express dynamical behaviour of small anisotropies by linearising the Einstein equations in variables such as the shear. This exposes ways to evade traditional constraints on anisotropy (particularly those from nucleosynthesis, for instance).

“An interesting and very readable approach to homogeneous but anisotropic Bianchi cosmological models.”

Comment from Editorial Board
General formulation of general-relativistic higher-order gauge-invariant perturbation theory

Kouji Nakamura

2011 Class. Quantum Grav. 28 122001

A gauge-invariant treatment of general-relativistic higher-order perturbations on generic background spacetime is proposed. After reviewing a general framework of the second-order gauge-invariant perturbation theory, we show the fact that the linear-order metric perturbation is decomposed into gauge-invariant and gauge-variant parts, which was the important premise of this general framework. This means that the development of the higher-order gauge-invariant perturbation theory on generic background spacetime is possible. A remaining issue to be resolved is also discussed. This is a result of the author’s series of works on gauge-invariant perturbation theories.

Statistical anisotropy from anisotropic inflation

Jiro Soda

2011 Class. Quantum Grav. 28 083001

This is a review of an inflationary scenario with the anisotropic expansion and vector hair, named anisotropic inflation. It is the first counter example to the cosmic no-hair conjecture. It turns out that anisotropic inflation is an attractor solution in the presence of gauge kinetic functions and ubiquitous in supergravity. Remarkably, the anisotropy is at most of the order of the slow roll parameter. Nevertheless, anisotropic couplings induced by the vector hair give rise to the sizable statistical anisotropy in primordial fluctuations and the cross correlation between curvature perturbations and primordial gravitational waves, which can be tested using the CMB.

A well written review of anisotropic inflation and its observable consequences, a topic that has been very active recently.

Comment from Editorial Board
On the trace-free Einstein equations as a viable alternative to general relativity

George F R Ellis, Henk van Elst, Jeff Murugan and Jean-Philippe Uzan

2011 Class. Quantum Grav. 28 225007

A key problem for gravitational theory is the discrepancy between quantum field theoretic predictions for the vacuum energy density, and the dark energy density observed in cosmology. It is known that this discrepancy can be resolved by replacing the Einstein Field Equations by their trace-free part, independently assuming energy–momentum conservation. However, one has to check that, as well as preserving the standard cosmological equations, this does not destroy the junction conditions that underlie the use of standard stellar models. We confirm that no problems arise here: hence, the Trace-Free Einstein Equations are indeed viable for cosmological and astrophysical applications.

A very good presentation of a way of decoupling the cosmological constant from vacuum energy.

Comment from Editorial Board

Forthcoming focus issue
Autumn 2013
Astrophysical black holes
Guest editors:
Luciano Rezzolla and David Merritt

Did you know?
CQG always consults two independent referees when peer reviewing a manuscript
Topical reviews

These comprehensive review articles are commissioned by the Editorial Board of CQG and are among the most popular articles in the journal. Below are the topical reviews that were published in 2012.

| Title                                                                 | Author(s)                                      | Year | Journal                  | Volume | Page     |
|----------------------------------------------------------------------|------------------------------------------------|------|--------------------------|--------|----------|
| Quantum cosmology: effective theory                                  | Martin Bojowald                                 | 2012 | Class. Quantum Grav.     | 29     | 213001   |
| Black hole uniqueness theorems in higher dimensional spacetimes      | Stefan Hollands and Akihiro Ishibashi           | 2012 | Class. Quantum Grav.     | 29     | 163001   |
| Entanglement entropy from a holographic viewpoint                    | Tadashi Takayanagi                              | 2012 | Class. Quantum Grav.     | 29     | 153001   |
| Chaos, decoherence and quantum cosmology                            | Esteban Calzetta                                | 2012 | Class. Quantum Grav.     | 29     | 143001   |
| Chern–Simons forms in gravitation theories                          | Jorge Zanelli                                   | 2012 | Class. Quantum Grav.     | 29     | 133001   |
| Boundary conditions for the gravitational field                      | Jeffrey Winicour                                | 2012 | Class. Quantum Grav.     | 29     | 113001   |
| Statistical anisotropy from anisotropic inflation                   | Jiro Soda                                       | 2012 | Class. Quantum Grav.     | 29     | 083001   |
| Geometric inequalities for axially symmetric black holes             | Sergio Dain                                     | 2012 | Class. Quantum Grav.     | 29     | 073001   |
Quantum cosmology

Challenges for string cosmology

C P Burgess and Liam McAllister

2011 Class. Quantum Grav. 28 204002

We critically assess the twin prospects of describing the observed universe in string theory, and using cosmological experiments to probe string theory. For the purposes of this short review, we focus on the limitations imposed by our incomplete understanding of string theory. After presenting an array of significant obstacles, we indicate a few areas that may admit theoretical progress in the near future.

Excellent review providing a clear and alluring description of the current status and challenges in string cosmology.

Comment from Editorial Board

Loop quantum cosmology: a status report

Abhay Ashtekar and Parampreet Singh

2011 Class. Quantum Grav. 28 213001

Over the last decade, quantum geometry effects underlying loop quantum cosmology have been shown to resolve cosmological singularities, replacing them with quantum bounces. The rich Planck scale physics that results provides a novel conceptual framework for the early universe. When combined with specific scenarios, such as inflation, it provides concrete avenues to confront loop quantum gravity with observations. This topical review provides an overview of this rapidly evolving field. Special effort was made to make the subject readily accessible to three distinct communities: young researchers, quantum gravity experts and cosmologists.

An authoritative presentation of loop quantum cosmology. An important reference.

Comment from Editorial Board

Forthcoming focus issue

Autumn 2013

Massive gravity

Guest editor: Shunji Mukohyama

Scalars and gravity

Guest editor: David Langlois
Generalizing Galileons

Mark Trodden and Kurt Hinterbichler

2011 Class. Quantum Grav. 28 204003

The Galileons are a set of terms within four-dimensional effective field theories, obeying symmetries that can be derived from the dynamics of a (3 + 1)-dimensional flat brane embedded in a 5-dimensional Minkowski bulk. These theories have some intriguing properties, including freedom from ghosts and a non-renormalization theorem that hints at possible applications in both particle physics and cosmology. In this brief paper, we will summarize our attempts over the last year to extend the Galileon idea in two important ways. We will discuss the effective field theory construction arising from flat branes, of co-dimension greater than 1, embedded in a flat background—the multi-Galileons—and we will then describe symmetric covariant versions of the Galileons, more suitable for general cosmological applications. While all these Galileons can be thought of as interesting four-dimensional field theories in their own rights, the work described here may also make it easier to embed them into string theory, with its multiple extra dimensions and more general gravitational backgrounds.

"An elegant summary of the literature on Galileon theories."

Comment from Editorial Board
Strings, branes, supergravity and gauge theory

**String theory: a perspective over the last 25 years**

Sunil Mukhi

*2011 Class. Quantum Grav. 28 153001*

This review provides some historical background and then reviews developments in string theory over the last 25 years or so. The structure of the theory is explained in largely intuitive terms, highlighting how it incorporates our present understanding of particles and gravity and how it proposes to address the outstanding problems. Both perturbative and non-perturbative approaches to string theory are surveyed. Each of the four principal chapters concludes with a section “New Insights about Quantum Gravity” that summarises the concrete lessons learned about gravity at each stage.

*An excellent review of string theory, from its early days trying to understand its perturbative formulation, up to the current focus on non-perturbative issues.*

Comment from Editorial Board

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**The geometry and phase structure of non-relativistic branes**

Nabamita Banerjee, Suvankar Dutta and Dileep P Jatkar

*2011 Class. Quantum Grav. 28 165002*

The AdS/CFT correspondence, an example of the holographic paradigm, suggests an equivalence between a d-dimensional gravity theory and a (d-1)-dimensional gauge theory. Non-relativistic generalization of this correspondence is an interesting aspect of current research. The dual theories with Schrödinger isometry are useful for studying interesting condensed matter phenomena.

We use a solution generating technique, the TsT-transformation, to obtain new solutions, which enjoys asymptotic Schrödinger symmetry, in type-II string theory and M-theory. We work out examples of rotating M2-branes and D1-D5-p-system, which have interesting field theory duals. Finally, we have devised a noble method to study the thermodynamics and phase structure of these newly-found stringy solutions.

*A very detailed analysis of the application of TsT transformations to string and M-theory.*

Comment from Editorial Board
The Bergmann-Wheeler Thesis Prize

The Bergmann-Wheeler Thesis Prize is sponsored by Classical and Quantum Gravity and is awarded by the International Society for General Relativity and Gravitation (ISGRG). The prize celebrates two great pioneers of quantum gravity: Peter Bergmann (1915–2002) and John Wheeler (1911–2008).

The prize is awarded every three years for the best PhD thesis in quantum gravity. The winner of the prize will receive $1500 and a certificate. Nominations can be made at any time. Full guidelines can be found at isgrg.org.

The winner of the prize, to be awarded at the 20th General Relativity and Gravitation meeting in Warsaw in July 2013, is Dr Aron C Wall. The award was made for his original and insightful proof of a local form of the generalized second law of thermodynamics. Dr Wall completed his PhD under the supervision of Prof. Ted Jacobson at the University of Maryland.

Interview with Aron C Wall, Bergmann-Wheeler Thesis Prize winner

What led you into science and your chosen area of research?
When I was seven, I read a physics book from the children’s section of the library. At the end it said that subatomic particles were made out of quarks of three different “colors”, and that each particle was made of “one quark of each color”. I asked my Dad whether the book meant one, or at least one. So he took me to the grown-up section of the library to look at pop particle-physics books. In high school I was inspired by the online writings of John Baez to study quantum gravity.

What do you find most interesting about this subject?
There’s a lot of deep conceptual questions about how we should think about spacetime: is it discrete or continuous, what is it made out of, what things should count as observables, what is the role of thermodynamics and Lorentz invariance, that I find fascinating.

Can you tell us a little bit about the work in your thesis?
It’s a proof of the Second Law of Thermodynamics for black holes and other causal horizons. Even when the quantum fields falling into the black hole are rapidly evolving, the entropy increases at every point on the horizon. It’s been published as three separate articles, freely available on the arXiv (0901.3865, 1007.1493, 1105.3445).
Quantum gravity

Loop quantum gravity: the first 25 years

Carlo Rovelli

2011 Class. Quantum Grav. 28 153002

The loop approach to quantum gravity has developed very rapidly in the last 25 years. The paper gives a synthetic presentation of the present state of the theory and attempts a critical evaluation of its successes and its present limits.

Well written introduction to the covariant definition of loop quantum gravity.

Comment from Editorial Board

Holography for asymptotically locally Lifshitz spacetimes

Simon F Ross

2011 Class. Quantum Grav. 28 215019

Detailed analysis of the holographic correspondence has mostly focused on asymptotically anti-de Sitter spacetimes, which are related to relativistic conformal field theories. The extension to field theories with anisotropic scaling symmetry is of interest for condensed matter physics; a holographic dual is provided by the Lifshitz spacetimes. This paper extends key features of the holographic dictionary to these cases by defining asymptotically locally Lifshitz spacetimes and showing how holographic renormalization can be implemented for arbitrary boundary data. We can thus study these field theories on general backgrounds, and we also obtain a deeper understanding of a new example of holography.

This paper lays out foundational technology for “non-relativistic AdS/CFT” analogous to that now standard in the context of the original AdS/CFT correspondence.

Comment from Editorial Board

Forthcoming focus issue

Spring 2013

Higher spins and holography

Guest editor: Simon Ross

Did you know?

The highlights brochure is highly visible. It is distributed at gravitational physics conferences worldwide

16 | iopscience.org/cqg/highlights11-12
Many-node/many-link spinfoam: the homogeneous and isotropic case

Francesca Vidotto

2011 Class. Quantum Grav. 28 245005

Loop Quantum Gravity describes the evolution of “quanta of spacetime” in terms of a local product of interaction vertices (spinfoam), reconstructing a Lorentzian spacetime. The resulting transition amplitudes are computed between states, where the quantum geometry is captured by SU(2)-decorated graphs. These states can describe a homogeneous and isotropic geometry, and for Minkowski and de Sitter space, the resulting transition amplitudes yield the Friedmann equation. In this paper it is shown that this result holds independently of the particular graph used in the boundary states.

The first spinfoam calculation indicating that the amplitude may be stable under refinement of the boundary node.

Comment from Editorial Board

General covariance in gravity at a Lifshitz point

Petr Horava

2011 Class. Quantum Grav. 28 114012

Gravity may be the one force of nature we are intuitively most familiar with, but its theoretical understanding—despite the beauty of general relativity and string theory—is still shrouded in surprisingly many layers of mystery. Perhaps we already have all the pieces of the puzzle and just need to find the correct way of putting them together, or perhaps new ideas are needed. In this context, the idea of gravity with Lifshitz-type anisotropic scaling has attracted a lot of attention recently.

In this paper, we briefly review some of the main features of quantum gravity with anisotropic scaling, in its original formulation, and comment on its possible relation to the causal dynamical triangulations (CDT) approach to lattice quantum gravity. We then explain the construction of gravity with anisotropic scaling with an extended gauge symmetry—essentially a nonrelativistic version of general covariance. This extra symmetry eliminates the scalar graviton polarization, and thus brings the theory closer to general relativity at long distances.

Excellent review about the author’s proposal to treat gravity with an anisotropic scaling.

Comment from Editorial Board
Focus issue: Applications of holography to condensed matter physics

Guest editor: Simon Ross

The focus issue brings together original research contributions at the forefront of the rapidly developing use of holography to study the dynamics of strongly coupled systems in condensed matter physics. Work in this direction has led to new perspectives on fundamental topics such as superconductors and Fermi liquids. The aim of the focus issue is to highlight some of the recent developments and strengthen the connections between this direction and other gravitational research.

Twistorial phase space for complex Ashtekar variables

Wolfgang M Wieland

2012 Class. Quantum Grav. 29 045007

In a series of pioneering articles Dupuis, Freidel, Livine, Speziale and Tambornino developed a spinorial description of loop quantum gravity (LQG). They considered the case of real-valued Ashtekar variables, which however, inherited the notorious limitations of the $SU(2)$ formalism. When considering local Lorentz transformations only spatial rotations act linearly.

In this article I find a generalisation to the full Lorentz group. I take the phase space $SL(2,\mathbb{C})$ of complex Ashtekar variables on a spin-network graph, and decompose it in terms of twistors. To every link there are two twistors attached, one for each boundary point. This setting embeds the non-linear phase space $SL(2,\mathbb{C})$ into a vector space with canonical Darboux coordinates, and provides a new derivation of the solution space of the simplicity constraints of LQG.

An introduction of some twistorial methods into loop quantum gravity.

Comment from Editorial Board
The gravitational exclusion principle and null states in anti-de Sitter space

Alejandra Castro, Thomas Hartman and Alexander Maloney

2011 Class. Quantum Grav. 28 195012

The holographic principle implies a vast reduction in the number of degrees of freedom of quantum gravity. This idea can be made precise in AdS$_3$, where the stringy or gravitational exclusion principle asserts that certain perturbative excitations are not present in the exact quantum spectrum. We show that this effect is visible directly in the bulk gravity theory: the norm of the offending linearized state is zero or negative. When the norm is negative, the theory is signalling its own breakdown as an effective field theory; this provides a perturbative bulk explanation for the stringy exclusion principle. When the norm vanishes the bulk state is null rather than physical. This implies that certain non-trivial diffeomorphisms must be regarded as gauge symmetries rather than spectrum-generating elements of the asymptotic symmetry group. This leads to subtle effects in the computation of one-loop determinants for Einstein gravity, higher spin theories and topologically massive gravity in AdS$_3$. In particular, heat kernel methods do not capture the correct spectrum of a theory with null states.

A very interesting paper about the careful quantization of pure 2+1 AdS gravity when the cosmological constant is Planck scale.

Comment from Editorial Board

de Sitter invariance of the dS graviton vacuum

Atsushi Higuchi, Donald Marolf and Ian A Morrison

2011 Class. Quantum Grav. 28 245012

The two-point function of linearized gravitons on de Sitter space is infrared divergent in the standard transverse traceless synchronous gauge defined by $k=0$ cosmological coordinates (also called conformal or Poincaré coordinates). We show that this divergence can be removed by adding a linearized diffeomorphism to each mode function, i.e. by an explicit change of gauge. It follows that the graviton vacuum state is well defined and de Sitter invariant in agreement with various earlier arguments.

The IR behavior of de Sitter invariant graviton has always been a problem. Here it is clearly shown that the IR divergence can be removed by a simple gauge transformation.

Comment from Editorial Board
More about Birkhoff’s invariant and Thorne’s hoop conjecture for horizons

M Cvetic, G W Gibbons and C N Pope

2011 Class. Quantum Grav. 28 195001

A recent precise formulation of the hoop conjecture in four spacetime dimensions is that the Birkhoff invariant $\beta$ (the least maximal length of any sweepout or foliation by circles) of an apparent horizon of energy $E$ and area $A$ should satisfy $\beta \leq 4\pi E$. This conjecture together with the cosmic censorship or isoperimetric inequality implies that the length $\ell$ of the shortest non-trivial closed geodesic satisfies $\ell^2 \leq \pi A$. We have tested these conjectures on the horizons of all four-charged rotating black hole solutions of ungauged supergravity theories and found that they always hold. They continue to hold in the presence of a negative cosmological constant, and for multi-charged rotating solutions in gauged supergravity. Surprisingly, they also hold for the Ernst–Wild static black holes immersed in a magnetic field, which are asymptotic to the Melvin solution.

Publisher’s note: this abstract has been truncated to fit this page.

An interesting attempt to seek a precise formulation of Thorne’s hoop conjecture.

Comment from Editorial Board

Ricci solitons, Ricci flow and strongly coupled CFT in the Schwarzschild Unruh or Boulware vacua

Pau Figueras, James Lucietti and Toby Wiseman

2011 Class. Quantum Grav. 28 215018

In recent years it has become clear that numerical methods will be key in finding new black hole solutions. Building on previous work of one of the authors (TW), in this paper we consider the Einstein–DeTurck equation as an elliptic equation to be solved numerically as a boundary value problem. For static vacuum spacetimes with zero or negative cosmological constant we show that under suitable boundary conditions, all solutions to the Einstein–DeTurck equation must be Einstein. As an example, we numerically construct (using Ricci flow) the gravitational dual of $\mathcal{N} = 4$ super-Yang–Mills in the background of the Schwarzschild black hole.

A very good work on numerically finding stationary solutions, with an application to AdS/CFT.

Comment from Editorial Board
Fast Track Communications

Fast Track Communications (FTCs) are short, timely papers presenting important new developments. These articles are given prime importance in the journal. Below are the FTCs that were published in 2012.

A no-singularity scenario in loop quantum gravity
Martin Bojowald and George M Paily 2012 Class. Quantum Grav. 29 242002

On the uniqueness of kinematics of loop quantum cosmology
Abhay Ashtekar and Miguel Campiglia 2012 Class. Quantum Grav. 29 242001

Late inspiral and merger of binary black holes in scalar–tensor theories of gravity
James Healy, Tanja Bode, Roland Haas, Enrique Pazos, Pablo Laguna, Deirdre M Shoemaker and Nicolás Yunes
2012 Class. Quantum Grav. 29 232002

Renewed relevance of new tests of the equivalence principle involving intrinsic properties of particles and antiparticles
C S Unnikrishnan and George T Gillies 2012 Class. Quantum Grav. 29 232001

Cosmological solutions of massive gravity on de Sitter
David Langlois and Atsushi Naruko 2012 Class. Quantum Grav. 29 202001

Evidence for the continuum in 2D causal set quantum gravity
Sumati Surya 2012 Class. Quantum Grav. 29 132001

Geometrodynamics of spherically symmetric Lovelock gravity
Gabor Kunstatter, Tim Taves and Hideki Maeda 2012 Class. Quantum Grav. 29 092001

Emergence of general relativity from loop quantum gravity: a summary
Chun-Yen Lin 2012 Class. Quantum Grav. 29 082001

Canonical analysis and stability of Lanczos–Lovelock gravity
S Deser and J Franklin 2012 Class. Quantum Grav. 29 072001

Bounds on area and charge for marginally trapped surfaces with a cosmological constant
Walter Simon 2012 Class. Quantum Grav. 29 062001

Chirality of tensor perturbations for complex values of the Immirzi parameter
Laura Bethke and João Magueijo 2012 Class. Quantum Grav. 29 052001
IOP GPG Thesis Prize

The Gravitational Physics Group (GPG) Thesis Prize, sponsored by *Classical and Quantum Gravity*, is awarded for excellence in postgraduate research and communication skills in gravitational physics.

The winner receives £500, and is invited to speak at the annual Britgrav meeting organized by the GPG. Further information about the prize and the nomination procedure can be found on the GPG website at [gp.iop.org](http://gp.iop.org).

The 2011 GPG Thesis Prize was awarded to Dr John Miller, who completed his PhD at the University of Glasgow under the supervision of Prof. Ken Strain and Prof. Norna Robertson. The award was made for Dr Miller’s development of new techniques for improving the sensitivity of gravitational-wave detectors.

Interview with John Miller, IOP GPG Thesis Prize winner

**What led you into science and your chosen area of research?**

It appealed to me because it wasn’t a subjective pursuit – theories can be tested, measurements made. I was also influenced by some very enthusiastic and capable teachers while at secondary school. I chose to study gravitational wave detection following a particularly inspiring lecture on the subject given by Prof. Jim Hough during my first year at Glasgow. It seemed like a great challenge and I wanted to be involved. It is an interesting field because it encompasses so many different aspects of physics, from the very smallest scales (thermal noise and quantum fluctuations) to the very largest (astrophysics and cosmological models).

**Can you tell us a little bit about your thesis?**

My thesis is entitled ‘On non-Gaussian beams and optomechanical parametric instabilities in interferometric gravitational wave detectors’. It describes two experiments: the creation of a laser beam with a flat-topped intensity profile and the study of an electrostatic actuator for damping the normal modes of large mirrors. Each investigation aimed to solve a problem that could limit the sensitivity of second-generation gravitational wave interferometers. The thesis is available from the University of Glasgow Theses Service ([http://theses.gla.ac.uk/1869/](http://theses.gla.ac.uk/1869/)).

**What are you working on at the moment?**

Combining techniques from classical interferometry and digital telecommunications to develop new methods for controlling the position and orientation of the mirrors in future gravitational wave interferometers.
Numerical relativity

Robustness of the Blandford–Znajek mechanism

Carlos Palenzuela, Carles Bona, Luis Lehner and Oscar Reula

2011 Class. Quantum Grav. 28 134007

The Blandford–Znajek mechanism has long been regarded as a key ingredient in models attempting to explain powerful jets in AGNs, quasars, blazars, etc. In such a mechanism, energy is extracted from a rotating black hole and dissipated at a load at far distances. In this work we examine the behavior of this mechanism with respect to different boundary conditions, revealing the robustness of the mechanism upon variation of these conditions, and closing a gap in our understanding of this important scenario.

A beautiful combination of analytic and numerical techniques used to explore the method by which black holes produce jets.

Comment from Editorial Board

Special issue: Selected articles from the 9th Edoardo Amaldi meeting and the 2011 Numerical Relativity and Data Analysis meeting (Amaldi 9/NRDA 2011), Cardiff University, July 10–15 2011

Guest Editors: M Hannam, S Hild, P Sutton and C Van Den Broeck

From July 10–15 2011 the 9th Edoardo Amaldi Conference on Gravitational Waves and the 2011 Numerical Relativity and Data Analysis (NRDA) meeting were held at Cardiff University.

The Amaldi meetings cover all aspects of gravitational-wave science, while the NRDA meetings bring together numerical relativists who simulate sources of gravitational radiation, and data analysts who search for these signals in gravitational wave detector data. This is the first time the two meetings were held together, and the result was a week of stimulating science.

CQG Volume 29 Issue 12 contains selected articles that feature some of the best work presented at this conference
**Numerical Relativity**

**Geometrodynamics of spherically symmetric Lovelock gravity**

Gabor Kunstatter, Tim Taves and Hideki Maeda

2012 *Class. Quantum Grav.* **29** 092001

Einstein’s theory of gravity must undergo corrections at microscopic distances. Lovelock gravity is the simplest generalization that incorporates higher dimensions and higher curvature terms as suggested by string theory and quantum mechanics. We derive the Hamiltonian (i.e. energy function) for spherically symmetric Lovelock gravity in terms of geometrical variables. Remarkably, the result is as simple and elegant as that of its Einstein counterpart, supporting the interpretation of Lovelock gravity as the most natural higher-dimensional extension of general relativity. More importantly, this provides a crucial first step towards the study of the quantum mechanics and formation of generic Lovelock black holes.

*We expect that this paper will open up a whole new field of understanding critical phenomena in higher-derivative gravity theories.*

Comment from Editorial Board

**A conservation law formulation of nonlinear elasticity in general relativity**

Carsten Gundlach, Ian Hawke and Stephanie J Erickson

2012 *Class. Quantum Grav.* **29** 015005

Although the neutron star crust contributes only a small fraction to the total mass of the star, it is expected to affect the dynamics of systems where interface or crustal modes are excited. To model these, we have rewritten the elasticity formalism of Carter and Quintana in the form of conservation-laws for the stress-energy tensor and a configuration gradient, $\Psi^a$; the form is a clear extension of existing methods. We show that, with an appropriate constraint addition, the system is symmetric hyperbolic; this clarifies issues with constraints found in the Newtonian literature. We also perform various strongly non-linear numerical tests.

*An important first step towards more realistic modelling of astrophysical compact objects.*

Comment from Editorial Board
Focus section: Non-astrophysical numerical relativity

David Garfinkle and Luis Lehner

In this focus section we cover some of the non-astrophysical applications of numerical relativity, with an emphasis on recent uses of numerical relativity in high energy physics and quantum gravity.

Topics covered include higher dimensional black holes, the AdS/CFT correspondence, loop quantum cosmology, singularities, and corrections to general relativity. The articles cover not only the current state of the art in the numerical treatment of these subjects, but also strategies for choosing problems in these areas that can be effectively treated using numerical techniques and for crafting numerical techniques that can be applied to these problems.

Read the invited articles in CQG Volume 29 Issue 24

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Mathematical relativity

The well-posedness of the null-timelike boundary problem for quasilinear waves

H-O Kreiss and J Winicour

2011 Class. Quantum Grav. 28 145020

The null-timelike initial-boundary value problem for a hyperbolic system of equations consists of the evolution of data given on an initial characteristic surface and on a timelike worldtube to produce a solution in the exterior of the worldtube. We establish the well-posedness of this problem for the evolution of a quasilinear scalar wave by means of energy estimates. The treatment is given in characteristic coordinates and thus provides a guide for developing stable finite difference algorithms. A new technique underlying the approach has potential application to other characteristic initial-boundary value problems.

A proof of well-posedness of the quasi-linear wave equation for initial-boundary problems. This will interest numerical relativists.

Comment from Editorial Board

A note on the post-Newtonian limit of quasi-local energy expressions

Jörg Frauendiener and László B Szabados

2011 Class. Quantum Grav. 28 235009

In Newton’s theory, the energy of an isolated system which is contained inside a large sphere turns out to be decreasing towards the total energy of the system as the sphere-radius increases towards infinity. This is due to the negatively contributing binding energy of the gravitational field. This observation suggests that a reasonable quasi-local mass expression should inherit this property. The existing quasi-local mass expressions are discussed in this context. Motivated by the relativistically corrected Newtonian theory one can introduce an ‘effective’ quasi-local energy expression in exact GR which is shown to be positive definite under suitable circumstances.

An interesting discussion featuring a new formula for energy expressions in the post-Newtonian limit.

Comment from Editorial Board
Boundary conditions for the gravitational field

Jeffrey Winicour

2012 Class. Quantum Grav. 29 113001

There are no natural boundaries for the gravitational field analogous to the conducting boundaries in electromagnetism. Consequently, boundary conditions only recently received attention because of their importance for numerical relativity. It is now known how to treat boundaries in the harmonic formulation of Einstein’s equations and a tetrad formulation of the Einstein–Bianchi system but a universal approach valid for the 3+1 formulations, which have been highly successful in black hole simulations, is not in hand. I review the history of the problem, its complications and the progress that has been made from the geometrical, differential equation and computational perspectives. I present a bare bones framework whose flexibility might open new approaches to important open questions.

A very detailed discussion of the difficulties that make the initial-boundary-value problem much more complicated than the Cauchy problem.

Comment from Editorial Board

Forthcoming focus issue

Autumn 2013

Pulsar timing arrays

Guest editors:
Marie-Anne Bizouard, Fredrick Jenet,
Richard Price and C M Will

Did you know?

Highly interesting articles are often published with the ‘IOP select’ tag. This tag not only symbolizes high-quality work, but also makes the article free to read for one year.
Black holes

Black hole instabilities and local Penrose inequalities

Pau Figueras, Keiju Murata and Harvey S Reall

2011 Class. Quantum Grav. 28 225030

Whilst four dimensional black holes are believed to be stable against gravitational perturbations, in higher dimensions there is the possibility of black objects with unstable horizons. Solving the equations that govern the gravitational perturbations is very complicated. In this paper we develop a simpler method for demonstrating instabilities based on constructing initial data that violates a Penrose inequality. We apply this method to recover the Gregory–Laflamme instability and we confirm the existence of the ‘ultraspinning’ instability of Myers–Perry black holes. Finally we show that ‘fat’ black rings are unstable and find no evidence of any rotationally symmetric instability in ‘thin’ rings.

Comment from Editorial Board

There paper introduces a wonderful new way of identifying instabilities of black holes.

Geometric inequalities for axially symmetric black holes

Sergio Dain

2012 Class. Quantum Grav. 29 073001

A geometric inequality in general relativity relates quantities that have both a physical interpretation and a geometrical definition. It is well known that the parameters that characterize the Kerr–Newman black hole satisfy several important geometric inequalities. Remarkably enough, some of these inequalities also hold for dynamical black holes. These kinds of inequalities play an important role in the characterization of the gravitational collapse, they are closely related with the cosmic censorship conjecture. Axially symmetric black holes are the natural candidates to study these inequalities because the quasi-local angular momentum is well defined for them.

Comment from Editorial Board

A well written review on a topic of high interest in classical relativity.
Is there life inside black holes?

V I Dokuchaev

2011 Class. Quantum Grav. 28 235015

Bound inside rotating or charged black holes, there are stable periodic planetary orbits, which neither come out nor terminate at the central singularity. Stable periodic orbits inside black holes exist even for photons. These bound orbits may be defined as orbits of the third kind, following the Chandrasekhar classification of particle orbits in the black hole gravitational field. The existence domain for the third-kind orbits is rather spacious, and thus there is place for life inside supermassive black holes in the galactic nuclei. Interiors of the supermassive black holes may be inhabited by civilizations, being invisible from the outside. In principle, one can get information from the interiors of black holes by observing their white hole counterparts.

An interesting and provocative idea that has enriched our view on black hole interiors.

Comment from Editorial Board

Focus issue: Relativistic quantum information

Guest Editors: R B Mann and T Ralph

Over the past few years, a new field of high research intensity has emerged that blends together concepts from gravitational physics and quantum computing. Known as Relativistic Quantum Information, or RQI, the subject pulls together concepts and ideas from special relativity, quantum optics, general relativity, quantum communication, and quantum computation.

This focus issue provides the first summary of the state of the art in research in RQI. Some of the articles in this issue review the subject while others provide interesting new results that will stimulate further research. What makes the subject all the more exciting is that it is beginning to enter the stage at which actual experiments can be contemplated, and some of the articles appearing in this issue discuss some of these exciting new developments.

One of the articles in this issue, “Optical Black Hole Lasers” by D Faccio et al, received considerable attention in the science media including the New Scientist news article: “Black-hole laser edges closer to testing Hawking” by Lisa Grossman.

For further information and to read the invited articles see CQG Volume 29 Issue 22
Measuring the spins of accreting black holes

Jeffrey E McClintock et al

2011 Class. Quantum Grav. 28 114009

We report spin measurements for eight stellar-mass black holes, which are located in X-ray binary systems. We measure spin by fitting the thermal continuum spectrum of a black hole of known mass and distance to the thin-disk model of Novikov and Thorne, thereby determining the radius of the innermost stable circular orbit. We demonstrate the robustness of our results both theoretically via GRMHD simulations and empirically by making dozens or hundreds of observations of selected black holes. Our measured values of spin range widely from near-zero to near-extreme Kerr ($a/M > 0.98$).

Does an atom interferometer test the gravitational redshift at the Compton frequency?

Peter Wolf et al

2011 Class. Quantum Grav. 28 145017

Gravimeters based on atom interferometry have been used to test the universality of free fall on quantum test masses. Müller et al recently argued that they also provide a very accurate test of the gravitational redshift. We show that this claim is incorrect in a large class of theories, including general relativity, all metric theories of gravity, most non-metric theories and most theoretical frameworks used to interpret the violations of the equivalence principle. Theories in which atom interferometers would test the redshift pose serious problems, such as violation of the principle of least action and of energy conservation.
Cryogenic mechanical loss measurements of heat-treated hafnium dioxide

M R Abernathy et al

2011 Class. Quantum Grav. 28 195017

One of the limiting noise sources in advanced interferometric gravitational wave detectors is the brownian thermal noise arising within the mirror coatings applied to the test masses. It has been shown that the largest contribution to this thermal noise comes from the high refractive index coating material, tantalum pentoxide (tantala). In this paper, hafnium dioxide (hafnia) is considered as an alternative high-index coating material. The mechanical loss, which is directly related to thermal noise in the interferometer, of various hafnia coatings is measured within the temperature range of 10-310 K. It is observed that the mechanical loss of hafnia is below that of tantala at temperatures below 100 K—a region of interest for future cryogenic detectors. Furthermore, it was found that the hafnia coatings were partially-crystalline, which has been shown to increase mechanical loss in tantala. Silica doping of hafnia has been shown to prevent crystallization in hafnia, indicating an avenue for further improving the mechanical loss of hafnia coatings.

“Possibly the breakthrough for conquering mirror coating thermal noise to enhance the detection rate of gravitational waves.”

Comment from Editorial Board

Characterization of the Virgo seismic environment

T Accadia et al

2012 Class. Quantum Grav. 29 025005

The Virgo gravitational wave detector is an interferometer with 3km arms located in Pisa, Italy. Despite several techniques previously adopted to isolate the interferometer from the environment, seismic noise remains an important issue for Virgo. I stationed a seismometer at various locations around the Virgo site hosting major infrastructure machines. The primary aim of this study was to identify noisy machines which seismically affect the ITF environment and thus require mitigation attention. It was found that noise from several Virgo infrastructure devices, such as water chillers, heaters, and pumps, seismically affects sensitive parts of the interferometer.

“A new point of view to widen the observational frequency band towards lower frequency in gravitational wave detection.”

Comment from Editorial Board
Focus issue: Tests of the weak equivalence principle

Guest Editors: C C Speake and C M Will

This focus issue reviews the current status of tests of the weak equivalence principle, or the universality of free fall, which underlies all metric theories of gravity. In addition to an article on the theoretical implications of WEP, the issue covers laboratory experiments, lunar-laser ranging tests, binary pulsar tests, proposed tests of the free fall of antimatter, and future possible tests in space.

Read the invited articles in CQG Volume 29 Issue 18

Reduced basis representations of multi-mode black hole ringdown gravitational waves

Sarah Caudill, Scott E Field, Chad R Galley, Frank Herrmann and Manuel Tiglio

2012 Class. Quantum Grav. 29 095016

We further explore the reduced basis (RB) approach for modeling and representing gravitational waves as developed in Field et al (2011 Phys. Rev. Lett. 106 221102). While Field et al focused on a matched filter search for non-spinning compact binary coalescences in Advanced LIGO, we focus on single and multiple quasi-normal mode (QNM) black hole ringdown matched filter searches as a demonstration of the very compact and high accuracy representations possible in higher dimensional spaces. Multimode searches would allow one to test the no-hair theorem and to improve parameter estimation among other advantages. For a minimal match of 0.99 of signal with template in a traditional matched filter bank, we find only 737 RB waveforms needed for a GR-constrained two-mode search (1198 for unconstrained two-mode search). These numbers stand in contrast to the 3500 (3400000) traditional templates needed. In fact, we find that the RB waveforms are able to represent any QNM in the original bank with error less than $10^{-13}$, and any QNM in the continuum of the search space with error less than $9.8 \times 10^{-10}$.

A promising new method for template bank based match filtering analysis.
Comment from Editorial Board
An all-sky search algorithm for continuous gravitational waves from spinning neutron stars in binary systems

E Goetz and K Riles

2011 Class. Quantum Grav. 28 215006

Rapidly spinning, non-axisymmetric neutron stars in binary systems are attractive targets in searches for continuous gravitational waves. All-sky searches for sources of continuous gravitational waves located in unknown binary systems, however, are a notorious computational challenge. Expanding the parameter space of current searches for isolated sources to include unknown binary orbital parameters is impractical. We have developed an algorithm called TwoSpect that exploits the periodic orbital modulation of the source waves by searching for specific patterns in doubly-Fourier transformed data. This new method allows one to probe previously unexplored regions in the parameter space of continuous gravitational waves.

Very well written. Describes a gravitational wave data analysis pipeline to search for continuous waves emitted by pulsars in binary systems.

Comment from Editorial Board

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| 2 | DC readout experiment in Enhanced LIGO                                | Tobin T Fricke et al             | 2012 | 29     | 06    | 065005|
| 3 | Quantum cosmology: effective theory                                   | Martin Bojowald                  | 2012 | 29     | 21    | 213001|
| 4 | Optical black hole lasers                                             | Daniele Faccio, Tal Arane, Marco Lamperti and Ulf Leonhardt | 2012 | 29     | 22    | 224009|
| 5 | Entanglement entropy from a holographic viewpoint                      | Tadashi Takayanagi               | 2012 | 29     | 15    | 153001|
| 6 | The characterization of Virgo data and its impact on gravitational-wave searches | J Aasi et al                    | 2012 | 29     | 03    | 035003|
| 7 | Boundary conditions for the gravitational field                        | Jeffrey Winicour                | 2012 | 29     | 11    | 113001|
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| 9 | Theoretical aspects of the equivalence principle                      | Thibault Damour                 | 2012 | 29     | 18    | 184001|
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| 2    | High-accuracy gravitational waveforms for binary black hole mergers with nearly extremal spins | Geoffrey Lovelace, Michael Boyle, Mark A Scheel and Bélá Szilágyi | 2012 | Class. Quantum Grav.                  | 29     | 045003|
| 3    | Scientific objectives of Einstein Telescope                         | B Sathyaprakash et al                                                   | 2012 | Class. Quantum Grav.                  | 29     | 124013|
| 4    | Anomaly-free scalar perturbations with holonomy corrections in loop quantum cosmology | Thomas Cailleteau, Jakub Mielczarek, Aurelien Barrau and Julien Grain | 2012 | Class. Quantum Grav.                  | 29     | 095010|
| 5    | On horizon structure of bimetric spacetimes                         | Cédric Deffayet and Ted Jacobson                                        | 2012 | Class. Quantum Grav.                  | 29     | 065009|
| 6    | Detector configuration of KAGRA—the Japanese cryogenic gravitational-wave detector | Kentaro Somiya                                                         | 2012 | Class. Quantum Grav.                  | 29     | 124007|
| 7    | A complete classification of higher derivative gravity in 3D and critically 4D | Nobuyoshi Ohta                                                        | 2012 | Class. Quantum Grav.                  | 29     | 15002 |
| 8    | The Einstein Toolkit: a community computational infrastructure for relativistic astrophysics | Frank Löffler et al                                                    | 2012 | Class. Quantum Grav.                  | 29     | 115001|
| 9    | The NINJA-2 catalog of hybrid post-Newtonian/numerical-relativity waveforms for non-precessing black-hole binaries | P Ajith et al                                                           | 2012 | Class. Quantum Grav.                  | 29     | 124001|
| 10   | Statistical anisotropy from anisotropic inflation                   | Jiro Soda                                                               | 2012 | Class. Quantum Grav.                  | 29     | 083001|
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CQG has the best peer review of any gravitational physics journal. It is supported by the advice of the 78 top researchers who sit on the Editorial Board and Advisory Panel (p6–7). The reputation of the journal has risen steadily over the years as a result of constant improvement in the high standard of peer review. The profile of the quality ratings of published articles assigned by the referees during peer review shows this improvement very clearly (p2).

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