

AIMS-GHANA & RESEARCH ON QUANTUM GRAVITY

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AIMS-Ghana & University of Ghana

Next Einstein Initiative and Rural Prenatal Care in Ghana

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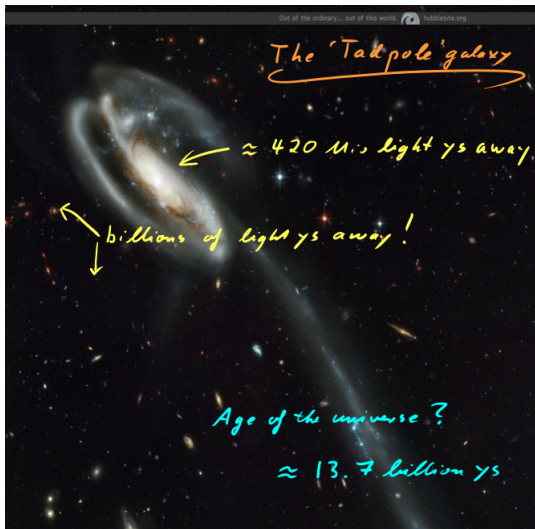
1 Research on Quantum Gravity

- Motivation
- Research Focus
- Others...

2 AIMS-Ghana

- Neil's vision = Our goal
- Academics
- Research
- Outreach

The universe as described by GR



Taken from hubblesite.org

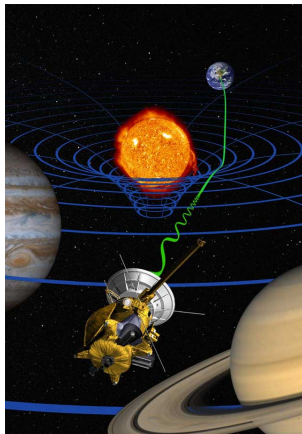
Einstein's General relativity

- Phenomena at large scales are governed by gravitational interactions
- Gravitation is inherent in the dynamic Riemannian geometry of spacetime
- Gravity is a property of spacetime

Formulation of GR

- Gravity = curvature of spacetime
- \implies curvature of spacetime is directly related to the energy and momentum of whatever matter and radiation are present.

Evidence of GR



Taken from Wikipedia

General relativity

Led to

General relativity

Led to

- cosmology
- relativistic astrophysics
- GPS

Leading us towards gravitational wave astronomy

Predicts

Predicts

- black holes
- gravitational waves
- expanding universe
- etc...

Quantum mechanics

- A theory for the microscopic world
- Shows that Phenomena at small scales are dominated by strong and electroweak interactions

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Quantum mechanics

Gave rise to

Quantum mechanics

Gave rise to

- particle physics
- atomic physics
- nuclear physics
- semiconductors
- computers

Formulation of QM

Quantum mechanics

- uses an external time variable or a fixed, non-dynamical background spacetime
- requires that any dynamical field be quantized, i.e. at small scales it manifests itself in discrete quanta governed by the laws of probability.

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- requires that any dynamical field be quantized, i.e. at small scales it manifests itself in discrete quanta governed by the laws of probability.

Formulation incompatible with general relativity!

Quantum gravity

- quantum gravity = quantum theory of spacetime

Quantum gravity

- quantum gravity = quantum theory of spacetime

QUESTION:

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- what then is the quanta of spacetime?
- how then does one describe a quantum spacetime?

Technical challenges:

Technical challenges:

- Einstein's general relativity is mathematically complicated
- Einstein's equations of motion which governs the theory of gravity are a set of highly non-linear differential equations which cannot be solve exactly.
- Even is a relatively simple case, one would require numerical techniques.

Approaches to quantum gravity

- perturbative quantum gravity
- canonical quantization & path integrals
- loop quantum gravity
- string theory

Approaches to quantum gravity

- perturbative quantum gravity
- canonical quantization & path integrals
- loop quantum gravity
- string theory
- noncommutative geometry
- Spin Foam

Research Focus

- Noncommutative structures in quantum gravity
- Spin Foam Models
- Others...

Proposal

Proposal

- quantum gravity will require or predict a new mathematical framework for differential geometry.

Proposal

- quantum gravity will require or predict a new mathematical framework for differential geometry.
- A candidate for such a framework is provided by noncommutative geometry

Noncommutative structures

Our focus

- a more general notion of geometry that by its noncommutative nature should be the correct setting for the phenomenology and testing of first next-to-classical quantum gravity corrections.
- the mathematical constraints of NCG may give us constraints on the structure of quantum gravity itself

Noncommutative structures

Our focus

- a more general notion of geometry that by its noncommutative nature should be the correct setting for the phenomenology and testing of first next-to-classical quantum gravity corrections.
- the mathematical constraints of NCG may give us constraints on the structure of quantum gravity itself
- in particular the role of quantum groups or Hopf algebras as the most accessible tool of NCG.

Some Results

- P. K. Osei and B. J. Schroers, On Semiduals of local isometry groups in 3d gravity, J. Math. Phys. 53, (2012) 073510, arxiv: 1109.4086v3 [gr-qc].
- P. K. Osei and B. J. Schroers, Classical r-matrices via semidualisation, J. Math. Phys. 54 (2013) 101702.
- P. K. Osei and B. J. Schroers, Classical r-matrices 3d gravity, in preparation.

Implications of Results

- This should lead to a coherent and precise scenerio of quantum gravity

Spin Foam Models

- Aimed at providing a non-perturbative and background independent quantisation of gravity via an auxiliary discretization.

Spin Foam Models

Our focus

- Study analogue spin foam and spin net models with q -deformed quantum groups
- understand the relation between them.

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Quantitative Risk Analysis

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- Credit and Operational risk

Quantitative market research for incremental Innovation

Using data to generate ideas for incremental product and service improvement

- Observation user
- Sales channel inputs
- Me too / me better
- Traditional quantitative marketing research

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Next Einstein Africa

- Neil's vision = Our goal

The result

Graduates who:

- are independent thinking

The result

Graduates who:

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- are technically strong
- are savvy

The result

Graduates who:

- are independent thinking
- are technically strong
- are savvy (entrepreneurial, at home, in academea/business/policy)

The result

Graduates who:

- have transferrable skills (software, English, groupwork, report)
- have African values.

How?

The AIMS model of pedagogy

How?

The AIMS model of pedagogy

- Skills, review, essay. (Balanced themes).
- Tutorial approach. (Problem based. Resident tutors.)
- Lectures of international MSc standard. (80% international.)

How?

The AIMS model of pedagogy

How?

The AIMS model of pedagogy

- Registration at 3 local universities. Local & International supervision.
- Academic quality (weekly reviews, continuing assessment).
- Network.
- Placement in Africa MPhil/PhD programmes (50% bursaries).

Research symbiosis

- Tutors are research active.
- Workshops.
- Weekly journal seminars.
- Evening and visiting seminars.
- Public lectures.
- Research visitors (short courses).



About 140km from Accra

BIRIWA CAMPUS - PRESENTLY



local

- University of Ghana
- University of Cape Coast
- Kwame Nkrumah University of Science and Technology

International

- Durham University, UK,
- Karlstad University, Sweden,
- Nanyang University, Singapore
- TU Chemnitz (Germany)
- Scottish Universities through the John Maxwell ICMS

- Board of Trustees
- Academic advisory board

40 students from 16 African countries made up of:

- 12 females and 28 males
- 14 Ghanaians and 26 Non-Ghanaians
- 4 Tutors

Graduation



2 Joint research Chair for AIMS-Gh/AIMS-SA & Canadian University partner

- Mathematical Biology - Immunology

BMBF Research Chair at AIMS-Ghana/University of Ghana

- Mathematical Modelling with differential equations
- Climate Modelling
- Water & Sanitation

Other research projects

- Rural Prenatal Care in Ghana
-

Workshops

- Annual workshop on differential equations
- Annual workshop on Mathematical Modelling

Outreach





Thank
you