Imperial College London

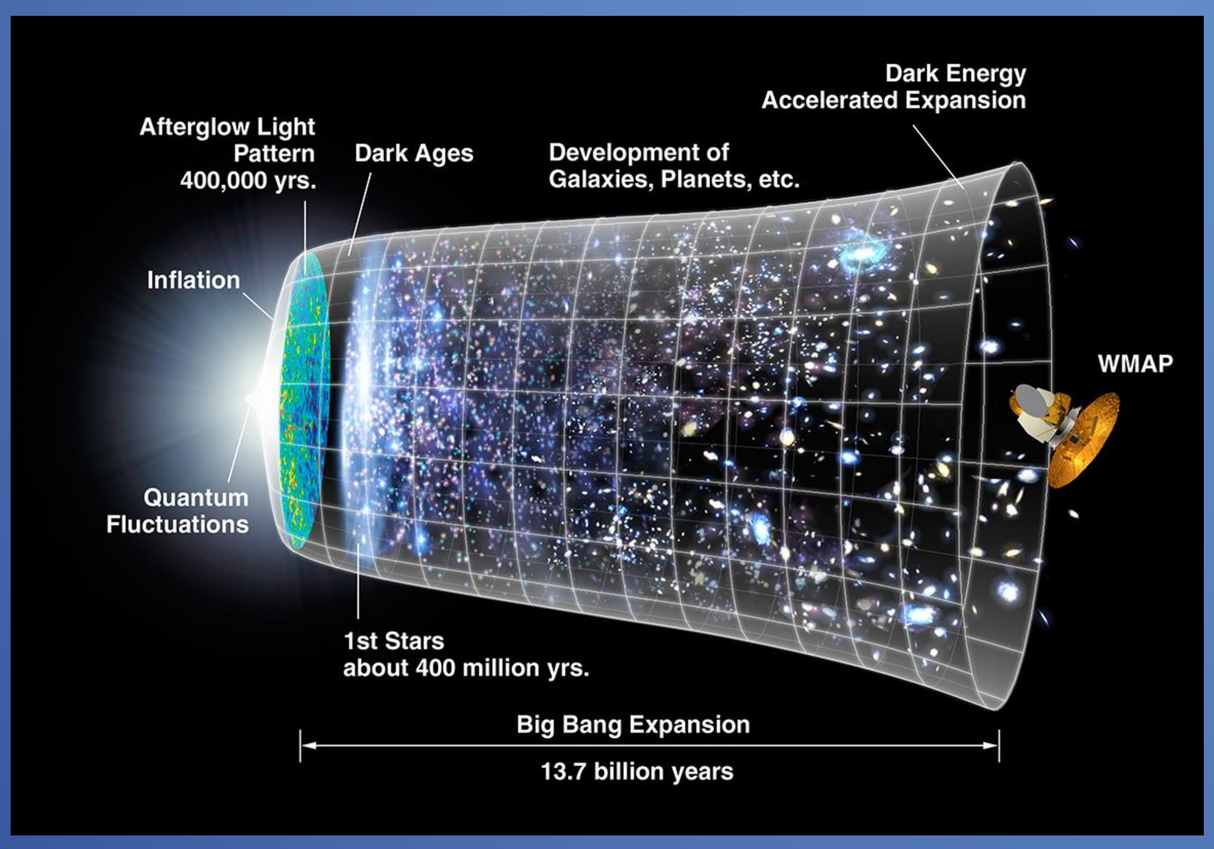
The work of the Theoretical Physics Group covers a wide range of research areas bound together by the theme of fundamental questions in cosmology, gravity, particle physics, and quantum theory.

Cosmology

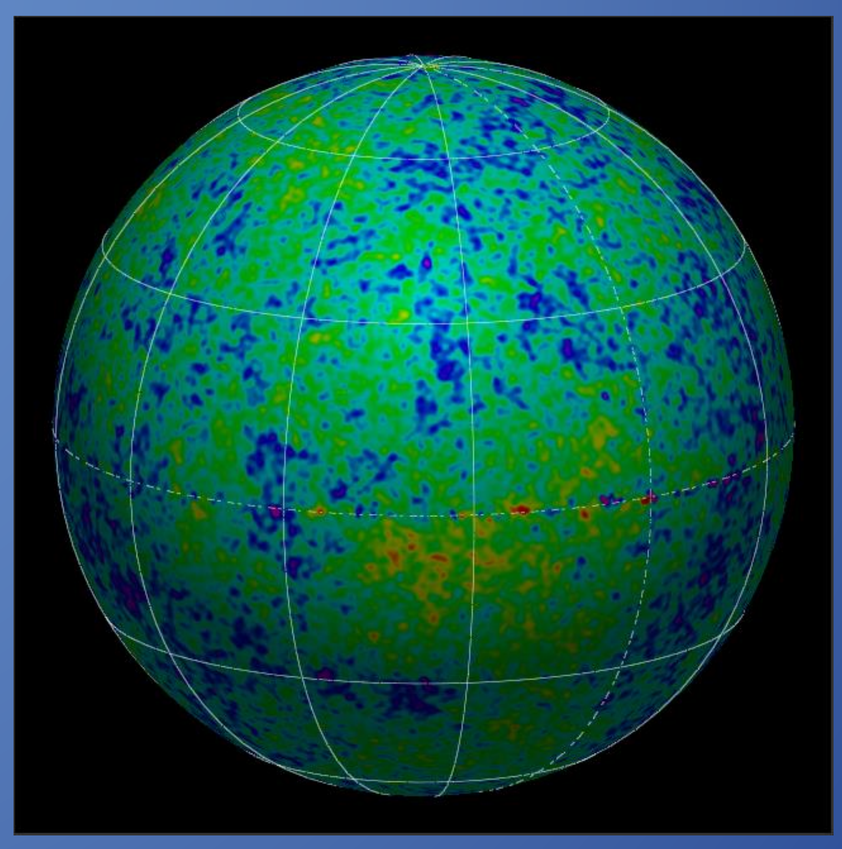
Cosmology links together the research of the group: fundamental physics will be tested by making cosmological predictions and cosmology needs fundamental physics to address outstanding questions. Cosmology is an experimental subject and as yet more detailed data on cosmic microwave background (CMB) fluctuations and Large Scale Structure (LSS) surveys arrives, our work continues in testing the detailed predictions of a number of cosmological models.

Some cosmological questions…

1) How can we use CMB experiments to find out more about the early universe?
2) Did the universe experience a period of inflation, and what was driving it?
3) Did cosmic strings play a role in structure formation?
4) Is Einstein's general relativity valid on cosmological scales?
5) How can we calculate the non-Gaussianity of CMB from first principles?

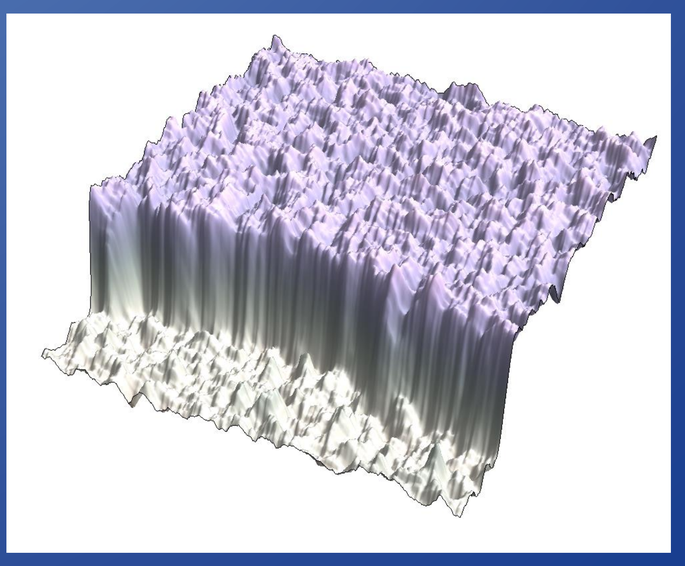


The CMB fluctuations observed by WMAP



Field Theory

Our research in quantum field theory covers a wide range of applications from particle physics and cosmology to effective theories of condensed matter systems and quantum gravity, and it even has connections with the theory of complex networks. We are particularly interested in topological defects and other non-perturbative aspects of field theories both in and out of equilibrium.



A configuration of a quantum field from a simulation

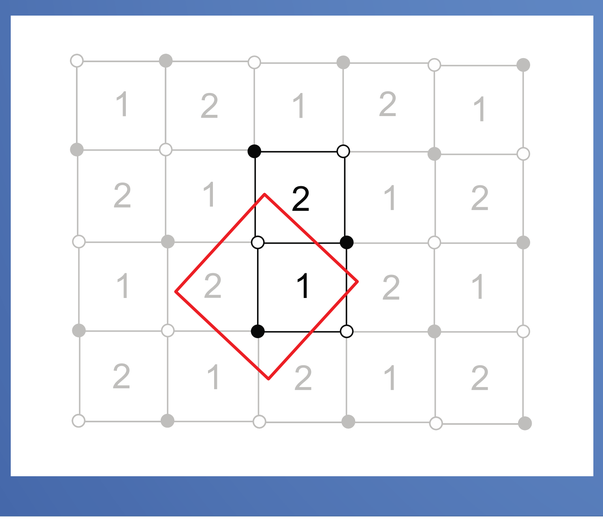
Theoretical Physics Group

String Theory

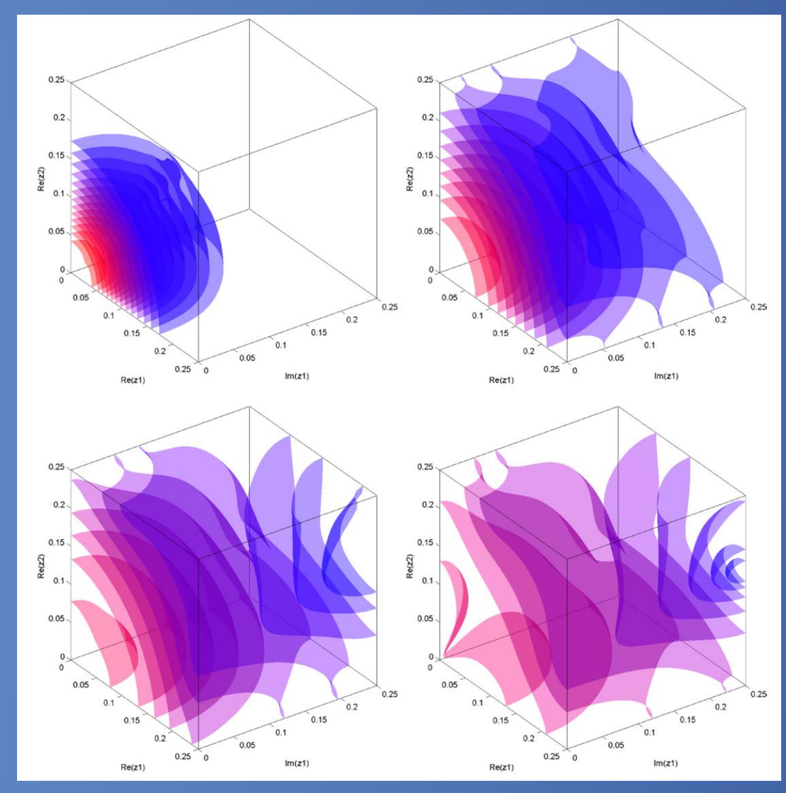
Superstring theory is now understood to arise from the more fundamental M-theory, in which strings are accompanied by higher dimensional extended objects, called branes. A crucial discovery is that quantum gravity and quantum field theory are different facets of a single structure. For example, the AdS/CFT correspondence relates conformal quantum field theory to string theory propagating on Anti de-Sitter (AdS) spacetime. This has revolutionised our understanding of strongly coupled quantum field theories and it may lead an analytic description of the strong-coupling dynamics of QCD, solving a major outstanding problem in high energy theory. We have made many key discoveries in the AdS/CFT correspondence.

Some stringy questions…

1) Can string theory describe our 4 dimensional physics?
2) What can we learn about quantum gravity and field theory from string theory?
3) What geometry do strings see?
4) Can gravity and black holes in string theory teach us new things about heavy ion collisions, condensed matter theory or even quantum information?



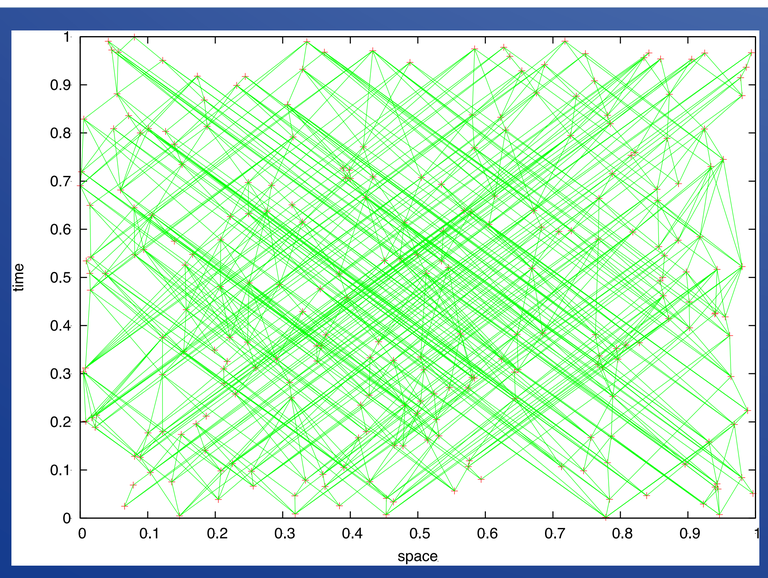
An example of a ‘tiling’ diagram, a new method of describing large families of new conformal field theories.



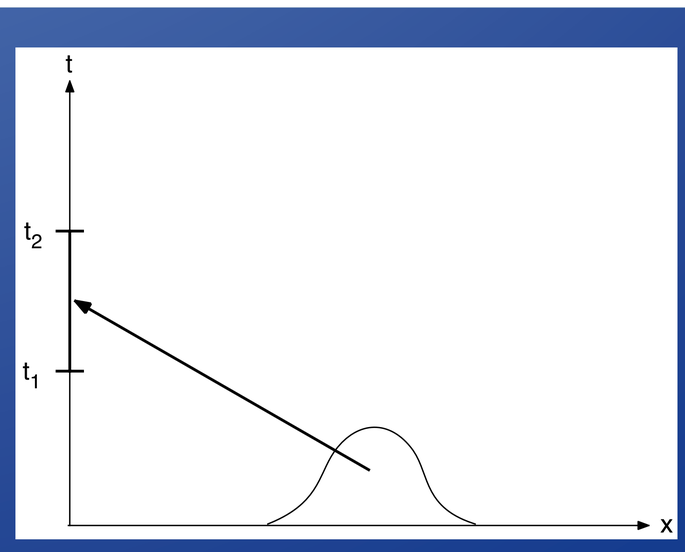
Depictions of the `K3’ geometry, an example of the Calabi-Yau manifolds that strings move in.

Quantum Gravity and Foundations of Quantum Mechanics

We work on different approaches to develop a consistent quantum theory of gravity. This leads to deep questions about the nature of space and time and the interpretation of quantum mechanics. For example, is information lost in black holes, and are space and time continuous at the microscopic level.



An example of a causal set, a method to discretely describe our spacetime geometry on the smallest scales.



A consistent histories approach to the `arrival time’ problem.

http://www.imperial.ac.uk/theoreticalphysics

Members of academic staff:

Prof Carlo Contaldi
Dr Claudia de Rham
Prof Fay Dowker
Prof Michael Duff
Dr Tim Evans
Prof Jerome Gauntlett
Prof Jonathan Halliwell
Prof Amihay Hanany
Prof Chris Hull
Prof Chris Isham (emeritus)
Dr Hugh Jones (emeritus)
Prof Joao Magueijo
Prof Arttu Rajantie
Prof Ray Rivers (emeritus)
Prof Kellogg Stelle
Dr Andrew Tolley
Prof Arkady Tseytlin
Prof Daniel Waldram (Head of Group)
Prof Toby Wiseman

The group currently consists of the academic staff, 08 postdocs, 05 visiting researchers and 22 PhD students. Our group administrator is Ms Graziela De Nadai Sowrey.

MSc in Quantum Fields and Fundamental Forces

Our MSc course covers all aspects of fundamental theoretical physics, from quantum field theory and string theory to cosmology and quantum gravity and bridges the gap between undergraduate work and the research frontier in these fields. The course is very popular, so please apply before the end of June. For more details see;

Prof Arttu Rajantie, room H605 email: qfff@imperial.ac.uk Tel. 020 7594 7835

PhD

Competition for places is **very intense,** so candidates will require outstanding academic grades and/or be able to demonstrate excellence in other ways. Applications for PhDs are welcome at any time but for the best chance of obtaining one of our research council grants, applications should arrive by the end of February.

For more details on MSc and PhD study in Theoretical Physics at Imperial College, see our web page, visit the group's administrator in room H/517, or email g.denadai@ic.ac.uk