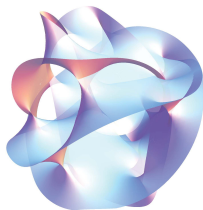
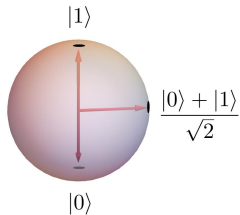
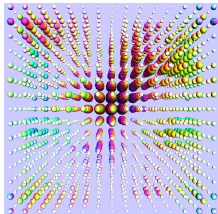
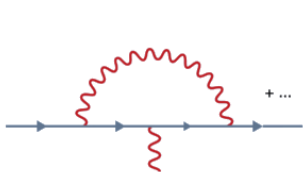


Theoretical Physics

at U. Liverpool and beyond

David Schaich



UoL Physics Work Experience Week, 29 June 2026

What is theoretical physics?

Very broadly speaking,
theoretical physics deals with the mathematical structures
underlying the physical universe

Huge diversity of...

- Styles
- Topics
- Techniques

What is theoretical physics?

Very broadly speaking,
theoretical physics deals with the mathematical structures
underlying the physical universe

Huge diversity of...

- Styles
 - ▶ 'Formal' implications of mathematical self-consistency
 - ▶ Interpretation of experimental results
 - ▶ Predictions of novel phenomena and ways to test them
- Topics
- Techniques

What is theoretical physics?

Very broadly speaking,
theoretical physics deals with the mathematical structures
underlying the physical universe

Huge diversity of...

- Styles

- Topics

- ▶ Particle physics
- ▶ Nuclear physics
- ▶ Condensed matter physics
- ▶ Biophysics
- ▶ Fluid dynamics
- ▶ Plasma physics
- ▶ Geophysics
- ▶ Astrophysics
- ▶ Cosmology and more

- Techniques

What is theoretical physics?

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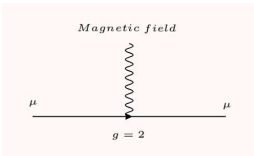
Huge diversity of...

- Styles
- Topics
- Techniques
 - ▶ Abstract mathematics, symmetries, dualities, topology, etc.
 - ▶ Evaluating lots of integrals to make precise predictions
 - ▶ Large-scale numerical calculations using (and developing) supercomputers

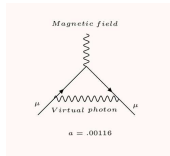
An example of theoretical physics research in the news

The 'anomalous' magnetic moment of the muon accounts for quantum effects

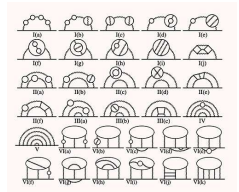
Infinitely many contributions, becoming infinitesimally small...



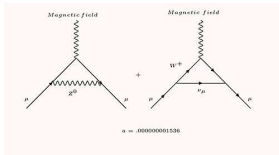
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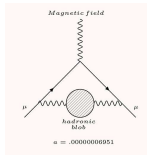
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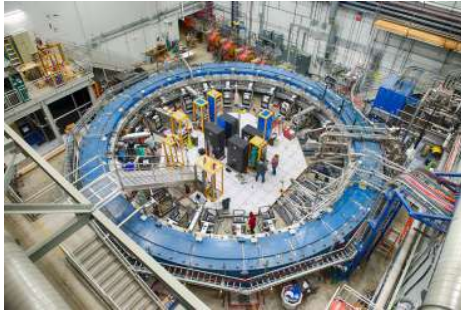
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more...

[images from bnl.gov/newsroom/news.php?a=217530]

An example of theoretical physics research in the news

The 'anomalous' magnetic moment of the muon accounts for quantum effects



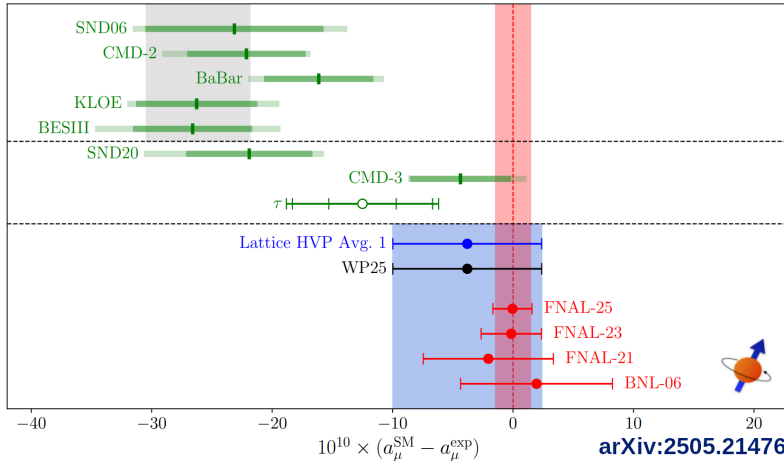
The New York Times

Muon Experiment Was 'Hugely Successful' but Clarified Little

The deviant behavior of a subatomic particle might point to undiscovered forms of matter and energy in the universe. Or it might not.

An example of theoretical physics research in the news

The 'anomalous' magnetic moment of the muon accounts for quantum effects



Theoretical physics at U. Liverpool

Part of the Department of Mathematical Sciences

13 academics, 8 postdoctoral researchers, 19 postgraduate researchers

- Styles — from formal string theory to collider phenomenology
- Topics — focus on particle physics,
with some nuclear, condensed matter, astrophysics & cosmology
- Techniques — from abstract maths to numerical supercomputing



Theoretical physics at U. Liverpool

Part of the Department of Mathematical Sciences

13 academics, 8 postdoctoral researchers, 19 postgraduate researchers

Joint degree programmes shared between MathSci & Physics

BSc (Hons) Physics and Mathematics

MMath (Hons) Mathematical Physics

MPhys (Hons) Theoretical Physics

More info: davidshaich.net/TheoPhys.pdf — or just chat with me!

Theoretical physics careers (mine and others)

My career path:

2011 PhD, Boston U.

2011–2013 postdoc, Boulder CO

2013–2016 postdoc, Syracuse NY

2016–2019 postdoc, Bern Switz.

since 2019 Lecturer/Reader here



Multiple fixed-term postdoctoral research positions in far-flung locations
typical of academic research careers in theoretical physics

~90% of theoretical physics PhD's take different paths. . .

Theoretical physics careers (mine and others)

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My colleagues over the years have gone to work at:

Nvidia	Amazon Health AI	Maxeler Technologies
Quantinuum	SecurityScorecard	CenturyLink Cognilytics
IBM	Enveda Biosciences	Peraton
Hugging Face	Braid Technologies	Ascent Robotics
Goldman Sachs	Siemens	Endress+Hauser
Insight Data Science	US National Nuclear Security Administration	

...and many more

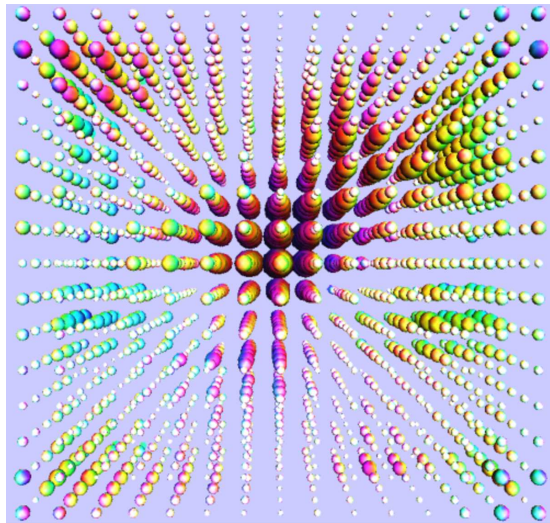
My research, briefly

Lattice quantum field theory

Formally all predictions require solving infinite-dimensional integrals

Approximation: Replace space and time by finite grid of discrete points

Integrate numerically,
extrapolate to 'continuum limit'



(Image credit: Claudio Rebbi)

My research, briefly

Modern supercomputers
evaluate up to $\sim$ billion-dimensional integrals
[lattices ~ 100 points in each direction]

I use this to research dark matter,
the Higgs boson, holographic duality, etc.
[davidshaich.net/research]



The usual approach breaks down in important cases,
which become **exponentially** expensive
[costs $\sim$ double for each additional lattice point]

In principle quantum computers can be far more efficient. . .

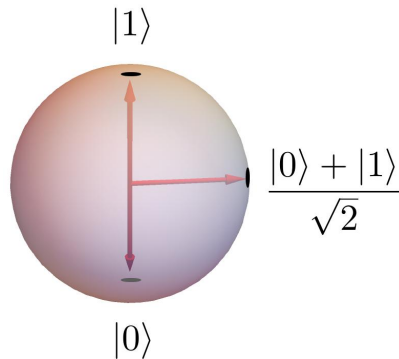
Research project, briefly

Quantum computing

Exploit quantum phenomena

[superposition, interference, entanglement]

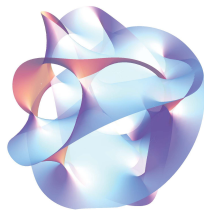
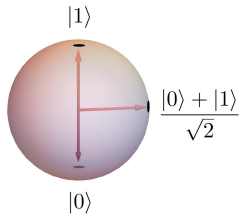
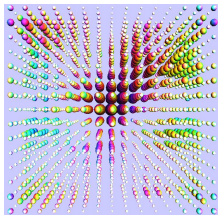
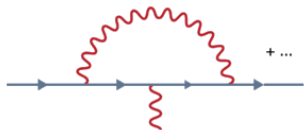
Very delicate $\longrightarrow$ large error rates
in existing quantum computers



Project will set up and run some simple quantum computations,
aiming to illustrate impact of errors

First emulate quantum hardware using ordinary computers,
then try running on real device

Enjoy your work experience week!



Happy to take questions now or later