STFC PPAP community meeting

Theory and its interplay with Experiment

07/07/2023

Claudia de Rham Many slides curtesy of Nick Evans

Formal Theory



















sets the ground rules for particle physics and fundamental physics as a whole in the UK and internationally

Formal Theory









... has a brand... that is crucial to physics recruitment, undergraduate teaching, public engagement





50% growth since 201110% growth since 2019

In total 56 science areas requested funding

The panel noticed not just a rise in academic numbers but also a rise in academic quality and leadership since 2019



+ IPPP and currently 3 virtual centres:

Lattice Field Theory UK Virtual Centre (UKLFT) UK Cosmology Virtual Centre (UK COSMO) Fundamental Physics UK Virtual Centre (FPUK)

• Foster interactions and sharing of knowledge between UK research groups

- Organise regular meetings of the formal UK theoretical physics community
- Represent the theory community within STFC







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0.30

0.35

Time (s)

0.40

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0.35

Time (s)



Hadron resonances and multihadron scattering

BSM studies using non-QCD theories – composite Higgs, DM, holographic cosmology

ML & quantum simulation for lattice field theories

Phenomenology

Guides search strategies & communicates theory and experimental constraints

IPPP lead for UK.

Parton distribution functions

Monte Carlo development - HERWIG, SHERPA AI/Machine Learning for data and models Precision SM:

- QCD N³LO
- higgs NLO & N³LO computations
- neutrino (with many expts)
- flavour (with LHCb and NA62 and g-2)

Model building – naturalness; discrete flavour symmetries – rise of EFTs and SMEFT

NOTE: no precision experiment can be done without a robust theoretical prediction!

Impact of LHCb recount of anomalies?

Re-evaluation of W mass?



Cosmology/Astro-particle/Dark Theory

DM – WIMPS, Axions, primordial BHs & their signals

Dark energy & fine tuning

Inflation, including Higgs Inflation and alternatives

No-boundary proposal & bubble nucleation

GW signals of phase transitions (SM or dark)

Preheating

String phenomenology

Gravity in the IR

Lab tests of dark energy and dark energy

Table top tests of fundamental physics







Strings & Quantum Gravity Gauge-Gravity Duality

Black Hole information loss progress; holographic interpretations of interior; fuzzball picture

Chaos and scrambling

Holography for boundary CFTs, black holes, neutron star equation of state, (magneto) hydrodynamics

ML in string cosmology

deeper understandings of M-theory/branes

dS space in string theory



dS space in string theory

Mathematical Physics, compactification & Geometry

Bootstrapping

Boundary EFTs for condensed Matter

Loop Quantum Gravity

Causal Sets

Quantum Field Theory

- * Supersymmetric gauge theories
- * Conformal theories (IR fixed points and UV asymptotic safety)
- * Integrable models eg N=4 SYM large sectors have been exactly solved even at strong coupling
- * Bootstrap methods in conformal models
- * Amplitude methods escaping Feynman Diagrams and efficient computation









Experiment – Theory Interplay

What Experimentalists need from Theorists?

What Theorists need from Experimentalists?

What is future particle physics strategy... ...in the UK? ...internationally?