YTF 20

Tuesday, 15 December 2020 - Wednesday, 16 December 2020

Centre for Particle Theory, Durham

Book of Abstracts

Contents

Parallel Stream 2 / 64

Covariant multipole expansion of local currents for massive states of any spin

Authors: Sabrina Cotogno[1]; Cédric Lorcé[1]; Peter Lowdon[1]; Manuel Morales[2]

[1] *CPHT, CNRS, École Polytechnique, Institut Polytechnique de Paris*

[2] *DAMTP, University of Cambridge*

Corresponding Author: manu.morales.alvarado@gmail.com

We study the structure of scalar, vector, and tensor currents for on-shell massive particles of any spin. When considering higher values for the spin of the particle, the number of form factors (FFs) involved in the decomposition of the matrix elements associated with these local currents increases. We identify all the fundamental structures that give rise to the independent FFs, systematically for any spin value. These structures can be conveniently organised using an expansion in covariant multipoles, built solely from the Lorentz generators. This approach allows one to uniquely identify the terms which are universal and those that arise because of spin. We derive counting rules which relate the number of FFs to the total spin j of the state, showing explicitly that these rules match all the well-known cases up to spin 2.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 66

Towards a Quantum Computing Algorithm for Helicity Amplitudes and Parton Showers

Authors: Khadeejah Bepari[1]; Sarah Malik[2]; Michael Spannowsky[1]; Simon Williams[2]

[1] *IPPP, Durham University*

[2] *Imperial College London*

Corresponding Authors: michael.spannowsky@durham.ac.uk, s.williams19@imperial.ac.uk, smalik@cern.ch, khadeejahbepari@hotmail.co.uk

The interpretation of measurements of high-energy particle collisions relies heavily on the performance of full event generators. By far the largest amount of time to predict the kinematics of multi-particle final states is dedicated to the calculation of the hard process and the subsequent parton shower step. With the continuous improvement of quantum devices, dedicated algorithms are needed to exploit the potential quantum computers can provide. In this talk I will discuss general and extendable algorithms for quantum gate computers to facilitate calculations of helicity amplitudes and the parton shower process, as a first step towards a quantum computing algorithm to describe the full collision event at the LHC. This method exploits the equivalence between spinors

and qubits and harnesses the quantum computer's ability to remain in a quantum state throughout the calculations.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 67

The performance and IRC safety of Spectral Clustering when Jet tagging.

Authors: Henry Day-Hall[1]; Billy Ford[1]; Stefano Moretti[1]; Srinandan Dasmahapatra [1]; Claire Shepherd-Themistocleous[2]

[1] *University of Southampton*

[2] *RAL*

Corresponding Authors: h.a.day-hall@soton.ac.uk, s.moretti@soton.ac.uk, claire.shepherd@stfc.ac.uk, sd@ecs.soton.ac.uk, b.ford@soton.ac.uk

Spectral clustering, developed by the machine learning community, has been seen to be a powerful and versatile clustering method. Jet clustering, particularly in the case of a boosted topology, is a key problem for particle identification in experimental physics. If spectral clustering can be shown to be suitable for the task it may be able to extract more information from the data we generate.

A key factor for the suitability of an clustering algorithm is infrared and collinear (IRC) safety. While there are algorithms that are not IRC safe, the most popular algorithms are. To be viable for use in QCD calculations the jet formation algorithm must be IRC safe.

In this talk I will discuss the mechanics, performance and the IRC safety of spectral clustering.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

Yes

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / 68

Double copy and homotopy algebras

Authors: Leron Borsten[None]; Branislav Jurčo[None]; Hyungrok Kim[1]; Tommaso Macrelli[None]; Christian Sämann[None]; Martin Wolf[None]

[1] *Heriot-Watt University*

Corresponding Author: hyungrokkim@gmail.com

There is a series of deep relations between the scattering amplitudes of Yang–Mills theory and those of Einstein gravity, known as *double copy*. This relation has been proven at tree level, but whether it holds at loop level has been a longstanding conjecture. In this talk we resolve this by constructing Lagrangians for Yang–Mills theory and Einstein gravity that manifest the double copy relation and formulate the result in terms of the theory of homotopy algebras (L_∞-, A_∞-algebras).

Based on 2007.13803, joint work with L. Borsten, B. Jurčo, T. Macrelli, C. Sämann, M. Wolf.

Would you be interested in receiving feedback on your talk?:

No

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / 69

Avoided Deconfinement in Randall-Sundrum Models

Authors: Michael Nee[1]; Prateek Agrawal[1]

[1] *Oxford University*

Corresponding Author: michael.nee@physics.ox.ac.uk

In this talk I will discuss first order phase transitions in Randall-Sundrum models which are dual to (de)confinement phase transitions in large-N gauge theories. The transition rate is suppressed by a factor $\exp(-N^2)$, and does not complete for $N \gg 1$, leading to an eternally inflating phase. The constraint on N to avoid this fate is strong enough that the RS effective field theory is only marginally under control. We present a mechanism where the IR brane remains stabilised at very high temperature, so that the theory stays in the confined phase at arbitrarily high energies. This mechanism of avoided deconfinement is similar to Weinberg's symmetry non-restoration mechanism. Avoided deconfinement allows for a viable cosmology for parametrically large-N theories. Early universe phenomena such as WIMP freeze-out, axion abundance, baryogenesis and phase transitions are qualitatively modified in the model, leading to new possibilities for phenomenological applications.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **70**

Synthetic Flux Attachment

Author: Gerard Valentí-Rojas[1]

Co-authors: Niclas Westerberg ; Patrik Öhberg

[1] *Heriot-Watt University*

Corresponding Author: gv16@hw.ac.uk

Flux attachment is a mechanism by which charged particles capture magnetic flux quanta and form composite entities. As a consequence of flux dressing, these composites may acquire fractional quantum numbers (e.g. electric charge) and statistics. This phenomenon is directly associated to the emergence of a Chern-Simons gauge field.

Although charge-neutral systems do not couple to vector potentials, geometric (Berry) phases induced in ultracold neutral atoms allow emulating the behaviour of charged particles in electromagnetic fields. Nowadays, these phases can be engineered in Bose-Einstein condensates by means of laser coupling.

We describe how a suitable interaction of this light-matter system generates an effective singular nonlinear gauge potential. Such a field is a function of matter density and performs a laser-tuned version of flux attachment. We derive bottom-up the macroscopics (i.e. emergence) of an Abelian Chern-Simons theory from a microscopic, weakly-interacting system of bosons. We find that the effective description of the condensate is that of a fractional quantum Hall fluid where anyonic flux-charge vortices are formed. Finally, we outline the implementation of the current scheme and its implications as a quantum simulation of a gauge theory in 2+1D that uses a single atomic species only.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **71**

Amplitudes and Backgrounds in Split Signature

Author: Matteo Sergola[1]

[1] *University of Edinburgh*

Corresponding Author: matteo.sergola@ed.ac.uk

In this talk we are going to explore classical features of electromagnetic and gravitational radiation using quantum scattering amplitudes. To do so we analytically continue to a spacetime with $(2,2)$ signature $\eta_{\mu\nu} = \text{diag}(+,+,-,-)$. This allows us to consider, at leading order, 3-point on-shell amplitudes which would otherwise be identically zero in usual Minkowski spacetime. Our main result is that, in the classical limit, the scattered state is a coherent state which is the exponential of a 3-point amplitude. This occurs for both EM and GR radiation, which happen to be related to each other through the double copy. This opens up new possibilities to study gravitational wave physics with quantum field theory and unitarity methods.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **72**

Dessins d'Enfants and Machine-Learning

Author: Ed Hirst[1]

Co-authors: Toby Peterken [2]; Yang-Hui He [1]

[1] *City, University of London*

[2] *University of Edinburgh*

Corresponding Author: edward.hirst@city.ac.uk

Dessins d'enfants will be introduced, discussing their link to Calabi-Yau manifolds in string theory and their importance in Galois theory. Following this we will briefly discuss work performed to classify a database of dessins d'enfants according to their Galois orbit size using machine-learning.

In relation to the paper: 2004.05218

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / **73**

Heavy $\rightarrow$ strange Semileptonic Decays in Lattice QCD

Author: William Parrott[1]

[1] *University of Glasgow*

Corresponding Author: 2399654p@student.gla.ac.uk

$D \rightarrow Kl\nu$ and $B \rightarrow Kl^+l^-$ are important heavy to strange semileptonic decay processes, giving us direct comparison with experiment, and access to CKM matrix elements and potential new physics. We can calculate form factors for both of these processes in lattice QCD and connect them together by determining heavy to strange form factors for heavy quark masses ranging from c to b. We can also explore the connection to form factors with different light quark masses.
Using the HISQ action on $N_f = 2+1+1$, we demonstrate how $D \rightarrow K$ calculations can be extended up towards the b mass and give preliminary $D \rightarrow K$ and $B \rightarrow K$ results, in both cases including results for the tensor form factor with an accurately renormalised tensor current.

Would you be interested in receiving feedback on your talk?:

No

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **74**

Curvy Parke-Taylors

Author: Atul Sharma[1]

[1] *University of Oxford*

Corresponding Author: atul.sharma@maths.ox.ac.uk

I will report on our discovery of the first-ever all-multiplicity formulae for scattering amplitudes in curved backgrounds. This will involve certain chiral backgrounds treated without any approximations, a slice of twistor theory, a taste of spinor-helicity variables, and a bit of holography for dessert. The end result is a beautiful extension of the Parke-Taylor formula of MHV gluon amplitudes from trivial backgrounds to an infinite class of self-dual radiative gauge field backgrounds.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / **75**

An analytical look at top tagging with N-subjettiness

Author: Jack Helliwell[1]

[1] *University of Manchester*

Corresponding Author: jack.helliwell@postgrad.manchester.ac.uk

I will examine the effectiveness and resilience to non perturbative effects of various top tagging procedures which make use of n-subjettiness, initially using Monte Carlo simulations. I will then present resummed calculations, at modified leading log accuracy, of the most effective variants of these taggers for both the signal and background. These calculations will then be used to understand the physics which drives these taggers, ultimately facilitating the simplification of them whilst improving the performance over a range of signal efficiencies.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **76**

Boundaries, Vermas, and Factorisation

Author: Daniel Zhang[1]

[1] *University of Cambridge*

Corresponding Author: danielzhang1729@gmail.com

I will discuss a recent work on the factorisation of closed 3-manifold partition functions and indices of 3d $\mathcal{N} = 4$ gauge theories. The building blocks are hemisphere partition functions equipped

with a class of UV $\mathcal{N} = (2,2)$ boundary conditions that mimic the presence of isolated vacua at infinity. Via the state-operator correspondence, these count local operators supported on a $(2,2)$ boundary condition on a plane. A subset of these operators are boundary Higgs and Coulomb branch operators, which form lowest weight Verma modules over the quantised bulk Higgs and Coulomb branch chiral rings. We show that certain limits of the hemisphere partition functions compute their characters. We find that the equivariant supersymmetric Casimir energy encodes the boundary 't Hooft anomaly, and also plays the role of highest weights. Applying these results to factorisation then leads to various "IR formulae"for partition functions on closed 3-manifolds in terms of these Verma characters.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / **77**

Complex structures in the dynamics of Kerr black holes

Author: Ben Maybee[1]

[1] *University of Edinburgh*

Corresponding Author: b.maybee@ed.ac.uk

The Kerr black hole in gravity, and its single copy $\sqrt{\text{Kerr}}$ in gauge theory, are very special spinning objects. Both are intimately connected to on-shell scattering amplitudes for particles with spin. In this talk I will show how insights from such amplitudes can lead to new, complex perspectives on the classical dynamics of these solutions.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / **78**

Black hole entropy from superconformal indices and a glimpse of black holes in AdS_5 x T^{1,1}

Authors: Ziruo Zhang[1]; Francesco Benini[2]; Alberto Zaffaroni[3]; Saman Soltani[4]; Edoardo Colombo[5]

[1] *SISSA*

[2] *SISSA, ICTP, INFN, Sezione di Trieste*

[3] *Università di Milano-Bicocca, INFN, Sezione di Milano-Bicocca*

[4] *SISSA, INFN, Sezione di Trieste*

[5] *Università di Milano-Bicocca*

Corresponding Author: zzhang@sissa.it

The large N limit of the four-dimensional superconformal index has been computed and successfully compared to the entropy of a class of AdS_5 black holes only in the particular case of *equal* angular momenta. Using the Bethe ansatz formulation of the index, we found a particular universal contribution to the sum over Bethe vacua that correctly leads to the entropy of BPS Kerr–Newman black holes in $AdS_5 \times S^5$ for *arbitrary* values of the conserved charges, thus completing the microscopic derivation of their microstates. We also consider theories dual to $AdS_5 \times SE_5$, where SE_5 is a Sasaki–Einstein manifold. In particular, we explicitly constructed the near-horizon geometry of as yet unkown BPS Kerr–Newman black holes in $AdS_5 \times T^{1,1}$. The entropies of these black holes were computed using the attractor mechanism and we found complete agreement with predictions from the index.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / 79

Never have I ever used a constant to fix my problem

Author: Bruno Bento[1]

[1] *University of Liverpool*

Corresponding Author: bruno.bento@liverpool.ac.uk

Was it calling it a blunder the actual blunder? The cosmological constant has always been controversial, to say the least. The past 20 years have seen an uprising of the cosmological constant, after the discovery in 1998 that the expansion of the universe is actually accelerating. This forced String Theory to try to accommodate de Sitter backgrounds into its 4d solutions, something that has proved difficult to accomplish. However, just as Inflation seems to be best dealt with using slowly rolling scalar fields rather than a de Sitter vacuum, so may the current expansion be driven by such fields, in what is known as Quintessence. In this talk I will address the problem with the cosmological constant, explain how Quintessence can provide an alternative, notwithstanding its own difficulties, and how this can be accomplished in String Theory.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **80**

Sp(2N) gauge theories on the lattice.

Author: Jack Holligan[1]

[1] *Swansea University*

Corresponding Author: jeholligan@gmail.com

Yang-Mills theories based on the Symplectic groups (denoted by $Sp(2N)$) have the potential to describe a composite Higgs particle. To gain a better understanding of such theories, it is important to understand the dynamics of the pure Yang-Mills sector as well as in the presence of fermions. A detailed study of the glueball spectrum has been carried out for $N = 1, 2, 3$ and 4 along with an extrapolation to the large-N limit. We begin a study of the meson spectrum as a logical continuation to these studies with a view to applying the results to composite Higgs models.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **81**

Classical Yang Mills observables from amplitudes

Author: Alasdair Ross[1]

[1] *University of Edinburgh*

Corresponding Author: alasdair.ross@ed.ac.uk

In this talk I'll present some recent work on studying classical observables in Yang Mills theory. Motivated by the double copy relation between YM and Gravity, and focusing on the YM side, I'll discuss the classical scattering of particles with a YM colour charge and compute the change in colour or 'colour impulse'that occurs during the scattering event using amplitudes techniques.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / 82

Non-SUSY String Phenomenology from $Z_2 \times Z_2$ Heterotic Orbifolds

Author: Benjamin Percival[1]

Co-authors: Viktor Matyas [2]; Alon Faraggi [2]

[1] *Liverpool University*

[2] *University of Liverpool*

Corresponding Authors: viktor.matyas@liverpool.ac.uk, benjamin.percival3@outlook.com, faraggi@liverpool.ac.uk

We explore the space of non-SUSY string models via two distinct routes: the tachyon-free $O(16)\times O(16)$ heterotic string in 10D and a tachyonic 10D heterotic string. We classify 4D $Z_2 \times Z_2$ orbifolds descending from these two starting points in the free fermionic construction. Having found a potentially stable Standard-like model descending from the tachyonic 10D vacuum in arXiv:1912.00061, the approach of taking these models on equal footing with the non-tachyonic 10D models is justified provided that the tachyonic states are projected out in the four dimensional models. In both classes of models we find examples of Type 0 and Type 0bar models, i.e. models free of fermionic massless states and models free of twisted massless bosons, respectively. Moving beyond these extreme configurations we seek to classify tachyon-free vacua according to standard phenomenological criteria in both classes of model, where an SO(10) GUT is broken to the Pati-Salam subgroup. An analysis of the cosmological constant and misaligned supersymmetry in the two classes of models finds notable vacua in both cases in which N_b=N_f at the massless level.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / 83

M2- and D3-branes wrapped on a spindle

Author: Pietro Ferrero[1]

Co-authors: Jerome Gauntlett ; Dario Martelli ; Juan Manuel Perez Ipina ; James Sparks

[1] *University of Oxford*

Corresponding Author: pietro.ferrero@gtc.ox.ac.uk

We consider the Plebanski-Demianski family of solutions of minimal gauged supergravity in d=4, which describes an accelerating, rotating and charged black-hole in AdS4. The 4d metric has conical singularities, but we show that it can uplifted to a completely regular solution of d=11 supergravity. We focus on the supersymmetric and extremal case, where the near-horizon geometry is AdS2 x \Sigma, where \Sigma is a spindle, or weighted projective space. We argue that this is dual to a d=1, N=(2,0) SCFT which is the IR limit of a 3d SCFT compactified on a spindle. This, in turn, should be realized holographically by wrapping a stack of M2-branes on a spindle. Such construction displays two interesting features: 1) supersymmetry is realized in a novel way, which is not the topological twist, and 2) the R-symmetry of the d=1 SCFT mixes with the U(1) isometry of the spindle. A similar idea also applies to a class of AdS3 x \Sigma solutions of minimal gauged supergravity in five dimensions.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 3 / 84

An Introduction to moduli spaces of 3d N=4 SUSY quiver gauge theories

Author: Kirsty Gledhill[1]

[1] *Imperial College London*

Corresponding Author: k.gledhill20@imperial.ac.uk

This talk is aimed at those who may be unfamiliar with many concepts that appear in the title. To this end, the topic will be broken down thoroughly, and along the way some basic concepts will be reviewed. It hopes to give an understandable and simple introduction into the rich field of supersymmetric quiver gauge theories. The ideas of gauge theories and group theory will be briefly reviewed, before discussing N=4 supersymmetry in 3 dimensions and the structure of the moduli space of vacua of theories with such symmetry. The quiver formulation of such theories is

presented, showing how to encode all the important information in a simple diagram. Motivations and directions of study are discussed. If time permits, a link to string theory will be established through the realisation of gauge theories on the world volume of Dirichlet branes.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 3 / 85

The Boostless Bootstrap: Amplitudes without Lorentz boosts

Authors: Jakub Supeł[1]; Enrico Pajer[1]; David Stefanyszyn[1]

[1] *University of Cambridge*

Corresponding Authors: js2154@cam.ac.uk, enrico.pajer@gmail.com, david.stefanyszyn@gmail.com

Poincare invariance is a well-tested symmetry of nature and sits at the core of our description of relativistic particles and gravity. However, in cosmology the ground state breaks invariance under Lorentz boosts, which motivated us to study scattering amplitudes without requiring this symmetry. In particular, using on-shell methods and assuming massless, relativistic and luminal particles of any spin, I explain how the allowed interactions around Minkowski spacetime are severely constrained by unitarity and locality in the form of consistent factorization. In particular, the existence of an interacting massless spin-2 particle enforces three-particle interactions to be Lorentz invariant, even those that do not involve a graviton, such as cubic scalar couplings. Our findings are highly sensitive to IR deformations and therefore these flat-space results do not straightforwardly apply to curved spacetime. Instead, I comment on the implications to Lorentz violating extensions of the Standard Model.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

Yes

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / 86

The Case Against Smooth Null Infinity

Author: Leonhard Kehrberger[1]

[1] *University of Cambridge*

Corresponding Author: lmak2@cam.ac.uk

In this talk, I hope to discuss various physical obstructions to Penrose's proposal of smooth conformal compactification of spacetime (a.k.a. smooth null infinity or asymptotic simplicity) and the "peeling property" implied by it.
More precisely, I will show that in the context of the N-body problem of GR, one should expect that the asymptotic expansions of the Weyl tensor near $\mathcal{I}^+$ contain *logarithmic terms* at leading order and hence the peeling property does not hold.
Finally, I will outline why these logarithmic terms should in principle be measurable.

Only basic familiarity with GR will be assumed.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 2 / 87

Multi-winding Magnetic Fluxtubes in Colour-superconducting Quark Matter

Author: Geraint Evans[1]

[1] *University of Southampton*

Corresponding Author: gwe1g19@soton.ac.uk

I will present results analysing the phase structure of dense, three-flavour, colour-superconducting quark matter in the presence of an external magnetic field using a Ginzburg-Landau approach. By contrasting with the massless case, I will discuss how the preferred magnetic defects in the type-II 2SC phase and overall phase diagram are affected when we consider the strange quark mass to be non-zero.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / **88**

Protected states in AdS3xS3xT4 from integrability

Authors: Suvajit Majumder[1]; Bogdan Stefanski[1]; Olof Ohlsson Sax[2]; Alessandro Torrielli[3]

[1] *City, University of London*

[2] *Nordita Institute for Theoretical Physics*

[3] *University of Surrey*

Corresponding Authors: olof.ohlsson.sax@gmail.com, a.torrielli@surrey.ac.uk, bogdan.stefanski.1@city.ac.uk, majumder.suvajit95@gmail.com

I will briefly review the integrability setup that works in AdS3/CFT2, in the planar limit, including its brane construction in type IIB string theory. Next, I will review algebraic Bethe ansatz(ABA) and how it is used to compute spectrum of integrable models by working with the concrete example of Heisenberg XXX spin chain. Finally, I will use the ABA technology for the massless modes in AdS3xS3xT4, and use it to compute the protected spectrum of states in this background.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / **89**

Charting the Fifth Force Landscape

Author: Hannah Banks[1]

[1] *University of Cambridge*

Corresponding Author: hmb61@cam.ac.uk

In recent years particle physics research has undergone somewhat of a phase transition, looking increasingly towards hidden sectors and the feebly interacting frontier. In this talk I will introduce a new approach to parameterising dark sector forces, underpinned by the Källén-Lehman representation, in which the effects of any general scalar fifth force are captured by a single positive-definite spectral function. Using this language, I will demonstrate how the effects of loop-level forces can be simply obtained, without needing to explicitly perform loop calculations. I will also show how experimental observables can be expressed in completely general terms, facilitating the straightforward extraction of limits to any specific model. Finally, I will discuss how this framework opens

the possibility to speculatively probe violations of unitarity, causality or locality within hidden sectors.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / 90

Towards Precision QCD Calculations

Author: Oscar Braun-White[1]

Co-author: Nigel Glover [1]

[1] *IPPP, Durham University*

Corresponding Authors: e.w.n.glover@durham.ac.uk, oscar.r.braun-white@durham.ac.uk

This talk is an overview of infrared divergences required in precision QCD calculations. The cancellation of these divergences is necessary by KLN theorem and must be verified when predicting observables. Improvements on methods in this type of work is necessary to extend predictions to N^3LO in α_s, to make comparisons with future precise collider experiments. Antenna subtraction is discussed, in addition to new analysis identifying structure in antenna functions.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

Yes

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / 91

Scheme dependence in pQCD at the four loop level

Author: Robert Mason[1]

[1] *University of Liverpool*

Corresponding Author: robert.mason@liverpool.ac.uk

Quantities representing measurables in physics should not depend on the method of calculating them in the underlying QFT. However, in perturbative QCD, computations must be truncated to a finite order meaning they are only approximations of the true quantity resulting in dependence on the renormalization scheme chosen. We investigate this dependence for the Bjorken sum rule and Adler D functions in various kinematic schemes with particular focus on the symmetric MOM schemes at four loops and compare with MSbar scheme behaviour as the benchmark.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **92**

Higher form symmetries and geometric engineering

Author: Saghar Sophie Hosseini[1]

[1] *Durham University*

Corresponding Author: sophiesaghar@gmail.com

I will briefly introduce my research work on higher form symmetries and it's connection to geometrically engineered field theories.

Would you be interested in receiving feedback on your talk?:

No

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / **93**

Determining the Coaction of two-loop Feynman Diagrams

Author: Aris Ioannou[1]

[1] *University of Edinburgh*

Corresponding Author: arisioannou765@gmail.com

The diagrammatic coaction is a conjectural statement regarding the algebraic and analytic structure of Feynman integrals. The beauty of the coaction on Feynman diagrams is that its form can be formulated through simple diagrammatic rules, based on "cutting" and "contracting" subsets of propagators, without any reference to the particular functions that the integrals evaluate to. However, in order to establish the coaction, and determine its precise structure given a particular basis of integrals, one needs to evaluate the corresponding integrals and their cuts and establish the relations between them. In this talk, I will go into the techniques used for the two-loop cut integral evaluations to all orders in the dimensional regularization parameter ϵ and how the results can be used to determine the diagrammatic coaction of two-loop Feynman Integrals.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 94

QCD Instantons at hadron colliders

Author: Daniel Milne[1]

[1] *IPPP, Durham University*

Corresponding Author: daniel.l.milne@gmail.com

Instantons are non-perturbative phenomena arising in field theory with degenerate vacua. They are one of the few remaining predictions of the Standard Model that has not been experimentally observed. Discovering instantons at a collider would be another piece of evidence for our current model of QCD and help to understand the vacuum structure of the standard model.

We will discuss the most recent calculation of the instanton cross section at hadron colliders before moving on to discuss their collider signature. We talk about shape variables as possible discriminating variables and how we might potentially discover instantons at the LHC.

[talk based on https://arxiv.org/abs/2010.02287]

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **95**

Enhancing the diagnostic performance of Raman spectroscopy based bowel cancer blood test using advanced machine learning algorithms and the incorporation of information from the patient's medical record

Author: Natalia Sikora[1]

[1] *Swansea University*

Corresponding Author: 2024597@swansea.ac.uk

Diagnosing cancer may be performed from biofluids, utilizing Raman spectrophotometry, multiple machine learning techniques and their applications in particle detectors. Nonetheless, algorithms which would allow for accurate classification model in this scenario would require incorporating the information from patient's medical record. Them main challenge of this project is to design an algorithm which considers both, medical data and pre-processing budget in a medical research. Several particle detector technologies, including a Silicon Vertex Detector, Time Projection Chamber, and a barrel of scintillating bars are challenging when it comes is to distinguishing between antihydrogen annihilation and cosmic rays. Presently, a common technique to resolve this is a use of cuts based on two high-level variables from the detectors for online analysis, and boosted decision trees with high-level variables in offline analysis. High-level variables are a powerful tool for discrimination, nonetheless slow to pre-process. This project aims to build both online and offline analyses that have different processing budgets and reduce pre-processing time by replacing the high-level variables with lower level variables. The goal is to create a small enough model that can interpret raw detector output to enable a real-time online analysis, with the ultimate objective of programming an FPGA or micro-controller to perform accurate, real-time classification of detector events.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 3 / **96**

Factorised 3d N=4 orthosymplectic quivers

Author: Mohammad Akhond[1]

[1] *Swansea University*

Corresponding Author: akhondmohammad@gmail.com

I will discuss families of 3d N=4 quiver gauge theories with unitary, orthogonal and symplectic gauge nodes that factorise into pairs of decoupled sectors. Each decoupled sector corresponds to a quiver gauge theory comprised solely of unitary nodes. I will then discuss the motivation behind this conjecture as well as the currently available evidence/tests.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 97

Precise Determination of CKM Matrix Elements with Lattice QCD+QED

Author: Andrew Yong[1]

[1] *University of Edinburgh*

Corresponding Author: andrew.yong@ed.ac.uk

The Cabibbo-Kobayashi-Maskawa (CKM) matrix is a 3×3 unitary matrix in the Standard Model of particle physics. In the age of precision physics, one of the ongoing efforts to extend the Standard Model is to test the unitarity of the CKM matrix. This requires a precise determination of its matrix elements from first principles. Since quarks hadronise into bound states at $E \approx \Lambda_{QCD} \sim 300$MeV, we will require a non-perturbative approach to obtain theoretical predictions of hadronic observables. This is where Lattice QCD(+QED) comes in. In this talk, I will present the progress made by the RBC-UKQCD collaboration in determining $\frac{V_{us}}{V_{ud}}$ and discuss our future plans on extracting the individual matrix elements.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / 98

On the Lagrangian formulation of the double copy to cubic order

Author: Pietro Ferrero[1]

Co-author: Dario Francia

[1] *University of Oxford*

Corresponding Author: pietro.ferrero@gtc.ox.ac.uk

We investigate the Lagrangian formulation of the double-copy correspondence between gauge theories and gravity, up to the cubic order. Building on the definition of the double-copy field as a convolution of two vectors, we obtain free gravitational Lagrangians as products of two Yang-Mills Lagrangians, in a form amenable to be easily extended to the massive case. We discuss the origin of these results from tensionless strings and show the existence of gauge fixings that mix the two spin-one sectors and lead to an alternative, especially simple, version of the free Lagrangian. We then construct cubic vertices for the full double-copy multiplet, comprising a graviton, a two- form and a scalar particle, by means of the Noether procedure. Both at the free and at the cubic level the result gets uniquely fixed only upon imposing, on top of gauge invariance, a left-right Lorentz symmetry ruling contraction of indices among double-copy fields. Whereas the outcome nicely matches the cubic interactions of N = 0 supergravity, including the gauge-invariant coupling between the scalar particle and the two-form, such a twofold Lorentz symmetry seems to conflict with the perturbative reconstruction of space-time geometry.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 1 / 99

Cosmological implications of EW vacuum instability: constraints on the Higgs curvature coupling from inflation

Author: Andreas Mantziris[1]

Co-author: Arttu Rajantie [1]

[1] *Imperial College London*

Corresponding Authors: a.rajantie@imperial.ac.uk, andreas.mantziris@gmail.com

The current experimentally measured parameters of the Standard Model (SM) suggest that our universe lies in a metastable electroweak vacuum, where the Higgs field could decay to a lower vacuum state with catastrophic consequences. Our measurements dictate that such an event has not happened yet, despite the many different mechanisms that could have triggered it during our past light-cone. Via this observation, we can establish a promising link between cosmology and particle

physics and thus constrain important parameters of our theories. The focus of our work has been to explore this possibility by calculating the probability of the false vacuum to decay during the period of inflation and using it to constrain the last unknown renormalisable SM parameter ξ, which couples the Higgs field with space-time curvature. In our latest study, we derived lower bounds for the Higgs-curvature coupling from vacuum stability in three inflationary models: quadratic and quartic chaotic inflation, and Starobinsky-like power-law inflation. In contrast to most previous studies we took the time-dependence of the Hubble rate into account both in the geometry of our past light-cone and in the Higgs effective potential, which is approximated with three-loop renormalisation group improvement supplemented with one-loop curvature corrections. We find that in all three models, the lower bound is $\xi \geq 0.051...0.066$ depending on the top quark mass. We also demonstrated that vacuum decay is most likely to happen a few e-foldings before the end of inflation.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / **100**

From tree-level perturbation theory to S-matrix bootstrap in two dimensions

Author: Davide Polvara[1]

[1] *Durham University*

Corresponding Author: davide.polvara@durham.ac.uk

In the past the bootstrap program has been able to find analytical results for the S-matrix of a variety of (1+1)-dimensional integrable models. Its connection to standard Feynman diagrams computations is however still unclear, in particular the underlying mechanism responsible for the cancellation of all non-elastic processes. In the talk I will show how bootstrap relations connecting different S-matrix elements and the absence of non-elastic scattering emerge at tree-level from perturbation theory for the class of untwisted affine Toda theories.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / 101

The Holographic Swampland

Author: Filippo Revello[1]

Co-author: Joseph P. Conlon

[1] *University of Oxford*

Corresponding Author: filippo.revello@physics.ox.ac.uk

We investigate whether Swampland constraints on the low-energy dynamics of weakly coupled string vacua in AdS can be related to inconsistencies of their putative holographic duals or, more generally, recast in terms of CFT data. In the first part of the talk, we shall illustrate how various swampland consistency constraints are equivalent to a negativity condition on the sign of certain mixed anomalous dimensions. This condition is similar to well-established CFT positivity bounds arising from causality and unitarity, but not known to hold in general. Our analysis will include LVS, KKLT, perturbative and racetrack stabilisation, and we shall also point out an intriguing connection to the Distance Conjecture. In the second part, we show how a different, recently derived inequality on mixed anomalous dimensions maps to novel constraints on four-derivative interactions on AdS. As an application, we use this to constrain the interactions of scalars with a non standard kinetic term, finding in particular that the DBI action for multiple scalar fields is at the boundary of the allowed region.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / 102

Chiral Fermions on the Lattice

Author: Kaan Onder[1]

[1] *University of Cambridge*

Corresponding Author: kaan@onder.net

Putting chiral fermions on a lattice has been a long standing problem due to the doubling problem. I'll briefly introduce this and talk about potential ways of solving it.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

Yes

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 103

Getting a number out of a QCD amplitude

Author: Ryan Moodie[1]

[1] *IPPP, Durham University*

Corresponding Author: ryan.i.moodie@durham.ac.uk

I will give an introductory review of modern methods to compute QCD amplitudes in the context of hadron collider phenomenology. We will build up the basic structure of such calculations and explore the technologies used at each step.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / 104

Soft Anomalous Dimension in QCD

Author: Niamh Maher[1]

[1] *University of Edinburgh*

Corresponding Author: n.maher@sms.ed.ac.uk

An introduction to the Soft Anomalous Dimension in QCD with a focus on the diagrammatic color structures that appear in it. The factorisation of scattering amplitudes into hard, soft and jet parts allows us to focus on the soft matrix. The Soft Anomalous Dimension contains the IR singularities and can be represented in terms of Wilson lines which will be discussed.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 1 / **105**

Finite Fields for Di-Photon Amplitudes

Author: Francesco Sarandrea[1]

[1] *Durham University*

Corresponding Author: francesco.sarandrea@durham.ac.uk

In this talk I will present the algorithms and techniques employed to efficiently obtain analytic expressions for loop-induced di-photon amplitudes at 5 and 6 legs . I will review the method of reconstruction over finite fields and how it is applied to OPP integrand reduction at one loop. The representation of the amplitudes using Momentum Twistor variables, which ensure that the process only involves rational expressions at every intermediate step, will be introduced. I will discuss advantages and current bottlenecks.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **106**

The Coaction of Feynman Diagrams

Author: Aris Ioannou[1]

[1] *University of Edinburgh*

Corresponding Author: arisioannou765@gmail.com

Research developments in recent years have given strong evidence that
one-loop Feynman diagrams admit a coaction, a conjectural statement
regarding the algebraic and analytic structure of the corresponding
Feynman integrals. In this talk, I will explain how one defines a coaction and show how it may apply to Feynman Diagrams.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

5 Minute Talks / **107**

Vacuum Transitions in Field Theory

Author: Christopher Hughes[1]

[1] *DAMTP, University of Cambridge*

Corresponding Author: ch845@cam.ac.uk

The WKB approximation describes the decay of metastable states in quantum mechanics but its extension to multidimensional field theory is not trivial. I will give a short overview of the original Euclidean approach developed by Coleman et al. in the 1980's as well as more recent approaches and comment on the different predictions between the two.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

3-5 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / **108**

Moduli space of five-dimensional black holes

Author: Fred Tomlinson[1]

Co-author: James Lucietti [1]

[1] *University of Edinburgh*

Corresponding Authors: j.lucietti@ed.ac.uk, f.tomlinson@ed.ac.uk

The classification of equilibrium black hole solutions is a fundamental problem in General Relativity. In four spacetime dimensions this is essentially answered by the black hole uniqueness theorem, which roughly states that the only asymptotically flat, stationary black hole solution to the vacuum Einstein equations is the Kerr solution. In higher-dimensional spacetimes, there is no such simple uniqueness theorem - this was revealed by the striking discovery of the black ring, a black hole with horizon topology $S^2 \times S^1$. Alongside the spherical topology Myers-Perry black hole (the natural higher dimensional Kerr analogue), this explicitly shows that even vacuum black holes are not uniquely specified by their mass and angular momenta.

So what is known about black holes in five-dimensional GR? In this talk I will give an overview of the situation and briefly discuss a new classification result leading towards a better understanding of a particular class of these solutions.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 1 / 110

Machine Learning Surrogates for Rapid Dark Matter Direct Detection Calculations

Author: Dorian Amaral[1]

[1] *IPPP, Durham University*

Corresponding Author: dorian.w.praia-do-amaral@durham.ac.uk

Dark matter direct detection is one of the most popular ways of searching for WIMP dark matter. However, the calculations involved when evaluating the recoil spectra can be expensive, especially when exploring the multi-dimensional parameter space resulting from the EFT description of dark matter and the inclusion of astrophysical uncertainties. Therefore, it is instructive to seek ways of accelerating this calculation. We explore the performance of several possible surrogate models which can replace the exact calculation, with a focus on machine learning models. We find that relatively simple surrogate models can adequately approximate the complete calculation with a sizeable jump in performance.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 2 / 111

Analytical Approximations for Curved Primordial Power Spectra

Author: Ayngaran Thavanesan[1]

[1] *University of Cambridge*

Corresponding Author: at735@cantab.ac.uk

Whilst interpretations of the level of experimental support for a curved present-day universe differ, universe models with percent-level spatial curvature remain compatible with CMB datasets. The inflationary framework successfully predicts the minimal present-day curvature. However, if one is to study inflation in a complete manner, one cannot assume a flat universe at the start of the expansion. There are also other theoretical reasons to consider the effect of curvature; particularly for the studies of inflation exits and quantum gravity.

This motivates us to study the effects of primordial curvature. In this work, we generalize the potential-independent inflationary model, popularized by Contaldi et al., to the curved case. We demonstrate that the Contaldi approximation still holds for the case of curved universes, and allows us to clearly illustrate the generic cut-off and oscillatory effects seen in numerically computed curved primordial power spectra. Through our analytical solutions, we are able to gain a better insight into the physics of curved inflating universes. We also discuss the possibility of developing our framework to include potential dependence.

https://arxiv.org/abs/2009.05573

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Parallel Stream 3 / 112

Towards an M5-Brane Model

Author: Dominik Rist[1]

[1] *Heriot-Watt University*

Corresponding Author: dr40@hw.ac.uk

Higher gauge theory is an extension of gauge theory in which one adds higher degree forms to generalize the concept of connection. This nascent field has been plagued by a lack of concrete non-trivial examples relevant to physics. In this talk we review the recent progress in constructing a model for a (1,0) superconformal field theory in 6 dimensions containing a non-abelian tensor multiplet using Sen's Lagrange multiplier approach and an object from higher gauge theory known as a string structure.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

No

Parallel Stream 3 / **114**

Color/ Kinematics Duality in AdS_4

Author: Connor Armstrong[1]

[1] *Durham University*

Corresponding Author: connor.armstrong@durham.ac.uk

In flat space, the color/kinematics duality states that perturbative Yang-Mills amplitudes can be written in such a way that kinematic numerators obey the same Jacobi relations as their color factors. This property leads to the BCJ relations between Yang-Mills amplitudes and underlies the double copy to gravitational amplitudes.
In this talk, I will explore how this extends to AdS_4, where a generalised gauge symmetry can be used to enforce the Jacobi relations away from the flat space limit; this lets us derive deformed BCJ relations. I will also review the spinor helicity in a curved background, leading to compact new expressions for 4pt Yang-Mills amplitudes in AdS_4.

Would you be interested in receiving feedback on your talk?:

Yes

Will you be pre-recording your talk?:

No

Length of talk:

15-25 minutes

Are you happy for your talk to be recorded?:

Yes

Plenary Speaker / **115**

Plenary session

Author: David Tong[1]

[1] *University of Cambridge*

Corresponding Author: d.tong@damtp.cam.ac.uk

Professor David Tong is a theoretical physicist at Cambridge studying quantum field theory. He is famous amongst students for his engaging lecturing and his thorough and approachable lecture notes. His research in QFT is diverse, with results in particle physics, gravity, black holes, dualities, string theory, cosmology, condensed matter physics, solitons, and geometry.