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Young Theorists' Forum

Durham University

17th - 18th December 2014

The Young Theorists' Forum kicks off on Wednesday 17th December with lunch in Collingwood College, kindly provided by the ATM.

There will be a series of 15 and 30 minute talks with the final 2 and 5 minutes (respectively) reserved for questions. Talks will be collected into parallel sessions punctuated by tea breaks. These will all be held on the ground floor of the Department of Mathematical Sciences. A detailed session timetable and a full list of abstracts and participants can be found below.

We are delighted to welcome Prof. Gerald Dunne from the University of Connecticut, who will be giving the plenary talk on Wednesday evening. Following this, we invite you to attend the "Poster and Pizza" session, which will be held in the Bransden Room of the Physics Department.

Two more parallel sessions are scheduled for Thursday morning, and the forum will close with a light buffet lunch.

Wednesday 17$^{\text{th}}$ December

12.30	Lunch (*Collingwood College*)	
14.00	1A BSM Physics (*CM101*)	1B String Pheno & Holography (*CM107*)
16.00	Tea & Coffee (*CM103 & CM105*)	
16.30	2A Cosmology (*CM101*)	2B Amplitudes & Solitons (*CM107*)
18.15	Plenary talk: G. Dunne – *Resurgence and the Physics of Divergence* (*CM101*)	
19.15	Poster & Pizza (*Bransden Room*)	

Thursday 18$^{\text{th}}$ December

09.00	3A Phenomenology (*CM101*)	3B String Theory (*CM107*)
11.00	Tea & Coffee (*CM103 & CM105*)	
11.30	4A QCD (*CM101*)	4B Gravity (*CM107*)
13.00	Lunch (*Bransden Room*)	

SESSION 1A: BSM PHYSICS *Chair: G. Ro*

14.00 **Colin Poole** (Liverpool)
The a-theorem: Constructing the A-function for a general theory

14.30 **Barry Dillon** (Sussex)
Non-Custodial Warped Extra Dimensions at the LHC?

14.45 **Juri Fiaschi** (Southampton)
Improving Z' searches with angular distribution analysis

15.15 **Susanne Ehret** (Edinburgh)
Introduction to the Wilson flow

15.30 **Fredrik Bjorkeroth** (Southampton)
CSD(n) vacuum alignments in neutrino models of flavour

15.45 **Christopher Harman** (Sussex)
The EWPT within natural GNMSSM models

SESSION 1B: STRING PHENO & HOLOGRAPHY *Chairs: I. Mavroudi & H. Maxfield*

14.00 **Peter Jones** (Southampton)
Holographic Graphene in a Cavity

14.30 **Johar Ashfaque** (Liverpool)
Can the strong CP problem be solved in the free-fermionic setting?

14.45 **Edwin Ireson** (Swansea)
Seiberg duality and level-rank duality from non-supersymmetric brane configurations

15.15 **Chakrit Pongkitivanichkul** (KCL)
Axiverse-induced Dark Radiation Problem

15.30 **Yang Lei** (Durham)
Scattering amplitudes in Lifshitz spacetime

SESSION 2A: COSMOLOGY *Chairs: T. Jubb & R. Wilkinson*

16.30 **Benjamin Wallisch** (Cambridge)
Turbulence at Weak and Strong Couplings in Quantum Field Theory

17.00 **John Heal** (KCL)
Dark Matter at Resonance

17.15 **Zac Kenton** (QMUL)
D-brane Potentials in the Warped Resolved Conifold & Natural Inflation

17.45 **Tom Charnock** (Nottingham)
Tension between the power spectrum of density perturbations measured on large and small scales

SESSION 2B: AMPLITUDES & SOLITONS *Chairs: A. Cockburn & R. Doobary*

16.30 **Matthew Elliot-Ripley** (Durham)
Toy Models for Holographic Baryons

17.00 **Jenny Ashcroft** (Kent)
Baby Skyrme models without a potential term

17.15 **Gustav Mogull** (Edinburgh)
The $N = 4$ Pentabox through Colour-Kinematics Duality

17.45 **Vladimir Prochazka** (Edinburgh)
Gluon Condensates from Hamiltonian Formalism

SESSION 3A: PHENOMENOLOGY *Chairs: T. Morgan & A. Wilcock*

09.00 **James Cockburn** (Edinburgh)
High Energy Jets – Pure Jet Processes at the LHC

09.30 **Karl Nordstrom** (Glasgow)
Constraining dark matter with the LHC

09.45 **Helen Brooks** (Durham)
Higgs production with High Energy Jets

10.15 **James Gratrex** (Edinburgh)
B Physics and $b \to s$ transitions

10.30 **Mark Ross-Lonergan** (Durham)
What do we really know about the 3×3 neutrino mixing matrix?

10.45 **Darren Scott** (Durham)
Resumming threshold logarithms at hadron colliders

SESSION 3B: STRING THEORY *Chair: J. Edwards*

09.00 **Charlotte Kirchhoff-Lukat** (Cambridge)
Generalised Geometry & M-Theory

09.30 **Gwendolyn Barnes** (Heriot-Watt)
The structure of quantum space-time: Non-associative geometry in flux compactifications of string theory

09.45 **Akash Jain** (Durham)
Entropy Current for Non-Relativistic Charged Fluids

10.15 **Panos Athanasopoulos** (Liverpool)
The correspondence between free fermionic models and orbifolds

10.30 **Siraj Khan** (Liverpool)
Induced Chern-Simons terms from 3d Field Theories with Massive Matter: A String Theorist's Perspective

SESSION 4A: QCD — *Chair: S. Armstrong*

11.30 **Ava Khamseh** (Edinburgh)
Lattice Phenomenology of Heavy Quarks Using Dynamical Fermions

12.00 **Heather McAslan** (Sussex)
New NNLL Resummation of Event-Shapes in e^+e^- *Annihilation*

12.30 **Thomas Morgan** (Durham)
Writing your own Monte Carlo integrator

SESSION 4B: GRAVITY — *Chair: A. Peach*

11.30 **Zoe Slade** (Southampton)
Solving the Reconstruction Problem in Asymptotic Safety

12.00 **Tugba Buyukbese** (Sussex)
$1/D$ *Expansion of Quantum Gravity*

12.15 **Spyridon Talaganis** (Lancaster)
Towards understanding behaviour of quantum loops in infinite-derivative theories of gravity

12.45 **Andrés Luna Godoy** (Glasgow)
BCJ duality, double copy and Black holes

Colin Poole (Liverpool): *The a-theorem: Constructing the A-function for a general theory*

Consider a renormalizable Quantum Field Theory with scalar couplings, Yukawa couplings, and gauge coupling corresponding to a simple gauge group. The couplings $\{I\} = \{\lambda, y, \bar{y}, g\}$ can be treated as points of a manifold in a "coupling-space", and it has been shown that there exists a function A satisfying $\partial_I A = T_{IJ}\beta^J$, such that $G_{IJ} = 1/2(T_{IJ} + T_{JI})$ defines a metric on this space. If G_{IJ} is positive-definite, then A satisfies the "a-theorem", i.e. for four-dimensional QFTs there exists a function of the couplings that decreases monotonically under RG flow. Perturbatively, the existence of such an A function and knowledge of the beta functions at particular orders is enough to derive consistency conditions on the form of higher-order beta functions, providing both non-trivial checks for known functions and necessary conditions for unknown functions. After a discussion of the background material I shall elaborate on the construction of the A function and metric, demonstrate a simple consistency condition, and investigate supersymmetric theories as a special case where a non-perturbative expression for A has been postulated.

Barry Dillon (Sussex): *Non-Custodial Warped Extra Dimensions at the LHC?*

With the prospect of improved Higgs measurements at the LHC and at proposed future colliders such as ILC, CLIC and TLEP we study the non-custodial Randall-Sundrum model with bulk SM fields and compare brane and bulk Higgs scenarios. The latter bear resemblance to the well studied type III two-Higgs-doublet models. We compute the electroweak precision observables and argue that incalculable contributions to these, in the form of higher dimensional operators, could have an impact on the T-parameter. This could potentially reduce the bound on the lowest Kaluza-Klein gauge boson masses to the 5 TeV range, making them detectable at the LHC. In a second part, we compute the misalignment between fermion masses and Yukawa couplings caused by vector-like Kaluza-Klein fermions in this setup. The misalignment of the top Yukawa can easily reach 10%, making it observable at the high-luminosity LHC. Corrections to the bottom and tau Yukawa couplings can be at the percent level and detectable at ILC, CLIC or TLEP (1410.7345).

Juri Fiaschi (Southampton): *Improving Z' searches with angular distribution analysis*

Searching for bumps is of course a very powerful and and model independent tool to discover new particles. In Drell-Yan processes we can improve the search for heavy neutral resonances (Z') by including Forward-Backward asymmetry (AFB) measurements. The analysis of the AFB observable is model dependent and it is presented as a complementary tool in the identification of such resonances. The best features of this observable are presented as well as the most promising scenarios where this analysis is worth.

Susanne Ehret (Edinburgh): *Introduction to the Wilson flow*

The Wilson flow is a promising tool to study strongly coupled theories on the lattice. Its remarkable renormalisation properties allow for a meaningful formulation of the energy-momentum tensor on the lattice. The non-perturbative computation of the latter can in turn be used to study IR fixed points, and hence theories beyond the Standard Model. In this talk I will focus on the perturbative treatment of the gradient flow in different models and its renormalisation properties. I will also summarise its previous and future applications.

Fredrik Bjorkeroth (Southampton): *CSD(n) vacuum alignments in neutrino models of flavour*

There is currently no widely accepted mechanism to explain the structure of the Yukawa couplings of leptons and quarks in flavour space, which account for a large fraction of the free parameters in the Standard Model. Models have been proposed based on discrete family symmetry. These can be realised by coupling matter to flavons, whose VEVs dictate the flavour mixing pattern. I present a class of models that employ vacuum alignments known as constrained sequential dominance (CSD), and perform a global fit analysis to current neutrino mixing and mass data.

Christopher Harman (Sussex): *The EWPT within natural GNMSSM models*

Now that a (favoured CP-even) scalar boson has become evident from the LHC run in 2013, the scientific community working on (Beyond the) Standard Model physics must embed such a particle in all their favourite theoretical frameworks. As a popular candidate, the Generalised Next-to-MSSM (GNMSSM) is a chiral singlet extension of the Minimal Supersymmetric Standard Model (MSSM) - which is itself a two Higgs Doublet Model of type II, plus Supersymmetric invariance at higher energies - and can both account for a 125 GeV CP-even Higgs boson, through its identification as the lightest or next-to-lightest CP-even state in the Higgs sector, and provide an interesting insight into the Electroweak Phase Transition (EWPT).

Peter Jones (Southampton): *Holographic Graphene in a Cavity*

The AdS/CFT correspondence or "holography" has been established as a valuable tool for studying systems at strong coupling. Graphene has been conjectured to be such a system, and holographic models exist which structurally resemble graphene. In this talk I will review the basics of holography, before discussing how one can consider, holographically, the problem of placing graphene in a cavity, in the hope of pushing it further to strong coupling.

Johar Ashfaque (Liverpool): *Can the strong CP problem be solved in the free-fermionic setting?*

Axions are the quanta of the axion field, $a(x)$, which is the phase of the PQ complex scalar field after the spontaneously breaking of the PQ symmetry gives it an absolute value f_a. It is well-known that axions arise in string compactifications. There are two axions in superstring models. One is the model-independent axion (MI axion) and the other is the Peccei-Quinn type one (PQ axion) namely the global anomalous U(1). The model-independent axion is present in all the superstring models due to the presence of the coupling. The global anomalous U(1) is present in all the models in the free fermionic formulation which arises as the Goldstone boson of the global anomalous U(1) in the theory. This global anomalous U(1) is a formal linear combination of the U(1)s in the gauge symmetry of the theory. The anomaly cancellation mechanism generates a Fayet-Iliopoulos D-term for the anomalous U(1) which in general would break supersymmetry and destabilize the vacuum. However, in all known instances one can give VEVs to scalar fields charged under anomalous U(1) to cancel the Fayet-Iliopoulos D-term. The scalar VEVs resulting from D constraint gives a large axion decay constant. It turns out that the MI axion and the axion of the anomalous U(1) can not solve the strong CP problem since they always have large masses and axion decay constants.

Edwin Ireson (Swansea): *Seiberg duality and level-rank duality from non-supersymmetric brane configurations*

We propose a non-supersymmetric version of Seiberg duality for three dimensional theories, using the celebrated results of Level-Rank duality for Chern-Simons theories, by studying a particular non-supersymmetric brane configuration.

Chakrit Pongkitivanichkul (KCL): *Axiverse-induced Dark Radiation Problem*

String theory suggests that cosmology is populated by many light pseudoscalar axions (an "Axiverse" scenario). Their presence in early universe give rise to dark radiation, non-standard model contribution to radiation imprinted onto Cosmic Microwave Background (CMB). Due to complexity of string compactification, it is natural to expect number of axions to be several hundreds up to thousands. Although there have been hints of dark radiation from Planck satellite and WMAP experiment, we show in this talk that large number of axions in typical axiverse scenario produces dark radiation much larger than observable value. Motivated by this problem, we study moduli space of compactified manifolds allowing by this constraint. We show that G2 manifold can relax strong dependency between number of axions and dark radiation. In addition, under plausible condition on moduli mass matrix, a compactified manifold with sufficiently large number of axions gives a phenomenologically acceptable value of dark radiation. The application on G2 compactified M-theory is also presented in great detail.

Yang Lei (Durham): *Scattering amplitudes in Lifshitz spacetime*

We consider the calculation of scattering amplitudes in field theories dual to Lifshitz spacetimes. These amplitudes provide an interesting probe of the IR structure of the field theory; our aim is to use them to explore the observable consequences of the singularity in the spacetime. We assume the amplitudes can be related by T-duality to a Wilson loop, as in the AdS case, and determine the bulk minimal surfaces for the simplest cusp Wilson loop. We use this to determine the leading IR singularity in the amplitude. We find there is a stronger IR singularity for $z > 1$ than for $z = 1$, with a coefficient which vanishes as z goes to 1.

Benjamin Wallisch (Cambridge): *Turbulence at Weak and Strong Couplings in Quantum Field Theory*

Non-equilibrium dynamics, including the phenomenon of turbulence, can be found in a wide variety of systems. Important examples range from preheating after cosmological inflation in the early universe to the pre-thermalisation processes in relativistic heavy-ion collisions and experiments with ultra-cold quantum gases. In this talk, I will present the out-of-equilibrium evolution of a scalar $O(N)$ symmetric quantum field theory with both weak and strong quartic self-interaction. I will report for the first time on the observation of the dual cascade picture directly in quantum field theory, without the standard mapping to a classical-statistical field theory. Furthermore, I will demonstrate that turbulence is not restricted to parameter ranges suitable for classical-statistical simulations, but can also occur at couplings of order one and larger. In addition, I will comment on the first observation of a stationary exponent of $5/3$, which is associated to elastic scattering in the energy cascade for large momenta and vanishing macroscopic field.

John Heal (KCL): *Dark Matter at Resonance*

In this talk I will consider a simplified model of dark matter where the couplings between the standard model and the dark sector fall at resonance due to kinematics and direct detection experiments become insensitive.

Zac Kenton (QMUL): *D-brane Potentials in the Warped Resolved Conifold & Natural Inflation*

In this talk I will present a model of Natural Inflation from string theory with a Planckian decay constant. In arXiv:1409.1221, D-brane dynamics were investigated in the background of the warped resolved conifold (WRC) throat approximation of Type IIB string compactifications on Calabi-Yau manifolds. When we glue the throat to a compact bulk Calabi-Yau, we generate a D-brane potential which is a solution to the Laplace equation on the resolved conifold. We can exactly solve this equation, including dependence on the angular coordinates. The solutions are valid down to the tip of the resolved conifold, which is not the case for the more commonly used deformed conifold. This allows us to exploit the effect of the warping, which is strongest at the tip. We inflate near the tip using an angular coordinate of a D5-brane in the WRC which has a discrete shift symmetry, and feels a cosine potential, giving us a model of Natural Inflation, from which it is possible to get a Planckian decay constant whilst maintaining control over the backreaction. This is because the decay constant for a wrapped brane contains powers of the warp factor, and so can be made large, while the wrapping parameter can be kept small enough so that backreaction is under control.

Tom Charnock (Nottingham): *Tension between the power spectrum of density perturbations measured on large and small scales*

There is a tension between measurements of the amplitude of the power spectrum of density perturbations inferred using the Cosmic Microwave Background (CMB) and directly measured by Large-Scale Structure (LSS) on smaller scales. We show that this tension exists, and is robust, for a range of LSS indicators including clusters, lensing and redshift space distortions and using CMB data from either Planck or WMAP+SPT/ACT. One obvious way to try to reconcile this is the inclusion of a massive neutrino which could be either active or sterile. Using Planck and a combination of all the LSS data we find that (i) for an active neutrino $m_\nu = (0.357 \pm 0.099)$ eV and ii) for a sterile neutrino $m^{\rm eff} = (0.67 \pm 0.18)$ eV and $\Delta N_{\rm eff} = 0.32 \pm 0.20$. This is, however, at the expense of a degraded fit to Planck temperature data, and we quantify the residual tension at 2.5 and 1.6 for massive and sterile neutrinos respectively. We also consider alternative explanations including a lower redshift for reionization that would be in conflict with polarisation measurements made by WMAP and ad-hoc modifications to primordial power spectrum.

Matthew Elliot-Ripley (Durham): *Toy Models for Holographic Baryons*

Inspired by the AdS/CFT correspondence and by Skyrme theory (a low-energy effective field theory for baryons), there have been many attempts to use holography as a way of studying strongly-coupled QCD. The pre-eminent example of this is the Sakai-Sugimoto model, in which bulk Yang-Mills instantons in five spacetime dimensions are dual to boundary Skyrmions (which in turn represent baryons). In this talk I will discuss some lower-dimensional analogues of this model, in which modifications to an O(2) sigma model in three spacetime dimensions take the place of the 5-d Yang-Mills instanton of the Sakai-Sugimoto model.

Jenny Ashcroft (Kent): *Baby Skyrme models without a potential term*

The baby Skyrme model has enjoyed much success both as a toy model for the Skyrme model and as an interesting physical model in its own right. However Derrick's theorem tells us that the baby Skyrme model requires a potential term to have topological solitons whereas the Skyrme model does not. Motivated by this discrepancy, we develop a family of new baby Skyrme models which do not require a potential term to have soliton solutions. We also require that that there is a linear bound on the energy of the solitons in terms of the topological charge, thus obtaining a one-parameter family of models satisfying our constraints. In this talk, I will provide a brief overview of the motivation behind and development of our models and present some of their interesting features.

Gustav Mogull (Edinburgh): *The $N = 4$ Pentabox through Colour-Kinematics Duality*

The duality between colour and kinematics recently discovered by Bern, Carrasco & Johansson (BCJ) sheds new light on Yang Mills amplitudes, easing their computation and allowing extrapolation of gravitational amplitudes both in the supersymmetric and non-supersymmetric regimes. In this talk I shall introduce the duality and, by deriving the "pentabox" in $N = 4$ Super-Yang Mills theory, outline a new strategy for computation of BCJ numerators.

Vladimir Prochazka (Edinburgh): *Gluon Condensates from Hamiltonian Formalism*

I will discuss the recently obtained relations, relating the logarithmic gauge coupling derivative of the hadron mass and the cosmological constant to the matter and vacuum gluon condensates, within the Hamiltonian framework. Such relations could serve as useful tools for studying non-perturbative QCD or models of SUSY breaking. The key ingredients of the derivation are a canonical transformation which brings the relevant part of the Hamiltonian into a suitable form and the application of the Feynman-Hellmann theorem. To illustrate the use of these relations in practice I will apply them to the Schwinger model and $N = 2$ Super Yang Mills theory (Seiberg-Witten theory). Finally, I will suggest potential areas of application which range from cosmology to lattice QCD.

James Cockburn (Edinburgh): *High Energy Jets – Pure Jet Processes at the LHC*

At its core, High Energy Jets (HEJ) uses the factorisation properties of the high energy limit to firstly approximate and then resum the QCD matrix elements relevant for LHC physics. In this talk, I will describe the formalism in more detail before moving on to discuss new work which will provide two things: one, a step towards next-to-leading log accuracy for pure jet production and two, a leading log prediction for a specific 4 jet sub-process.

Karl Nordstrom (Glasgow): *Constraining dark matter with the LHC*

The so-called WIMP miracle suggests dark matter could be a weakly interacting particle with a mass of O(100 GeV). Direct detection experiments have searched for such particles for years, and considerable effort to detect them has also recently been made by ATLAS and CMS. However the effective interaction theory used by direct detection experiments as a limit-setting model has limited applicability at the LHC, and the results should preferably be interpreted in a framework which allows the dark mediator to be resolved instead – for this purpose minimal simplified dark matter models have been proposed. I will briefly discuss the limitations of the effective theory as applied to the LHC and then present a study of the full four parameter space of a particular simplified model.

Helen Brooks (Durham): *Higgs production with High Energy Jets*

I will discuss how to calculate scattering amplitudes for Higgs plus jets within the High Energy Jets Formalism. I shall explain how HEJ extends the formulation of a t-channel factorized matrix element from the pure jets case to include Higgs production, first using an effective field theory approach, and then including finite quark mass corrections. I shall discuss the importance of these corrections and their phenomenological implications.

James Gratrex (Edinburgh): *B Physics and $b \to s$ transitions*

B Physics provides an important testing ground both in testing the predictions of the Standard Model and in searching for New Physics. In this talk I introduce some of the core concepts and techniques involved in the filed. While the methods discussed apply generally to a rich variety of B meson decays, I will focus on the channel $B \to K^* l^+ l^- \to K \pi l^+ l^-$. Predicted to be rare within the Standard Model, this decay could prove to be a particularly important one in NP searches.

Mark Ross-Lonergan (Durham): *What do we really know about the 3×3 neutrino mixing matrix?*

Unitarity is a fundamental property of any theory required to ensure we work in a theoretically consistent framework. Unlike in the quark sector, unitarity has never been experimentally verified for the 3×3 PMNS matrix which enters into modern oscillation experiments. It must be remembered, however, that the vast majority of large-statistics experiments run thus far that provide the bulk of information on the mixing angles focus mainly on the electron sector, with the assumption of unitarity being invoked to constrain the tau and muon sectors. What can this non-unitartity do to our understanding of the neutrino sector parameters, and what bounds do we have on this non-unitarity?

Darren Scott (Durham): *Resumming threshold logarithms at hadron colliders*

It is well known that, at hadron colliders, a LO prediction from theory is insufficient. Even at NLO theoretical predictions can vary by 10% due to uncertainties in PDFs or varying unphysical scales. However, one way to improve on NLO predictions is to use resummation techniques in order to capture (hopefully) dominant contributions from higher orders in perturbation theory. This talk will focus on top quark physics and describe how soft collinear effective theory (SCET) can be used to derive a factorisation formula for the cross-section in the partonic threshold limit. With the different scales separated it is possible to use renormalisation group equations to solve each piece at a suitable scale and, by running to a common scale, resum large logarithms which would otherwise be present. Finally there'll be some comments on the differences between performing resummation in momentum space vs Mellin (or moment) space and present some predictions - time permitting.

Charlotte Kirchhoff-Lukat (Cambridge): *Generalised Geometry & M-Theory*

I will give an introduction to Generalised Geometry, a method to unify different structures on smooth manifolds in Differential Geometry. It can be used to reformulate string theory and M-theory to put all fields in the theory on an equal footing and is thus of interest in theoretical physics.

Gwendolyn Barnes (Heriot-Watt): *The structure of quantum space-time: Non-associative geometry in flux compactifications of string theory*

Flux compactifications in string theory are a promising candidate for an accurate model of the nature of the quantum vacuum. Curiously, closed strings in flux compactifications probe a non-commutative and non-associative geometry. In this talk I will present to you how one might understand the concept of a non-commutative and non-associative spacetime, making use of the capable language of category theory wherein differential geometry is internal to a certain quasi-Hopf representation category and quantisation is achieved by the application of the twist deformation quantisation functor.

Akash Jain (Durham): *Entropy Current for Non-Relativistic Charged Fluids*

I will be talking about transport properties of non-relativistic fluids, and how can they be deduced though light-cone reduction of a relativistic fluid. This is a work I did at IISER Bhopal with my collaborators during my Masters. We aim to study transport properties of a parity-odd, non-relativistic charged fluid in presence of background electric and magnetic fields. To obtain the stress tensor and charge current of the non-relativistic system, we start with the most generic relativistic fluid living in one higher dimension, and reduce the constitutive equations of the relativistic system along the light-cone direction. This mechanism is known as light-cone reduction. In a similar way, reducing the equation satisfied by the entropy current of the relativistic theory we obtain a consistent entropy current for the non-relativistic system. Demanding the second law of thermodynamics, we impose constraints on various first order transport coefficients (like viscosity, thermal conductivity, electric conductivity etc.) of the fluid. One of our important results is that in $(2+1)$ dimensions, one can have a first derivative, parity-odd fluid only if the fluid is incompressible and is subjected to a constant magnetic field.

Panos Athanasopoulos (Liverpool): *The correspondence between free fermionic models and orbifolds*

Both the orbifold and the free fermionic formalism have been used widely to construct semi-realistic models in heterotic string theory. There have also been extensive scans in the space of these models in search for realistic ones. In this talk I will describe the correspondence between the two formalisms and briefly explain how to translate models from one to the other.

Siraj Khan (Liverpool): *Induced Chern-Simons terms from 3d Field Theories with Massive Matter: A String Theorist's Perspective*

It has long been known that Chern-Simons terms can be induced in the Lagrangian of a low energy 3d field theory by integrating out massive fermions from the high energy theory. In doing so the Chern-Simons level of the effective theory is increased. I explain details of the procedure and how it can be described by a corresponding string theory. I then describe how induced Chern-Simons terms can be used to 'flow' between two different strong-weak dualities in the low energy theory.

Ava Khamseh (Edinburgh): *Lattice Phenomenology of Heavy Quarks Using Dynamical Fermions*

Standard Model is believed to be only the low energy limit of a more fundamental theory. In order to determine its range of validity, a major part of theoretical and experimental programme in physics is dedicated to precision tests of the Standard Model. Lattice QCD which involves numerical calculations of hadronic matrix elements on a discretised space-time, plays an important role in flavor physics by providing calculations of non-perturbative strong interaction contributions to weak processes involving quarks. In particular, LQCD calculations are required in theoretical study of the heavy mesons (B-mesons) currently being subject to intense research both and theoretical and experimental levels. In this talk I will present the latest UKQCD collaboration results of physical observables such as masses and decays constants as well as the Bag and Xi parameters. Such measurements are required as theoretical inputs in testing the Standard Model and searches for New Physics.

Heather McAslan (Sussex): *New NNLL Resummation of Event-Shapes in e^+e^- Annihilation*

Soft-gluon resummation is necessary to attain reliable predictions for observable cross-sections at colliders, as well to aid precision measurements of the strong coupling. So far, many observables have been resummed to next-to-leading logarithmic accuracy (NLL), however only a few have been calculated to the subsequent order (NNLL), and only on a case-by-case basis. We have recently derived a generic approach to the resummation of event-shape observables in e^+e^- to NNLL accuracy, based on the principles of CAESAR (Computer Automated Expert Semi-Analytical Resummer, which is valid to NLL). I will discuss the assumptions made for the observable, the method of resummation, and its numerical implementation in a self-contained computer code. We have produced new results for three event-shapes as well as reproducing four previously-known results. Our method is fully generalisable to any observables with the appropriate scaling properties, both at e^+e^- and hadron collider machines.

Thomas Morgan (Durham): *Writing your own Monte Carlo integrator*

BSM physics at the LHC is dead, or so we're led to believe. However, because of huge theoretical uncertainties it could well be that New Physics is hidden in the 7 and 8 TeV data and we just can't see it. By improving the precision of our Standard Model calculations we hope to be able to distinguish your favourite SUSY model from backgrounds. With this in mind, I'll discuss how to build your own LHC Monte Carlo integrator. I'll start with a brief overview of all the ingredients we need (parton distribution functions, matrix elements, etc.) and how we can glue them together to get something that vaguely resembles physics. I'll then move on to talking about improving our Monte Carlo simulation by including higher order corrections to the underlying born process, motivating the need for subtraction terms to deal with unphysical infra-red singularities in our improved simulation.

Zoe Slade (Southampton): *Solving the Reconstruction Problem in Asymptotic Safety*

The goal of asymptotic safety is to find a well-behaved theory of quantum gravity via the existence of a UV fixed point of the theorys renormalization group flow. The object most favoured by the asymptotic safety community to investigate this flow is the effective average action, Γ. Upon finding an asymptotically safe theory using Γ, one would like to reconstruct the bare action, S, to find a path integral representation of the theory; this is known as the reconstruction problem. In this talk I will review the basics of asymptotic safety, discuss the reconstruction problem and present a way to solve it.

Tugba Buyukbese (Sussex): $1/D$ *Expansion of Quantum Gravity*

We study the UV completion of quantum gravity in a large number of dimensions using exact renormalisation group methods. Starting with an Einstein-Hilbert action, we provide a $1/D$ expansion of the non-trivial fixed points of quantum gravity. In this short talk I will discuss the results for the $1/D$ expansion of the fixed points from various approximations.

Spyridon Talaganis (Lancaster): *Towards understanding behaviour of quantum loops in infinite-derivative theories of gravity*

In this talk, I will consider quantum aspects of infinite-derivative scalar field theory - a toy model depiction of an infinite-derivative extension of the Einstein's theory of general relativity (GR), introduced by Biswas, Gerwick, Koivisto and Mazumdar (BGKM). The gravitational action of BGKM has been shown to be free from ghosts around the Minkowski background and also free from space-like and time-like singularities. In particular, the gravitational propagator in the BGKM gravity gets an exponential suppression, in order for the theory to be ghost-free and possibly asymptotically free, while maintaining the general covariance of the massless graviton from the infrared (IR) to the ultraviolet (UV) scales. In this talk, I will be studying the quantum aspects of a scalar toy model, which mimics some of the properties of BGKM gravity. In particular, I will consider 1-loop and 2-loop Feynman diagrams within this toy model and discuss the nature of divergences. I will find that at 1-loop, the theory is still divergent, and requires counter terms to make the 1-loop convergent, but at higher loops the toy model seems to be well under control in the UV. I will discuss how one may be able to generalize our computations and arguments to arbitrary loops and assess the prospects of renormalizability for such infinite-derivative theories.

Andrés Luna Godoy (Glasgow): *BCJ duality, double copy and Black holes*

In spite of having different physical behaviours, gauge and gravity theories are intimately linked (the most famous example of this is AdS/CFT correspondence). Bern, Carrasco and Johansson observed that (classical) tree level gauge theory amplitudes can be rearranged to display a duality between color and kinematics (BCJ duality), and once this is imposed, gravity amplitudes are obtained using two copies of gauge theories diagram numerators. Later, they conjectured this holds to all loop orders (double copy). One interesting matter is investigate if this relation holds to classical solutions level, instead of scattering amplitudes. In this talk, I will briefly review the main features of BCJ duality, the double copy, and a general class of solutions that double copy to gravity involving stationary Kerr-Schild metrics.

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