

# **Twistor Theory and Beyond**

## **Report of Contributions**

Contribution ID: 1

Type: **not specified**

## Rod Gover – A conformally invariant Yang-Mills energy and equation on 6-manifolds

*Monday 27 September 2021 10:00 (1 hour)*

A conformally invariant Yang-Mills energy and equation on 6-manifolds. The gauge field equations known as the Yang-Mills equations are extremely important in both mathematics and physics, and their conformal invariance in dimension 4 is a critical feature for many applications. In dimension 4, and when specialised to the Cartan/tractor connection, the Yang-Mills current recovers exactly the Bach tensor. This provides a nice link between the Yang-Mills equations and (for example) the conformally-Einstein condition.

We show that there is a simple and elegant route to higher order equations in dimension 6 that are analogous, and arise as the Euler-Lagrange equations of a conformally invariant action. The functional gradient of this action recovers the conformal Fefferman-Graham obstruction tensor when the gauge connection is taken to be the conformal Cartan (or tractor) connection – so there is a nice analogy to the dimension 4 case. As well as providing evidence that these equations provide a good notion of higher Yang-Mills, this result leads to potential applications to the study of Einstein 6-manifolds. Other potential applications will be touched on if time allows.

This is joint work with Larry Peterson and Callum Sleight:  
arXiv:2107.08515

Contribution ID: 2

Type: **not specified**

## David Skinner – Twistors, Integrability and 4d Chern-Simons Theory

*Monday 27 September 2021 11:30 (1 hour)*

Costello, Witten & Yamazaki have recently introduced a new approach to 2d integrable systems based on a variant of Chern-Simons theory living in 4d. I'll review this story, and show how it is deeply connected both to Lionel's work on the twistor construction of integrable systems, and to his more recent work on scattering amplitudes in four dimensional gauge theories.

Contribution ID: 3

Type: **not specified**

## **Nathan Berkovits – Twistors and the $\text{AdS}_5 \times S^5$ Superstring**

*Monday 27 September 2021 14:00 (1 hour)*

I will describe recent approaches to including twistors in the worldsheet description of the superstring in an  $\text{AdS}_5 \times S^5$  background.

Contribution ID: 4

Type: **not specified**

## **Claude LeBrun – Einstein Manifolds, Conformal Curvature, and Anti-Holomorphic Involutions**

*Monday 27 September 2021 15:30 (1 hour)*

Contribution ID: 5

Type: **not specified**

## **Anastasia Volovich – Recent Developments in N=4 Yang-Mills Amplitudes.**

*Monday 27 September 2021 16:30 (1 hour)*

Contribution ID: 6

Type: **not specified**

## Prim Plansangkate – Einstein-Weyl structures and dispersionless equations

*Tuesday 28 September 2021 10:00 (1 hour)*

We shall demonstrate via a simple transformation that, under symmetry assumption, the equations governing a general anti-self-dual conformal structure in four dimensions can be explicitly reduced to the Manakov-Santini system, which determines the three-dimensional Einstein-Weyl structure on the space of orbits of symmetry. Then we move on to discuss the mn-dKP equation, which is a generalisation of the dispersionless Kadomtsev-Petviashvili (dKP) equation in higher dimensions and is related to the Einstein-Weyl structures in  $n+2$  dimensions. Its integrability can be investigated by constructing solutions constant on central quadrics.

Contribution ID: 7

Type: **not specified**

## Jerzy Lewandowski – Spacetime, structures, equations and solutions

*Tuesday 28 September 2021 11:30 (1 hour)*

When I met Lionel at Syracuse in the winter of 1991, he was interested in null structures, the spacetimes that admit them and the equations they may satisfy. Some of these, along with a few others and new results, will be discussed in this lecture.

For curved spacetime, the twistor equation relates the local twistor connection to the Chern-Moser connection of the CR structure and the corresponding conformal Fefferman geometry. The Fefferman family of metric tensors contains examples of spacetimes that are flat in the Bach sense but not conformally Einstein.

The CR structures appear in a larger class of spacetimes as null shear free geodesic congruences. Einstein equations imply their realisability while the spacetimes are algebraically special.

In the case of Petrov type D, the spacetimes admit 2-dimensional groups of isometries. When the NUT parameter does not vanish, two Killing vectors are distinguished, each defining a space of orbits free of the conical singularity. This property was used to construct globally defined, singularity-free Kerr-NUT-(A)dS spacetimes. Some of them are globally hyperbolic, while others contain Killing horizons of the Hopf fibration structure.

Quasi-local generalisation of Killing horizons leads to isolated horizons. Geometric structure of the isolated horizons is subject to equations implied by Einstein's equations. The solution space of the equations of an isolated horizon has many properties analogous to those proved in the global black hole theory: the topology of connected components of sections must be spherical, the rigidity, no-hair, uniqueness.

In the theory of gravitational radiation through a non-expanding horizon, the symmetry group is the BMS group extended by one more generator. The canonical fluxes vanish to first order, the energy flux is positively definite to second order.



Contribution ID: 8

Type: **not specified**

## Ian Strachan – Twistor Theory and Donaldson-Thomas Invariants

*Tuesday 28 September 2021 14:00 (1 hour)*

Lionel taught us how to use the Lie algebra of volume preserving diffeomorphism of a surface in Lax pairs, thus making the connection between integrable systems and curved twistor spaces. He also taught us how isomonodromy problems have a natural twistorial interpretation. In this talk it is shown how the wall-crossing phenomena in the theory of Donaldson-Thomas invariants results in a Riemann-Hilbert problem, and hence, via a (complex) hyperkahler manifold, to twistor theory. [joint work with Tom Bridgeland]

Contribution ID: 9

Type: **not specified**

## Jaroslav Trnka – Negative Amplituhedron Geometries and Amplitudes at Strong Coupling

*Tuesday 28 September 2021 15:30 (1 hour)*

We define negative Amplituhedron geometries which generalize the Amplituhedron picture for scattering amplitudes in planar  $N=4$  SYM theory. We show that these geometries naturally describe the logarithm of the amplitude, and we use them to define a certain IR finite object as the dlog form on negative geometries. In certain limits, we determine this object to all loop orders, perform resummation and expand at strong coupling. Finally, we discuss quantitative features of our result and future work.

Contribution ID: **10**

Type: **not specified**

## **Lance Dixon – Surveying the Mason-Dixon Line**

*Tuesday 28 September 2021 16:30 (1 hour)*

I recount some of my cherished overlaps and interactions with Lionel, both linear and nonlinear, over the past 16 years, as we have pursued complementary approaches to understanding what amplitudes are.

Contribution ID: 11

Type: **not specified**

## Yvonne Geyer – Loop integrands from the Ambitwistor String

*Wednesday 29 September 2021 10:00 (1 hour)*

In this talk, I will present an overview of the Ambitwistor String, a class of worldsheet models describing field theory, with particular focus on the progress in understanding loop amplitudes in Yang-Mills theory and gravity. While the worldsheet model naturally represents these amplitudes as correlators on higher genus Riemann surfaces, a residue theorem on the moduli space relates the complicated higher-genus expressions to much simpler formulae on (multi-)nodal spheres. The resulting formalism on the nodal sphere manifests many beautiful connections to other corners of the amplitudes community, such as the colour-kinematics duality. To conclude, I will discuss some recent work on three-loop results for supergravity, and a closely related proposal on how to uplift the field theory results obtained from the ambitwistor string to superstring loop amplitudes.

Contribution ID: 12

Type: **not specified**

## Paul Tod – One-sided type-D vacuum metrics are integrable

*Wednesday 29 September 2021 11:30 (1 hour)*

I show that any 4-dimensional Riemannian Ricci-flat metric for which either the SD or the ASD Weyl spinor is type-D has a symmetry and is determined by a solution of the Toda field equation. As a corollary, if there is a second symmetry commuting with the first then the metric is determined by an axisymmetric solution of the flat 3-dimensional Laplacian.

Contribution ID: 13

Type: **not specified**

## **Eduardo Casali – Threading the history of twistors with strings**

*Wednesday 29 September 2021 14:00 (1 hour)*

I will present a review of the various successes obtained by combining twistors (and ambitwistors) with string theory, from the seminal work of Witten almost twenty years ago to recent developments in flat space holography.

Contribution ID: 14

Type: **not specified**

## **George Sparling – The relation between string theory, twistor theory and gravity: the past and present**

*Wednesday 29 September 2021 15:30 (1 hour)*

Lionel Mason and his cohorts have pioneered the twistor string theory of Einstein's gravity, based on an intense study of the propagation of gravity in null directions. I will discuss this work, invoking the spirits of the ancestors, particularly those associated with my former college, Isaac Newton, Subrahmanyan Chandrasekhar, Hermann Bondi and Jeffrey Goldstone.

Contribution ID: 15

Type: **not specified**

## **Zvi Bern – From Twistor Theory to Gravitational Waves**

*Wednesday 29 September 2021 16:30 (1 hour)*

I will start with a few anecdotes about twistor theory making comments on supergravity before turning to current problems in gravitational wave physics.



Contribution ID: **16**

Type: **not specified**

## **Lionel Mason – Overview**

*Wednesday 29 September 2021 17:30 (30 minutes)*