**Higgs Centre Workshop: Celestial Sphere: holography, CFT and amplitudes**

**13-15 September 2021**

**Abstracts**

**Laura Donnay** (TU Vienna)

**BMS flux algebra in celestial holography**

In this talk, we construct the BMS momentum fluxes, which are given by non-local expressions of the solution space of asymptotically flat spacetimes. They transform in the coadjoint representation of the extended BMS group and correspond to Virasoro primaries under the action of bulk superrotations. We will also discuss their relation with celestial CFT currents and deduce the OPEs of the celestial CFT operators from the BMS flux algebra.

**Stephan Stieberger** (MPI Munich)

**Celestial Gluon Amplitudes: Single-valued Correlators and Conformal Blocks**

**Lionel Mason** (Oxford)

**On the twistor origin of celestial W-infinity symmetry**

This talk will first set out to explain how the loop algebra of the the w-infinity algebra, understood as the area-preserving diffeomorphisms, acts on the space of Self-dual gravitational phase space via Penrose's twistor correspondence. Using a recently introduced sigma model, we show how the algebra can be expressed on the celestial sphere via a sigma model with the twistor space as target in such a way as to express the w-infinity algebra in terms of the soft algebra recently found by Strominger, based on earlier joint work.

**Andrew Strominger** (Harvard)  
**w infinty and the celestial sphere**

**Ana-Maria Raclariu** (Perimeter Institute)  
**Shadow momenta and new constraints on celestial amplitudes**  
Celestial amplitudes compute S-matrices in a basis of boost as opposed to standard energy-momentum eigenstates. This choice of basis is not unique: shadow- and light-transforms map conformal primary solutions to new conformal primary solutions and were recently proposed to be involved in an alternate basis for celestial holography. In this talk I will present expressions for the Poincare generators in the shadow and light-transformed bases and use them to derive new constraints on celestial two- and three-point amplitudes. The constraints take the form of recursion relations on two- and three-point coefficients and their solutions will be shown to match the results obtained by direct computation of shadow-transforms of celestial amplitudes

**Jelle Hartong** (Edinburgh)

**Carroll: to run or to stand still**

In 1965 Lévy-Leblond studied the contraction of the Poincaré group in which the speed of light c is sent to zero. This is called the Carroll limit and it is a bit of an unconventional limit to study. However, gradually, it is becoming clear that this limit is potentially relevant for physics. We are accustomed to taking non-relativistic approximations and expand around c=\infty. Much less is known about the `opposite' question: is expanding a relativistic theory around c=0 a useful approximation and what can we do with it? In this talk I will give an overview of the basic properties of systems with Carroll symmetry. I will show that there are two types of particles: those that do not move and those that cannot stand still. We will also take a look at fluids and field theories as well as Carroll geometry and its occurrences in GR: e.g. every null hypersurface is a Carrollian spacetime. This includes black hole horizons and of course null infinity: scri. Finally and time permitting, I will show that one can discuss inflationary cosmology from a Carrollian perspective.

**Andrea Puhm** (Ecole Polytechnique)

**From diamonds to pyramids on the celestial sphere**

Celestial diamonds encode the global conformal multiplets of the conformally soft sector of celestial CFT, elucidating the role of soft theorems, symmetry generators and Goldstone modes. Upon adding supersymmetry they stack into a pyramid. I will discuss this structure with emphasis on the soft charges associated to the fermionic layers that tie it together. This extends the analysis of conformally soft currents for photons and gravitons which have been shown to generate asymptotic symmetries in gauge theory and gravity to infinite-dimensional fermionic symmetries.

**Hugh Osborne** (Cambridge)

**Eduardo Casali** (UC Davis)

**Twistor strings and the Celestial OPE**

Twistor strings are worldsheet theories similar to string theory but possessing only massless degrees of freedom, making them suitable to describe the S-matrix of QFTs. They are defined by a free, chiral 2D CFT and thus all local information is contained in the OPEs of local operators which can be computed explicitly. I will describe how the worldsheet OPE in these theories relates to the target space OPE in the CCFT.

**Atul Sharma** (Oxford)  
**Twistors, light transforms, and the celestial Grassmannian**  
I will discuss recently discovered connections between light transforms in celestial CFT and Witten's half-Fourier transform to twistor space. Motivated by this, I will describe celestial amplitudes in an ambidextrous basis of light transformed boost eigenstates. The resulting amplitudes are found to be non-distributional in the celestial kinematics. Finally, I will mention ongoing work on the Grassmannian geometry of celestial amplitudes.

**Glenn Barnich** (ULB)  
**Photons & gravitons in a Casimir box**  
We study finite size effects in gauge and gravitational theories.

(i) The partition function of electromagnetism and linearized gravity with perfectly conducting boundary conditions is shown to be equivalent to that of a massless scalar field with periodic boundary conditions on a box of double the size.

(ii) Exact results for background spacetimes of the form 𝕋q×ℝd+1−q\mathbb T^{q}\times \mathbb R^{d+1-q} are derived in terms of Eisenstein series. Modular invariance and the associated high/low temperature dualities are generalized to higher dimensions.

(iii) For low temperature/small boxes, the leading contribution to the entropy scales like the area in the case of 𝕋2×ℝ2\mathbb T^2\times \mathbb R^2.

**Lorenzo Magnea** (Torino)

**Non-abelian infrared divergences on the celestial sphere**

I will consider the all-order infrared factorisation of non-abelian multi-particle scattering amplitudes, mostly focusing on colour-dipole contributions, and I will show that the infrared factor has a remarkably simple expression in celestial coordinates, with scale and coupling dependence factorised from kinematics and colour. Generalising earlier suggestions in the abelian theory, I will then show that the infrared factor can be computed as a correlator of vertex

operators in a conformal field theory of Lie-algebra-valued free bosons on the celestial sphere. The same conformal theory correctly predicts the all-order structure of collinear limits, and the tree-level factorisation of soft real radiation.

**Sabrina Pasterski** (Princeton)

**Fun with Celestial Dressings: Harbingers of Chaos, Heralds of Symmetry**

**Akshay Yelleshpur Srikant** (Brown)

**Celestial MHV amplitudes: polytopes, singularities and differential equations**

I'll review the structure of celestial MHV gluon amplitudes and discuss their singularity structure in the space of conformal dimensions. I will then describe polytopes which govern these singularities. Finally, I'll talk about some recently discovered null state differential equations satisfied by these amplitudes and their interpretation in momentum space.