

Double Scaled Sachdev-Ye-Kitaev Model: From Gravity to Many-Body Quantum Chaos

Events for:
Monday, May 11th - Friday, May 15th

Monday, May 11th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Vladimir Narovlansky - SCGP 102**

Speaker: Vladimir Narovlansky

Title: Chaos in de Sitter and quantum mechanics

Abstract: I will discuss the chaotic behavior in de Sitter using the out-of-time-order correlator. When embedding it in a quantum framework it gives rise to a tension between the gravitational behavior and quantum mechanics through the bound on chaos. I will compare the gravitational result to a proposed microscopic principle for describing an observer in de Sitter which can be realized using DSSYK.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Mark Mezei - SCGP 102**

Speaker: Mark Mezei

Title: Fluctuating hydrodynamics of the SYK lattice

Abstract: To capture universality in many-body quantum chaos, it is useful to reformulate the dynamics of solvable models in the framework of effective field theory. The SYK lattice is a spatially local generalisation of the SYK model. In the low-temperature limit we derive the nonlinear action of pseudo-Goldstone bosons that dominate its dynamics. In a further long wavelength limit, we reorganise this action as the effective field theory for fluctuating hydrodynamics. We compute the hydrodynamic effective action to high orders in the derivative expansion, determine all the corresponding transport coefficients, and discuss its symmetries. We outline how this framework extends to the computation of OTOCs and the second Renyi entropy using a fourfold contour. We also discuss moving beyond the low-temperature limit.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Jonah Kudler-Flam - SCGP 102**

Speaker: Jonah Kudler-Flam

Title: Large fluctuations in the large-N limit

Abstract: It has recently been argued that AdS/CFT states describing closed universes fail to admit a conventional large-N limit due to large fluctuations. Motivated by this, I re-examine the double-cone wormhole, a well-understood saddle contributing to the spectral form factor. The spectral form factor has similar fluctuations in the late-time regime where the double cone controls the semiclassical answer, obstructing a large-N limit. I then analyze correlations between theories at different values of N in general one-cut matrix models and in higher-dimensional AdS/CFT examples, and assess if a procedure resembling an average over N in the CFT can accurately reproduce the semiclassical wormhole.

2:30pm **Workshop: Leonard Susskind - SCGP 102/ZOOM**

Speaker: Leonard Susskind

Title: A toy hologram leads to toy standard model

Abstract: I'll discuss the proposed duality between DSSYK (at $T = \infty$) and the 't Hooft model in de Sitter space.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Masataka Wanatabe - SCGP 102**

Speaker: Masataka Wanatabe

Title: A JT/KPZ correspondence

Abstract: I will argue for a correspondence between JT gravity on a disk and the stationary measure of a stochastic differential equation called the Kardar-Parisi-Zhang equation. I will first relate the double-scaled SYK model to a Markov process called ASEP, and then take a certain limit on both sides to argue for our correspondence.

4:30pm **Workshop: Beatrix Muhlman - SCGP 102**

Speaker: Beatrix Muhlman

Title: dS^4 Metamorphosis

Abstract: I will discuss the Euclidean path integral of minimal higher spin theory on the four-sphere and argue for a gluing formula in which the four-sphere is obtained by joining two hemispheres along an S^3 boundary. The resulting boundary theory is the $Sp(N)$ -invariant sector of N anticommuting, conformally coupled scalars, with conformal higher spin gauge fields mediating the gluing. This S^3 theory was previously shown to compute the Hartle–Hawking wavefunction in dS_4/CFT_3 at future infinity, whereas here we realize it with conformal boundary conditions at finite size, and the four-sphere partition function captures aspects of its norm. By supersymmetrising the gluing formula we obtain a $\mathcal{N}=2$ SCFT as the boundary theory, while the leading piece of the four-sphere partition function is 2^N .

Tuesday, May 12th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Herman Verlinde - SCGP 102**

Speaker: Herman Verlinde

Title: The soft mode of DSSYK and 3D near-de Sitter gravity

Abstract: I will describe the 1D effective action of the complex reparametrization mode that governs the soft dynamics of double-scaled SYK in the presence of a time-dependent Maldacena-Qi coupling. I then show that the dual gravity system takes the form of 2+1-dimensional Einstein-de Sitter gravity with an energy source localized on a 2D de Sitter slice. This talk is based on recent work with Tommaso Marini and Xiaoliang Qi.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Andreas Blommaert - SCGP 102**

Speaker: Andreas Blommaert

Title: Towards a worldline hologram of three dimensional dS

Abstract: We propose a calculation of the density of states of the static patch in dS₃ via canonical quantization. We ask what is the amplitude to find a particle with energy E and spin J in the static patch, imposing the boundary condition that the horizon is smooth. There is an $SL(2, \mathbb{Z})$ family of such smooth horizons associated with lens spaces, which all contribute to the static patch density of states. To compute the amplitudes exactly, we must pick a quantization scheme. We draw inspiration from the $SL(2, \mathbb{C})$ CS formulation of dS₃. We find that there is a dual calculation of the amplitude for each lens space that involves two copies of complex Liouville string theory. The holographic direction in this 3d-2d duality is the spatial angle. The CLS calculation gives a robust answer for the Lens space amplitudes that agrees with the semiclassical path integral. For one of the lens spaces, the two copies of CLS are in turn holographically dual to two copies of the DSSYK GSigma model living on the observer's worldline. This goes towards establishing a 3d-1d worldline hologram.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

12:00pm **Workshop: Group Photo - SCGP Lobby**

Title: Group Photo

2:30pm **Workshop: Juan-Diego Urbina - SCGP 102**

Speaker: Juan-Diego Urbina

Title: Periodic orbit theory in a class of classically-chaotic systems (hopefully) dual to JT and Airy quantum gravity

Abstract: I will present a progress report on the search for a quantum mechanical system whose (suitably defined) spectral correlations match order-by-order the genus expansion of the correlation functions that define quantum Jackiw-Teitelboim gravity and its low-dimensional (Airy) limit. An example of such perturbative duality is the well known exact identification of JT gravity with a fine-tuned matrix ensemble, and here we will attack such correspondences from the perspective of old-fashioned quantum chaos where the existence of a classical limit displaying Hamiltonian chaos automatically guarantees the emergence, for individual systems, of an universal (late-time or τ -scaling in the gravity jargon) spectral correlations given by the gaussian matrix ensembles. Since at this universal limit any chaotic theory is dual to any other, the big question is whether one can also obtain the exact same non-universal features of the JT(and Airy) correlators by means of a specific, unique, quantum system.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Betrand Eynard - SCGP 102**

Speaker: Betrand Eynard

Title: An overview of topological recursion in random matrices

Abstract: Topological recursion was initially introduced as a method for recursively solving Schwinger-Dyson equations in random matrices, order by order in the large N expansion. This is useful for all theories that can be modeled with random matrices, this includes topological strings, some SYK aspects and the Weil-Petersson volumes, i.e. the JT gravity. We shall review what is topological recursion, how it can be used, and its beautiful mathematical properties: special geometry, modular invariance, integrable system...

Wednesday, May 13th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Mario Kieburg - SCGP 102**

Speaker: Mario Kieburg

Title: RMT Models to solve the Quantum Information Paradox

Abstract: The information paradox of black holes sits at the center of compatibility of General Relativity and Quantum Physics since Hawking postulated that black holes should radiate thermally while quantum physics requires unitary evolution. It was Page who suggested a statistical approach by bipartition a Hilbert space and average over all pure states in a uniform way. He found with the help of the entanglement entropy that almost all states look maximally mixed in the considered subsystem. The critique of this approach was that it would require strong correlations between particles that are spatially and temporarily far apart. We investigated with a new, more physical random matrix model for bosonic modes whether this critique is justified. This model considers bosonic Gaussian pure states conditioned on their marginals by Hawking's predictions but otherwise uniformly distributed on the resulting compact manifold. We found that actually with high probability any two modes are separable. In the talk, I will summarize this ongoing research and what type of progress we have made.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Lucas Sa - SCGP 102**

Speaker: Lucas Sa

Title: Chaos and universality in the dissipative SYK model

Abstract: The dissipative SYK model is an analytically tractable setting for exploring spectral and dynamical signatures of quantum chaos in open many-body systems. I will discuss our recent work identifying universal spectral features and their connection to chaotic dynamics. In the bulk of the spectrum, the model exhibits non-Hermitian RMT statistics in different universality classes, which can be tuned by changing the model parameters. Beyond this universal bulk, the spectrum also contains special modes that reveal finer properties of dissipative chaotic dynamics. In particular, the Liouvillian gap, which controls the approach to equilibrium, has a non-monotonic dependence on dissipation strength (signaling the existence of an exceptional point). In the thermodynamic limit, the gap does not vanish even when the dissipation strength goes to zero—the first recognized instance of anomalous relaxation, which now serves as a dynamical signature of quantum chaos (for both isolated and weakly-dissipative systems). The spectrum also hosts special, symmetry-protected eigenmodes. These include topological transient modes, which enhance dissipative universality and ergodicity, and “Lindblad scars”, which evade it. Together, these results highlight how the dissipative SYK model provides a simple yet rich platform for understanding the interplay between chaos, dissipation, and nonergodic structures in open quantum many-body dynamics.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Lea Santos - SCGP 102**

Speaker: Lea Santos

Title: Dissipation as a Resource: From Transient to Steady-State Chaos

Abstract: Ginibre statistics is often taken as an indicator of dissipative chaotic dynamics. However, the Grobe-Haake-Sommers conjecture, which links Ginibre statistics to chaos and 2D Poisson statistics to integrability, can break down. This talk shows that Ginibre spectral correlations primarily reflect short-time instability and therefore signal transient chaotic dynamics rather than steady-state chaos. The quantum-classical correspondence can instead be restored through a dynamical perspective based on information scrambling, using the von Neumann entropy and out-of-time-ordered correlators, which distinguish transient from steady-state chaotic behavior. Building on this result, it is further shown that dissipation can serve as a tool to regulate the duration of chaotic dynamics and information scrambling, enabling the recovery of coherence at long times.

2:30pm **Workshop: Kazumi Okuyama - SCGP 102**

Speaker: Kazumi Okuyama

Title: ETH matrix model for DSSYK

Abstract: I discuss the ETH matrix model for DSSYK introduced by Jafferis et al. Topics of my talk include the discrete volume of the moduli space and the relation to de Sitter JT gravity.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Yin Can - SCGP 102**

Speaker: Yin Can

Title: Symmetry in Non-Hermitian Quantum Many-Body Systems: From the Classification of PT-Symmetric Quantum Chaos to Measurement-Induced Phase Transitions

Abstract: We propose a symmetry classification of PT-symmetric quantum many-body systems using a two-site non-Hermitian Sachdev-Ye-Kitaev model. This enriches the classification of non-Hermitian quantum chaos by revealing a more nuanced structure based on the existence of fully real modes that encode Hermitian level statistics. The number of these modes serves as a topological invariant and defines new universality classes. In the second half of the talk, we turn to the entanglement dynamics of monitored one-dimensional free fermionic chains with and without disorder. By mapping the problem to a nonlinear sigma model, we show that the symmetries of the problem, which are different in clean and disordered cases, also play an important role in identifying the conditions for the existence of measurement-induced phase transitions. These theoretical results are confirmed by explicit numerical simulations on Graphics Processing Units which enable us to reach system sizes of ~ 20000 , an order of magnitude larger than those in previous studies.

4:30pm **Workshop: Damian Galante - SCGP 102**

Speaker: Damian Galante

Title: Renormalization group flows of the Sachdev-Ye-Kitaev model

Abstract: Studying renormalisation group flows of finite-temperature, large- N , strongly coupled quantum systems is a challenging problem, closely tied to the emergence of a dual bulk spacetime. The Sachdev–Ye–Kitaev (SYK) model provides a rare setting where this can be explored with high precision, combining numerical results at finite N with analytic control in the large- N (and large q) limit. In this talk, I will present a landscape of possible infrared behaviours of the SYK model, which may (but need not) be dominated by Schwarzian physics. I will discuss diagnostics based on thermodynamic entropy, correlation functions, and dynamical probes such as Lyapunov and Krylov exponents.

Thursday, May 14th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Ahmed Almheiri - SCGP 102**

Speaker: Ahmed Almheiri

Title: A model for DSSYK at infinite temperature

Abstract: Abstract: DSSYK at infinite temperature can be modelled by the algebra of the Quantum Harmonic Oscillator. This model has several puzzling features that appear to be reminiscent of dS, for instance, that perturbed wormholes grow more slowly than unperturbed wormholes. I will also describe upcoming work on reinterpreting the Harmonic Oscillator Hamiltonian as describing eternal traversable wormholes.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Scott Collier - SCGP 102**

Speaker: Scott Collier

Title: $c=1$ strings as a matrix integral

Abstract: I will argue for a triality between three distinct formulations of the $c=1$ string: the string worldsheet, matrix quantum mechanics, and a new double-scaled matrix integral description governed by topological recursion. Starting from the complex Liouville string, we derive closed-form Feynman rules for $c=1$ string amplitudes as intersection numbers on the moduli space of Riemann surfaces. These expressions naturally compute amplitudes on a discretized target space; the physical S-matrix is recovered by restriction to the first Brillouin zone. We use this description to prove perturbative spacetime unitarity, derive a Mirzakhani-type recursion relation for the discretized amplitudes, and find detailed agreement with known matrix quantum mechanics results.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Jiuci Xu - SCGP 102**

Speaker: Jiuci Xu

Title: Emergent States and Algebras from Double-Scaling Limit of Pure States in SYK

Abstract: Recent work has highlighted a subtle feature of large- N limits in holography: a sequence of pure microscopic states need not remain pure with respect to the emergent algebra of observables. In this talk, I will discuss this phenomenon for Kourkoulou--Maldacena (KM) states in the double-scaling limit of the SYK model, and show that their ensemble-averaged algebraic description depends crucially on which observables are retained in the limit. For fermionic operators of size $p \sim N^{1/2}$, generic operators converge to the usual chord operators of double-scaled SYK. The resulting von Neumann algebra is the standard Type II $_1$ factor, and the KM pure states at infinite temperature converge to the tracial state. In this sense, generic probes lose access to microscopic purity. I will then explain how this conclusion changes once one includes a special class of operators adapted to the KM state. These operators survive the double-scaling limit as dressed chord creation and annihilation operators, with the dressing encoding the distance to the KM state through the Euclidean bulk. With these operators included, the limiting algebra becomes a Type I $_{\infty}$ factor, and the sequence of KM states converges to a pure state. This provides a solvable example in which adding sufficiently state-adapted operators to the emergent algebra restores access to the purity of the underlying state. Along the way, I will describe the modified chord rules governing the dressed operators and explain their correlation functions, semiclassical limit, and connections to JT gravity coupled to matter and end-of-the-world branes. I will also discuss a solvable deformation to the Hamiltonian in which bound states emerge above a critical threshold. I will end by drawing broader lessons for emergent algebras in holography, including possible analogies with black hole interiors and closed universes.

2:30pm **Workshop: Ohad Mamroud - SCGP 102**

Speaker: Ohad Mamroud

Title: Chaos and the Berry curvature of BPS microstates

Abstract: Holographic theories present a fascinating case where the same physics can be described from two different points of view: either as a (strongly coupled) quantum field theory, or as a theory of quantum gravity. Certain subspaces of the Hilbert space can have very different gravitational descriptions, like those associated with black holes or with horizonless geometries. In the field theory description, it is believed that this distinction is encoded in how chaotic is the subspace, with various ways of defining what we mean by chaos. In this talk, based on ongoing work with Yiming Chen, Sean Colin-Ellerin, and Kyriakos Papadodimas, I will concentrate on the case of degenerate supersymmetric states, where we conjecture that these subspaces can differ in the way they behave under (marginal) deformations of the theory. These deformations map the subspace into itself, inducing a Berry matrix that describes the mixing of these states. For states associated with black holes, the resulting Berry curvature is a strongly chaotic, exhibiting eigenvalue repulsion throughout its spectrum. For states associated with other kinds of geometries, it is not. We support this conjecture by computations in various theories, including super JT gravity, SYK, $N=4$ super Yang Mills, and the D1-D5 system.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Budhaditya Bhattacharjee - SCGP 102**

Speaker: Budhaditya Bhattacharjee

Title: Heavy-Tailed Distributions — Invitation to a new Double-Scaled SYK Model

Abstract: I shall present a study of the Lévy Sachdev-Ye-Kitaev (LSYK) model, in which the disorder couplings are drawn from a Lévy Stable (heavy-tailed) distribution parameterized by a tail exponent μ between $(0,2]$. The spectral properties of the model will be discussed for finite N , examining the eigenvalue distribution, long- and short-range correlations, and extreme statistics. The model demonstrates a crossover from chaotic to integrable behavior as the distribution becomes increasingly heavy-tailed, which is investigated through a hierarchical analysis based on the multi-fractal structure of the Lévy Stable distribution. This crossover is explained as a genuine many-body effect, distinct from the mobility-edge-driven transition found in Lévy random matrices. An exact solution of the LSYK model in the large- N limit will be discussed, focusing on large- q and strongly coupled regimes. The chaotic properties will be discussed through chaos exponents. The parameter μ will be shown to continuously interpolate between a free theory at $\mu = 0$ and the maximally chaotic Gaussian SYK model at $\mu = 2$, with non-maximal chaos throughout the intermediate regime. Thermodynamic quantities will be discussed and compared with their Gaussian SYK counterparts, with interpretations discussed in the context of the holographic dual and non-Fermi liquid theory. Finally, I shall discuss possible double- or triple-scaled generalization of this model and the physical properties that we expect from such a model.

4:30pm **Workshop: Fedor Popov - SCGP 102**

Speaker: Fedor Popov

Title: Double Scaled Tensor Model

Abstract: We develop an explicit construction of disorder-free tensor models that exhibit melonic large- N dynamics with arbitrary potentials that are odd in the fields. Unlike previous constructions where the interaction order is tightly constrained by the tensor rank, our model utilizes a single tensor field transforming in the bi-antisymmetric representation of $O(N) \times O(N)$. We explicitly construct interaction vertices for any odd integer $p \geq 5$ and prove that the resulting perturbative expansions are dominated by melonic diagrams in the large- N limit. This construction allows us to define a supersymmetric model that possesses a double-scaling limit in which the interaction order p and the rank N are taken to infinity simultaneously. We argue that this limit closely resembles the supersymmetric double-scaled Sachdev-Ye-Kitaev (DSSYK) model while being a purely unitary, disorder-less quantum mechanical system. Finally, we extend this framework to higher dimensions and identify a new perturbative bosonic and supersymmetric melonic conformal fixed point for quintic interactions.

6:00pm **Workshop: Banquet - SCGP Cafe**

Title: Banquet Dinner

Friday, May 15th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Mikhail Isachenkov - SCGP 102**

Speaker: Mikhail Isachenkov

Title: Non-commutative geometry of the DSSYK model

Abstract: Double-scaled SYK model is known to give rise to discretized bulk geometry, captured by combinatorics of chord diagrams and integrable structures behind it. In this talk I will discuss a couple of approaches (using tools from representation theory and non-commutative geometry) to a more detailed understanding of that discretized geometry and its physics implications. I will mainly focus on the approach by von Neumann algebraic (vNa) versions of quantum homogeneous spaces. First, I'll show how the vNa quantum group deforming the normalizer of $SU(1,1)$ Lie group in its complexification plays a natural role of symmetry algebra for the operator algebra of DSSYK. The technical result making this analysis possible is a novel generalized Gauss decomposition of the vNa quantum group. We will then see how both AdS and de Sitter physics can be extracted by picking appropriate homogeneous spaces of that vNa quantum group. Some things difficult in other setups come 'for free' in this approach, for example length/chord number positivity and discreteness. Time permitting, I'll discuss work in progress on the more traditional, 'Connes-style', approach to the non-commutative geometry of DSSYK.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Sergio Aguilar - SCGP 102**

Speaker: Sergio Aguilar

Title: q-Askey deformations of Double-Scaled SYK

Abstract: We construct families of deformations of the double-scaled SYK model and investigate their bulk interpretation. We introduce microscopic deformations of the SYK model which, after ensemble averaging, and in the double-scaling limit, encode recurrence relations of basic orthogonal polynomials in the q-Askey scheme. For certain families of deformations in the semiclassical limit, at finite temperature, the chord number, encoding Krylov complexity, corresponds to the length of an Einstein-Rosen bridge connecting an end-of-the-world brane to an anti-de Sitter asymptotic boundary. By increasing one of the deformation parameters, the models eventually exhibit discrete energy levels signaling a geometric transition in sine dilaton gravity, like in Cauchy slice holography. Via the SYK-Schur duality, Krylov complexity admits a representation-theoretic interpretation as the spread of the $SU(2)$ spin in the index of an $\mathcal{N}=2$ $SU(2)$ gauge theory. We investigate the operator algebras of the deformed theories, which are type II_1 or type I_∞ factors, depending on the operators that are included. The entanglement entropy between the type II_1 algebras manifests as an extremal surface through the Ryu-Takayanagi formula. At last, we show q-Askey deformations encode baby universes in the bulk.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Ying Zhao - SCGP 102**

Speaker: Ying Zhao

Title: The Hartle–Hawking state and quantum mechanics for de Sitter observers

Abstract: The one-state statement for closed universes has sparked considerable discussion. In this talk, we examine its physical meaning in the context of the Hartle–Hawking state and de Sitter space. We argue that the one-state property of closed universes is fully compatible with the finite-dimensional quantum mechanics experienced by observers inside de Sitter space, and that this compatibility requires neither mixing of \pm -sectors nor any modification of the rules of the gravitational path integral. The apparent tension is resolved by sharply distinguishing the baby-universe Hilbert space (the space of closed universes viewed from the outside) from the bulk Hilbert space that governs quantum mechanics for an observer inside a single de Sitter universe.

2:30pm **Workshop: Matthew Dodelson - SCGP 102**

Speaker: Matthew Dodelson

Title: Bouncing off stringy singularities

Abstract: In AdS/CFT, the black hole singularity is encoded as a divergence in a certain analytic continuation of the two-point function. This divergence corresponds to a null geodesic that bounces off the singularity. In this talk, we will study the fate of this null geodesic at finite 't Hooft coupling, finding that it is smoothed out by stringy effects in the example of the SYK model. We will then generalize this computation to matrix quantum mechanics. Our results will uncover a fractal structure underlying the black hole singularity.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Jeremy van der Heijden - SCGP 102**

Speaker: Jeremy van der Heijden

Title: Quantum Symmetry and Geometry in DSSYK

Abstract: In this talk, I will explore the quantum group structure underlying the chord algebra in the double-scaled SYK model. Starting from chord operators acting on the doubled Hilbert space, I will show that the one-particle sector organizes into positive discrete series representations of $U_q(\mathfrak{su}(1,1))$. The rules governing chord interactions then naturally align with the fusion rules of these representations, providing a systematic way to construct multi-particle states. Within this framework, the quantum $6j$ -symbols that appear in crossing configurations of chords arise directly from the fusion data. I will conclude by discussing how these algebraic structures suggest a gravitational bulk dual.