Titles and abstracts

Contents

1 Mini-lectures

Mari-Carmen Bañuls

Title: *Tensor Network States for the study of quantum many-body systems*

Abstract: The term Tensor Network States (TNS) has become a common one in the context of numerical studies of quantum many-body problems. It refers to a number of families that represent different ansatzes for the efficient description of the state of a quantum many-body system. The first of these families, Matrix Product States (MPS), lies at the basis of Density Matrix Renormalization Group methods, which have become the most precise tool for the study of one dimensional quantum many-body systems. Their natural generalization to two or higher dimensions, the Projected Entanglement Pair States (PEPS) are good candidates to describe the physics of higher dimensional lattices. They can be used to study equilibrium properties, as ground and thermal states, but also dynamics.

Quantum information gives us some tools to understand why these families are expected to be good ansatzes for the physically relevant states, and some of the limitations connected to the simulation algorithms.

Originally introduced in the context of condensed matter physics, these methods have become a state-of-the-art technique for strongly correlated one-dimensional systems. Their applicability extends nevertheless to other fields.

These lectures will present the fundamental concepts behind TNS methods, the main families and the basic algorithms available.

Sylvain Carrozza

Title: *The combinatorics of random tensors: from random geometry to strongly-coupled phenomena*

Abstract: I will provide an overview of combinatorial methods underlying the analysis of random tensors in the so-called large N limit – that is, the limit of large index-space dimension. Such techniques were initially devised to explore higher-dimensional generalizations of an approach to two-dimensional quantum gravity based on random matrices. Of primary interest in this context are highly structured distributions over tensors, going under the name of "colored tensor models". The partition function of a colored tensor model can be reinterpreted as the generating function of a family of discrete geometries with fixed topological dimension. What makes this interesting is that the continuum limit of such discrete random geometries can then be reached by tuning the partition function of the underlying tensor model to criticality. As a main example, I will review how the so-called "melonic large N expansion" gives rise to a continuum limit dominated by branched polymers (or, equivalently, continuous random trees). In the second part of this mini-course, I will illustrate how the same type of melonic limit can be used to explore aspects of strongly-coupled quantum (field) theory in solvable models. This has in turn motivated the investigation of more generic classes of tensor models, that do not rely on colored structures but are still governed by a melonic limit, and which I will briefly review.

Joseph Landsberg

Title: *The geometry of tensors*

Abstract: This will be an introduction to the geometry of tensors, with an emphasis on the geometry of random tensors. We have been doing linear algebra (studying matrices, i.e., order two tensors) for a long time, and have come to accept it, and the intuition it provides, as "normal". I will begin by explaining why this *not* the case and how one may obtain better intuition about tensors from a more general geometric perspective. This leads one to study many invariants of tensors of higher order. I will describe these invariants and what they tell us about tensors, with an emphasis on what is known about their behavior for random tensors and exciting open questions.

Michael Walter

Title: *Random tensor networks in quantum information and holography*

Abstract: In recent years, tensor networks built from random tensors have become increasingly popular. Originally conceived as toy models of complicated phenomena in quantum gravity and quantum information, they provide natural ensembles of random quantum states, codes, and circuits. In this minicourse we will give a gentle introduction to this topic. We will discuss the definition and motivation of random tensor networks and explain how to mathematically analyze their key properties, including entropies, eigenvalue distribution and entanglement structure.

2 Talks

Benson Au & Jorge Garza-Vargas

Title: *Spectral asymptotics for contracted tensor ensembles*

Abstract: Let $\mathbf{T}_{d,N} : \Omega \to \mathbb{R}^{N^d}$ be a random real symmetric Wigner-type tensor. For unit vectors $(u_N^{(i,j)})_{i\in I, j\in[d-2]} \subset \mathbb{S}^{N-1}$, we study the contracted tensor ensemble

$$\left(\frac{1}{\sqrt{N}}\mathbf{T}_{d,N}\left[u_N^{(i,1)} \otimes \cdots \otimes u_N^{(i,d-2)}\right]\right)_{i\in I}.$$

For large N, we show that the joint spectral distribution of this ensemble is well-approximated by a semicircular family $(s_i)_{i\in I}$ whose covariance $(\mathbf{K}_{i,i'}^{(N)})_{i,i'\in I}$ is given by the rescaled overlaps of the corresponding symmetrized contractions

$$\mathbf{K}_{i,i'}^{(N)} = \frac{1}{d(d-1)}\langle u_N^{(i,1)} \odot \cdots \odot u_N^{(i,d-2)}, u_N^{(i',1)} \odot \cdots \odot u_N^{(i',d-2)}\rangle,$$

which is the true covariance of the ensemble up to a $O_d(N^{-1})$ correction. In particular, if the limits $\mathbf{K}_{i,i'} = \lim_{N\to\infty} \mathbf{K}_{i,i'}^{(N)}$ exist, then the contracted tensor ensemble converges in distribution almost surely to a semicircular family $(s_i)_{i\in I}$ of covariance $(\mathbf{K}_{i,i'})_{i,i'\in I}$. In the single-matrix model $\#(I) = 1$, this implies that the empirical spectral distribution of the contracted tensor ensemble is close to the semicircle distribution

$$\frac{1}{2\pi\mathbf{K}_{i,i}^{(N)}}(4\mathbf{K}_{i,i}^{(N)} - x^2)_+^{1/2}\, dx$$

in Kolmogorov-Smirnov distance with high probability. We further characterize the extreme cases of the variance $\mathbf{K}_{i,i}^{(N)} \in [\frac{1}{d!}, \frac{1}{d(d-1)}]$. Our analysis relies on a tensorial extension of the usual graphical calculus for moment method calculations in random matrix theory.

Guillaume Aubrun

Title: *Asymptotic tensor powers of Banach spaces*

Abstract: Motivated by considerations from quantum information theory, we study the asymptotic behaviour of large tensor powers of normed spaces and of operators between them. We define the tensor radius of a finite-dimensional normed space X as the limit of the sequence $A_k^{1/k}$, where A_k is the equivalence constant between the projective and injective norms on $X^{\otimes k}$. We show in particular that Euclidean spaces are characterized by the property that their tensor radius equals their dimension.

Joint work with Alexander Müller-Hermes, arXiv:2110.12828

Gérard Ben Arous

Title: *Tensor PCA*

Abstract: I will survey here the recent rich line of works on the statistical problem of Tensor PCA. How hard is it to denoise a (small-rank) tensor in high dimension? I will discuss the natural thresholds obtained from the point of view of Information Theory, Statistics and Optimization.

Shih Yu Chang

Title: *Concentration of random tensors*

Abstract: In probability theory, tail bounds (concentration inequalities) provide bounds on how a random variable deviates from some value, e.g., its expected value. The law of large numbers of classical probability theory states that sums of independent random variables are close to their expectation with a large probability. Tail bounds for random variables or random matrices have already found a place in many areas of mathematical science and engineering, for example: numerical linear algebra, combinatorics, algorithms analysis, etc. In recent years, tensors have been applied to deal with multirelational data in science and engineering which is crucial in the current Big Data era. However, there are very few works about tail bounds investigation for random tensors. In this talk, we will extend tail bounds for random variables and random matrices to tensors. We will explore three main approaches: Laplacian transform with concavity method, majorization approach, and Markov Chain embedding for non-independent tensors sum. All these methods will be applied to consider random tensors under Einstein product and T-product for tensor multiplication.

Matthias Christandl

Title: *Asymptotics of Ranks of Tensors*

Abstract: Unlike the matrix case, there are many different types of ranks for tensors. Unlike the matrix case, these types of ranks are rarely multiplicative, requiring us to look at amortized/regularized/asymptotic versions. Asymptotic ranks have important applications ranging from computational complexity to combinatorics to quantum information (my favorite corner of the world). I will present a bunch of results on (1) weighted slice rank and (2) symmetric subrank that might amuse fans of Strassen, Comon or Tao.

Benoît Collins

Title: *Strong convergence for random tensors*

Abstract: The presenter and Male proved that any random unitary representation of the free group converges strongly in the limit of large dimension, with respect to the fundamental representation of the unitary group. We will report on work in collaboration with Charles Bordenave, where we prove that this result extends when one replaces the fundamental representation by an arbitrary tensor representation, after removing the fixed points. In particular, this means

that the only obstruction to strong asymptotic freeness seems to be the trivial representation of the unitary group, which sheds light on many results in quantum information theory. The result relies on a refinement of Weingarten's calculus, and a generalization of operator-valued non-backtracking operators. Time allowing I will elaborate on these concepts and their applications.

Jens Eisert

Title: *Random tensor networks from statistical mechanics over complexity to holography*

Abstract: Random tensor networks provide proxies for situations involving interacting complex quantum systems, amenable to rigorous analysis. In this talk, we will argue that random tensor networks allow us to study problems in statistical mechanics, in notions of complexity and in holography that are otherwise hard to grasp. Indeed, a meaningful set of states that can be efficiently prepared in experiments are ground states of gapped local Hamiltonians, which are well approximated by matrix product states. In the first part of the talk, we introduce a picture of generic states within the trivial phase of matter with respect to their non-equilibrium and entropic properties [1]. We arrive at these results by exploiting techniques for computing moments of random unitary matrices and by exploiting a mapping to partition functions of classical statistical models, a method that has led to valuable insights on local random quantum circuits. Specifically, we prove that such disordered random matrix product states equilibrate exponentially well with overwhelming probability under the time evolution of Hamiltonians featuring a non-degenerate spectrum. In the second part, we discuss a solution of the prominent Brown-Susskind conjecture of the linear growth of complexity [2]. If time allows, we will mention how random Clifford circuits can be uplifted to full high order designs using a sub-linear number of T gates [3]. In the final part, we will discuss ongoing efforts of achieving analytical results on random matchgate tensor networks, giving rise to models of holography allowing for a continuum limit [4].

[1] Emergent statistical mechanics from properties of disordered random matrix product states, J. Haferkamp, C. Bertoni, I. Roth, J. Eisert, PRX Quantum 2, 040308 (2021).

[2] Linear growth of quantum circuit complexity, J. Haferkamp, P. Faist, N. B. T. Kothakonda, J. Eisert, N. Yunger Halpern, Nature Physics, in press (2022).

[3] Quantum homeopathy works: Efficient unitary designs with a system-size independent number of non-Clifford gates, J. Haferkamp, F. Montealegre-Mora, M. Heinrich, J. Eisert, D. Gross, I. Roth, arXiv:2002.09524.

[4] Holographic random tensor networks, C. Wille, A. Jahn, J. Eisert, A. Altland, in preparation (2022).

Henrique Goulart

Title: *A random matrix perspective on random tensors*

Abstract: The task of recovering a low-rank tensor from noisy observations is at the heart of various methods used for information extraction in signal processing, data analysis and machine

learning. While it is generally quite hard to analyze the performance of such methods, substantial progress has been recently achieved in the large-dimensional setting, thanks in large part to fairly advanced results and tools borrowed from statistical physics. In particular, sharp results were derived in the case of a deterministic rank-one symmetric tensor corrupted by symmetric Gaussian noise, unveiling an abrupt, discontinuous phase transition in the performance of maximum likelihood estimation as the signal-to-noise ratio grows. The random landscape of this maximum likelihood problem has also been thoroughly studied, shedding light on geometric phase transitions that take place and explain the aforementioned discontinuity.

In this talk, we will connect these results to the notion of tensor eigenpairs, which are by definition critical points of the maximum likelihood problem. A simple but crucial observation is that each eigenpair of a tensor is also an eigenpair of a matrix obtained from that tensor by a contraction with the concerned eigenvector. As we will argue, this link opens the door to the use of standard tools from random matrix theory, leading to an alternative and more elementary way of reaching some of the same predictions that had been obtained with the statistical physics machinery, while also providing interesting additional insights. Finally, we will discuss possible extensions, perspectives and open questions related to this approach.

Razvan Gurau

Title: *The tensor Harish-Chandra-Itzykson-Zuber integral*

Abstract: I will present some recent results concerning the generalization of the Harish-Chandra-Itzykson-Zuber integral to the case where the group integrated over is not $U(N^D)$, but the subgroup $U(N)^{\otimes D}$. This case is relevant for the study of D-partite quantum systems. While the HCIZ integral can no longer be expressed in terms of eigenvalues of the source matrices, it can be explicitly computed using Weingarten calculus. This result allows us to formulate a criterion for the detection of entanglement in multipartite quantum systems, which I will discuss in some detail.

Mario Kieburg

Title: *Entanglement Entropy of Pure Quantum States in Fermionic Many-Body Systems*

Abstract: I am going to report on recent progress of computing Haar distributed quantum states in fermionic systems with the help of random matrix theory. For this aim, I will review the result by Page who studied uniformly distributed pure states in the full system which are then measured in a subsystem with a specific dimension. We extended this setting to systems with fixed particle numbers and Gaussian states. This project has been carried out in collaboration with E. Bianchi, L. Hackl, M. Rigol, and L. Vidmar.

Benjamin Lovitz

Title: *New techniques for bounding stabilizer rank*

Abstract: In this work, we present number-theoretic and algebraic-geometric techniques for bounding the stabilizer rank of quantum states. First, we refine a number-theoretic theorem of Moulton to exhibit an explicit sequence of product states with exponential stabilizer rank but constant approximate stabilizer rank, and to provide alternate (and simplified) proofs of the best-known asymptotic lower bounds on stabilizer rank and approximate stabilizer rank, up to a log factor. Second, we find the first non-trivial examples of quantum states with multiplicative stabilizer rank under the tensor product. Third, we use algebraic-geometric techniques to prove new bounds on the generic stabilizer rank.

Camille Male

Title: *Freeness over the diagonal and the spectre of the sum of random matrices*

Abstract: In this talk, I present a method to compute the spectrum of the sum of two large random matrices thanks to fixed points equations. I first review Pastur's equation and Voiculescu's subordination equations, that compute the free convolution of two probability measures. Then I introduce their generalization that have been discovered more recently to compute spectra in more general situations.

Tim Netzer

Title: *Abstract operator systems: where quantum information theory meets free semialgebraic geometry*

Abstract: Abstract operator systems provide an interesting geometric framework in which many tensor-related concepts from quantum information theory can be studied. This includes separable states, states, ppt states, positive maps, decomposable maps and more. The crucial feature in operator systems is that the objects are not of a fixed dimension, but all dimensions are considered simultaneously. This often reveals important structure which is otherwise invisible. We will give an introduction to these exciting structures, including examples and some recent results.

Norbert Schuch

Title: *Symmetric vs. random tensors in quantum many-body systems*

Abstract: Tensor networks form a powerful framework for modelling the physics of complex quantum many-body systems. A key feature of such systems are unconventional quantum phases, which are characterized by the way in which the symmetries of the system interplay with their entanglement (that is, the contracted indices in the tensor network). In my talk, I will discuss the role played by such symmetries in this context, especially in the description of exotic so-called "topological" systems. A particular focus will be on investigating the extent to which the description of such systems requires to impose symmetries, that is, to restrict to highly non-generic tensors, and when the same phenomena can be described by generic tensors which do not exhibit any symmetries.

Yizhe Zhu

Title: *Community detection in random hypergraphs*

Abstract: The stochastic block model has been one of the most fruitful research topics in community detection and clustering. We consider the community detection problem in a sparse random tensor model called the hypergraph stochastic block model. Angelini et al. (2015) conjectured a threshold for detecting the community structure in this model, and we confirmed the positive part of the phase transition by analyzing the non-backtracking operator for random hypergraphs, whose leading eigenvectors give a correlated reconstruction of the community. Based on joint work with Soumik Pal and Ludovic Stephan.

Jeroen Zuiddam

Title: *The subrank of random tensors*

Abstract: We determine the subrank (introduced by Strassen in 1987 to study matrix multiplication) of random tensors, establishing a large gap between the subrank on the one hand and the slice rank, analytic rank and geometric rank on the other hand. This is joint work with Derksen and Makam.

3 Posters

Purbayan Chakraborty

Title: *Nice Error Basis and Study of Quantum Maps*

Abstract: A nice error basis is a convenient orthonormal basis of M_n which comes from a projective representation of a group G. We can use this basis to study the relation between a kernel K on $G \times G$ and positive or completely positive (CP) maps. Furthermore we can characterize semigroups of CP maps and k-positive maps in terms of its generator.

Dina Faneva Andriantsiory

Title: *Multi-Slice Clustering for 3-order Tensor*

Abstract: Several methods of triclustering of three-dimensional data require the specification of the cluster size in each dimension. This introduces a certain degree of arbitrariness. To address this issue, we propose a new method, namely the multi-slice clustering (MSC) for a3-order tensor data set. We analyze, in each dimension or tensor mode, the spectral decomposition of each tensor slice, i.e. a matrix. Thus, we define a similarity measure between matrix slices up to a threshold (precision)parameter, and from that, identify a cluster. The intersection of all partial clusters provides the desired triclustering. The effectiveness of our algorithm is shown on both synthetic and real-world data sets.

Marco Fanizza

Title: *Asymptotics of SL(2,$\mathbb{C}$) coherent invariant tensors*

Abstract: We study the semiclassical limit of a class of invariant tensors for infinite-dimensional unitary representations of SL(2,$\mathbb{C}$) of the principal series, corresponding to generalized Clebsch-Gordan coefficients with $n \geqslant 3$ legs. We find critical configurations of the quantum labels with a power-law decay of the invariants. They describe 3d polygons that can be deformed into one another via a Lorentz transformation. This is defined viewing the edge vectors of the polygons are the electric part of bivectors satisfying a (frame-dependent) relation between their electric and magnetic parts known as γ-simplicity in the loop quantum gravity literature. The frame depends on the SU(2) spin labelling the basis elements of the invariants. We compute a saddle point approximation using the critical points and provide a leading-order approximation of the invariants. The power-law is universal if the SU(2) spins have their lowest value, and n-dependent otherwise. As a side result, we provide a compact formula for γ-simplicity in arbitrary frames. The results have applications to the current EPRL model, but also to future research aiming at going beyond the use of fixed time gauge in spin foam models.

Noa Feldman

Title: *Randomness-based entanglement estimation in tensor network states*

Abstract: We develop a new method for extracting entanglement measures of tensor network states in general dimensions. Current methods require explicit reconstruction of the density matrix, which is highly demanding, or the contraction of replicas, which is strongly exponential in the number of replicas, and very costly in terms of memory. In contrast, our method requires sampling matrix elements of the reduced density matrix between random states chosen from a simple finite set of tensor product states. Such matrix elements are straightforward to calculate for states represented by tensor networks, and their moments give the Renyi entropies and negativities as well as their symmetry-resolved components. Although the cost is exponential in the subsystem size, it is moderate enough that, in contrast with other approaches, accurate results can be obtained on a personal computer for relatively large subsystem sizes. We discuss the quantum informational insights which can be raised based on the performance of such random sampling.

Khurshed Fitter

Title: *Geometric measure of entanglement of random multipartite quantum states*

Abstract: Genuine multipartite ent.element of a given multipartite pure state can be quantified through its so-called geometric measure of entanglement. Up to logarithms, the latter is simply the maximum overlap of the corresponding unit tensor with product unit tensors, a quantity which is also known as the injective norm of the unit tensor. Our general goal in this work is to estimate this injective norm for randomly sampled tensors. To this end, we develop various

algorithms, based either on the widely used alternating least squares algorithm or on a novel normalized gradient descent based algorithm, and suited to either symmetrized or non-symmetrized random tensors. We first benchmark their respective performances on the case of symmetrized real Gaussian tensors, whose average injective norm can be analytically computed, thanks to a series of celebrated works on the complexity of spin glasses. We then test the algorithms on non-symmetrized Gaussian tensors and thus provide approximate numerical values for their average injective norm. In both cases, our proposed normalized gradient descent algorithm substantially outperforms the widely used alternating least squares algorithm. Further, we establish that our proposed normalized gradient descent algorithm is robust to symmetrization and employ it to study the effects of symmetrization on the entanglement present in a random Gaussian tensor. Finally, we show that projecting a random Gaussian tensor onto the symmetric subspace results in a less entangled tensor.

Masoud Gharahi

Title: *Algebraic-Geometric Characterization of Tripartite Entanglement*

Abstract: To characterize entanglement of tripartite $\mathbb{C}^d \otimes \mathbb{C}^d \otimes \mathbb{C}^d$ systems, we employ algebraic-geometric tools that are invariants under Stochastic Local Operation and Classical Communication (SLOCC), namely k-secant varieties and one-multilinear ranks (one-multiranks). Indeed, by means of them, we present a classification of tripartite pure states in terms of a finite number of families and subfamilies. At the core of it stands out a ine-structure grouping of three-qutrit entanglement.

Dmitry Grinko

Title: *Linear programming with unitary-equivariant constraints*

Abstract: Unitary equivariance is a natural symmetry that occurs in many contexts in physics and mathematics. Optimization problems with such symmetry can often be formulated as semidefinite programs for a $dp + q$-dimensional matrix variable that commutes with $U \otimes p \otimes U \otimes q$, for all U in $U(d)$. Solving such problems naively can be prohibitively expensive, especially when the local dimension d is large. We show that, under additional symmetry assumptions, this problem reduces to linear programming and we provide a general framework for solving such programs in time that does not scale in d. Our approach uses a compact parameterization of the solution space by diagrammatically expressed walled Brauer algebra idempotents which we adapt from a general construction in Doty et al. (https://arxiv.org/abs/1606.08900). We present several applications of our framework to problems in quantum information. Namely, deciding the principal eigenvalue of a quantum state, quantum majority vote, and asymmetric cloning. We expect our methods to extend to general unitary-equivariant semidefinite programs.

Andreas Klingler

Title: *General decompositions with invariance, positivity and approximations*

Abstract: We present a framework to study invariant decompositions of elements in tensor product spaces, possibly with positivity constraints. Every tensor decomposition is represented as a simplicial complex; a group action models symmetry constraints on the complex. We study the existence of various decompositions as well as their ranks in the approximate case. Further, we apply our framework to derive results for quantum many-body systems and decompositions of multivariate polynomials.

Jinyeop Lee

Title: *Real eigenvalues of elliptic random matrices*

Abstract: We consider the real eigenvalues of an $(N \times N)$ real elliptic Ginibre matrix whose entries are correlated through a non-Hermiticity parameter $\tau_N \in [0, 1]$. In the almost-Hermitian regime where $1 - \tau_N = \Theta(N^{-1})$, we obtain the large-$N$ expansion of the mean and the variance of the number of the real eigenvalues. Furthermore, we derive the limiting densities of the real eigenvalues, which interpolate the Wigner semicircle law and the uniform distribution, the restriction of the elliptic law on the real axis. Our proofs are based on the skew-orthogonal polynomial representation of the correlation kernel due to Forrester and Nagao.

Victor Nador

Title: *Double scaling limit of the quartic $O(N)^3$ tensor model*

Abstract: We study the double scaling limit of the $O(N)^3$-invariant tensor model, initially introduced in Carrozza and Tanasa, Lett. Math. Phys. (2016). This model has an interacting part containing two types of quartic invariants, the tetrahedric and the pillow one. For the 2-point function, we rewrite the sum over Feynman graphs at each order in the $1/N$ expansion as a *finite* sum, where the summand is a function of the generating series of melons and chains (a.k.a. ladders). The graphs which are the most singular in the continuum limit are characterized at each order in the $1/N$ expansion. This leads to a double scaling limit which picks up contributions from all orders in the $1/N$ expansion. The tools used in order to prove our results are combinatorial, namely a thorough diagrammatic analysis of Feynman graphs, as well as an analysis of the singularities of the relevant generating series.

Carlos I. Perez-Sanchez

Title: Reviewing Random Multi-Matrix Methods in Noncommutative Geometry

Abstract: At this stage, the feasibility of the quantisation of noncommutative geometry (spectral triples) imposes finite-dimensionality. Accepting this restriction, then "random noncommutative geometry (NCG)" (or its Euclidean quantum theory) becomes multi-matrix models of a particular kind; this escapes any solved model. We review how these multi-matrix models [1912.13288] appear and how they are able to describe Yang-Mills gauge fields inside Connes' spectral formalism [2105.01025]. Additionally, we address their functional renormalization [2007.10914]. Renormalization of n-matrix models takes then place on $M_n(\mathcal{B})$ where $\mathcal{B}$ is certain bigger cousin of the free algebra $\mathbb{C}\langle n\rangle$. The product of $\mathcal{B}$ found in [2111.02858] is unique (and could be interesting).

Mohamed El Amine Seddik

Title: *When random tensors meet random matrices*

Abstract: Relying on random matrix theory (RMT), this work studies asymmetric order-d spiked tensor models with Gaussian noise. Using the variational definition of the singular vectors and values of (Lim, 2005), we show that the analysis of the considered model boils down to the analysis of an equivalent spiked symmetric block-wise random matrix, that is constructed from contractions of the studied tensor with the singular vectors associated to its best rank-1 approximation. Our approach allows the exact characterization of the almost sure asymptotic singular value and alignments of the corresponding singular vectors with the true spike components, when $\frac{n_i}{\sum_{j=1}^d n_j} \to c_i \in [0, 1]$ with n_i's the tensor dimensions. In contrast to other works that rely mostly on tools from statistical physics to study random tensors, our results rely solely on classical RMT tools such as Stein's lemma. Finally, classical RMT results concerning spiked random matrices are recovered as a particular case.

Daniel Stilck França

Title: *Optimization at the boundary of the tensor network variety*

Abstract: Tensor network states form a variational ansatz class widely used, both analytically and numerically, in the study of quantum many-body systems. It is known that if the underlying graph contains a cycle, e.g., as in projected entangled pair states, then the set of tensor network states of given bond dimension is not closed. Its closure is the tensor network variety. Recent work has shown that states on the boundary of this variety can yield more efficient representations for states of physical interest, but it remained unclear how to systematically find and optimize over such representations. We address this issue by defining an ansatz class of states that includes states at the boundary of the tensor network variety of given bond dimension. We show how to optimize over this class in order to find ground states of local Hamiltonians by only slightly modifying standard algorithms and code for tensor networks. We apply this method to different models and observe favorable energies and runtimes when compared with standard tensor network methods.

This is joint work with Matthias Christandl, Fulvio Gesmundo and Albert H. Werner. Reference: Phys. Rev. B 103, 195139

Reiko Toriumi

Title: *Trisections in Colored Tensor Models*

Abstract: We give a procedure to construct (quasi-)trisection diagrams for closed (pseudo-)manifolds generated by colored tensor models without restrictions on the number of simplices in the triangulation, therefore generalizing previous works in the context of crystallizations and PL-manifolds. We further speculate on generalization of similar constructions for a class of pseudo-manifolds generated by simplicial colored tensor models.

Mirte Van Der Eyden

Title: *Halos and undecidability of tensor stable positive maps*

Abstract: A map is tensor stable positive (tsp) if all its tensor powers are positive, and essential tsp if it is not completely (co)-positive. Are there essential tsp maps? We prove existence of essential tsp maps and hence NPT bound entangled quantum states on the hypercomplex numbers. We also prove undecidability of tsp on the matrix multiplication tensor, and conjecture that tsp is undecidable. Proving this conjecture would imply existence of essential tsp maps and NPT bound entanglement.

Rik Voorhaar

Title: *Randomized streaming methods for approximating tensor trains*

Abstract: By contracting a tensor X by random tensors, we can project X to certain random subspaces of tensor trains (also known as MPS). We obtain an efficient algorithm for approximating X by a tensor train of a certain rank. This is a streaming algorithm, meaning we can cheaply update the decomposition of X + Y without using X again. The algorithm is also highly parallelizable. Based on joint work with Daniel Kressner (EPFL) and Bart Vandereycken (University of Geneva).

Qinghua Zhang

Title: *A note on uncertainty relations of metric-adjusted skew information*

Abstract: We study uncertainty relations based on metric-adjusted skew information for finite quantum observables. Motivated by the paper [Physical Review A 104, 052414 (2021)], we establish tighter uncertainty relations in terms of different norm inequalities. Naturally, we generalize the method to uncertainty relations of metric-adjusted skew information for quantum channels and unitary operators. As both the Wigner-Yanase-Dyson (WYD) skew information and the quantum Fisher information (QFI) are the special cases of the metric-adjusted skew information corresponding to different Morozova-Chentsov functions, our results generalize some existing uncertainty relations.

Yizhe Zhu

Title: *Deterministic tensor completion with hypergraph expanders*

Abstract: We provide a novel analysis of low-rank tensor completion based on hypergraph expanders. As a proxy for rank, we minimize the max-quasinorm of the tensor, which generalizes the max-norm for matrices. Our analysis is deterministic and shows that the number of samples required to approximately recover an order-t tensor with at most n entries per dimension is linear in n, under the assumption that the rank and order of the tensor are O(1). As steps in our proof,

we find a new expander mixing lemma for a t-partite, t-uniform regular hypergraph model, and prove several new properties about tensor max-quasinorm.