Since 2009, the String Group at the University of the Witwatersrand has hosted an annual workshop in formal theory. This year's meeting is held at the Wits Rural Facility from 15–20 December 2024. In addition to being the First Joint India/South Africa String Theory Meeting, this is the 14th Joburg Workshop on String Theory.

Schedule

Talk 1:	**Anosh Joseph** (University of the Witwatersrand)
Talk 2:	**Vishnu Jejjala** (University of the Witwatersrand)
Talk 3:	**Suman Das** (University of the Witwatersrand)
Talk 4:	**Tanay Kibe** (University of the Witwatersrand)
Talk 5:	**Ashoke Sen** (International Centre for Theoretical Sciences)
Talk 6:	**Sumathi Rao** (International Centre for Theoretical Sciences)
Talk 7:	**Suvrat Raju** (International Centre for Theoretical Sciences)
Talk 8:	**Costas Zoubos** (University of Pretoria)
Talk 9:	**Pallab Basu** (University of the Witwatersrand)
Talk 10:	**Sam van Leuven** (University of the Witwatersrand)
Talk 11:	**Abhijit Gadde** (Tata Institute of Fundamental Research)
Talk 12:	**Ronak Soni** (Chennai Mathematical Institute)

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Pallab Basu: "Chaos from a simple spin model"

Abstract: We will discuss the origin of chaotic scattering from a simple spin model with a large spin J. We will discuss why scattering from a string state is chaotic and then discuss how much of it is carried out in a large spin state.

Suman Das: "Brick wall, normal modes, and emerging thermality"

Abstract: Black holes are chaotic objects, but identifying signatures of late-time chaos is particularly challenging for higher-dimensional black holes, especially from the bulk perspective. In this talk, I will demonstrate how these signatures may appear in the probe sector by quantizing a scalar field in the black hole geometry with a brick wall (Dirichlet) boundary condition near the horizon. When the brick wall is placed very close to the horizon, the quantized modes exhibit quasi-degeneracy along the angular momentum quantum number, as opposed to the principal quantum number. This quasi-degeneracy can be linked to the production of area-proportional entropy and the emergence of a linear ramp in the spectral form factor. In this regime, the two-point function is well-approximated by the thermal two-point function. Additionally, I will discuss how this Dirichlet boundary condition naturally arises in a gravitational collapse scenario.

Abhijit Gadde: "Multi-invariants and bulk replica symmetry"

Vishnu Jejjala: "Colored Jones polynomials and the volume conjecture"

Abstract: I explain how different topological invariants of knots can be machine learned. The volume conjecture supplies a case study for opening the black box and identifying salient features in a dataset.

Anosh Joseph: "Nonperturbative phase diagram of $2d$ $N = (2, 2)$ super-Yang-Mills theory"

Abstract: We study two-dimensional super-Yang-Mills theory with 4 supercharges and gauge group $SU(N)$, compactified on a torus in Euclidean signature. Non-perturbative lattice analyses are performed for large $12 \leq N \leq 20$. While a holographic dual for this theory is not yet known, we conduct numerical investigations to identify potential features similar to those found in the two-dimensional Yang-Mills theory with 16 supercharges, which has a well-established gravity dual. Our lattice field theory calculations reveal the phase diagram, including a spatial deconfinement transition reminiscent of the maximally supersymmetric case. However, this transition does not persist at low temperatures, suggesting the absence of a topology-changing transition between black hole geometries in any possible holographic dual of this four-supercharge theory.

Tanay Kibe: "QNEC bounds on quenches in critical many-body systems"

Abstract: Quantum thermodynamics generalizes the Clausius inequality stating that the irreversible entropy produced in any process is not only positive, but has both a lower and an upper bound. In this talk I will describe how the quantum null energy condition (QNEC) implements similar bounds on entropy production after a global quench in $1+1$ dimensional holographic conformal field theories (CFT). I will also describe ongoing CFT calculations of QNEC violations and bounds in apparently innocuous setups for local quenches and periodic driving.

Suvrat Raju: "Holographic perspective on bulk subalgebras in AdS"

Abstract: We study the algebra of observables in a time band on the holographic boundary in a theory of quantum gravity in anti-de Sitter space. In a strict sense, this algebra does not have a commutant because products of operators within the time band can give rise to operators outside the time band. For low energy states in AdS, this problem is visible even in perturbation theory. We show that in the presence of a heavy state, which can be thought of as an "observer", it is possible to define a coarse-grained algebra of observables whose resolution is limited by properties of the observer state. This algebra acts on a "little Hilbert space" that corresponds to low-energy excitations of the observer. The commutant of this algebra can be obtained by generalizing techniques used previously to construct operators in the black-hole interior. At leading order in perturbation theory, and with a certain choice of dressing, our construction reduces to the crossed-product described previously in the literature.

Sumathi Rao: "Anyons and topological quantum computation"

Ashoke Sen: "Supersymmetric index of black holes"

Ronak Soni: "Towards the multipartite entanglement structure of AdS_3 gravity"

Abstract: Consider a $2d$ holographic CFT split into n subregions. For $n = 2$, developments built upon the RT formula have shown us that the boundary state looks like a bunch of Bell pairs at leading order. We don't have any generalisation of this statement for $n > 2$, i.e. the multipartite case. I will describe a preliminary proposal for the leading order entanglement structure for an arbitrary number of subregions, with particular focus on $n = 3$. Based on 2404.03651 and work in progress with Manish Ramchander.

Sam van Leuven: "$4d$ modularity"

Abstract: Modular invariance plays an important role in the study of two-dimensional CFTs. Most famously, it exhibits the universality of CFT spectra at high energy, but there are numerous other applications, including in the context of holography. In recent years, a combination of exact results in supersymmetric CFTs and developments in AdS/CFT have sparked renewed interest in possible generalizations of modularity to CFTs in dimensions greater than two. We briefly mention some of these developments for both supersymmetric and non-supersymmetric CFTs. We then focus on an unconventional modular property associated with the $4d$ $N = 1$ superconformal index, referred to by "modular factorization". We aim to improve the current understanding of this property, which relies on a supersymmetric localization argument, by providing a conceptually simpler Hamiltonian perspective. We use the $4d$ free chiral multiplet as our main example, but also comment on generalizations to non-trivial $4d$ SCFTs and other dimensions.

Costas Zoubos: "Symmetries of $N = 2$ marginally deformed orbifold theories"

Abstract: I will argue that the $N = 2$ theories obtained by orbifolding planar $N = 4$ SYM and then marginally deforming have a large amount of hidden symmetry which can be seen by moving beyond the Lie-algebraic framework to that of Lie algebroids and then Drinfeld-twisting. I will discuss implications of this additional symmetry for the spectrum of the theory.

Other participants: Adwait Gaikwad (University of the Witwatersrand), Kevin Goldstein (University of the Witwatersrand), Garry Kemp (University of Johannesburg), Yannick Mvondo-She (University of the Witwatersrand), Laila Tribelhorn (University of Pretoria).