

# Workshop Schedule

Events for:  
**Monday, September 19th - Friday, September 23rd**

## Monday, September 19th

9:30am **Kantaro Ohmori - SCGP 102**

**Speaker:** Kantaro Ohmori

**Title:** Developments in Non-invertible symmetry: Recent and Near Future

**Abstract:** In this talk, I will review the recent developments in the topic of non-invertible symmetry, which is under intense and rapid research recently. I will review the case of the 1+1d critical Ising CFT, and see how that examples can be generalized in the higher dimensions in various ways. Then I will describe possible directions regarding the topic.

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

11:00am **Sahand Seifnashri - SCGP 102**

**Speaker:** Sahand Seifnashri

**Title:** Representation theory for non-invertible symmetries and asymptotic density of states

**Abstract:** We find the appropriate notion of representation for non-invertible symmetries needed to derive selection rules on correlation functions. We use this understanding to derive a Cardy-like formula for 2d CFTs with a finite non-invertible symmetry. More specifically, we derive a universal formula for the asymptotic density of states transforming in an irreducible representation of a non-invertible symmetry.

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

2:30pm **Yunqin Zheng - SCGP 103**

**Speaker:** Yunqin Zheng

**Title:** Symmetry TFT for non-invertible duality defects

**Abstract:** Symmetry TFT (SymTFT) is a useful tool to decouple the universal data including global symmetries and their 't Hooft anomalies from the dynamics of quantum field theories. In this talk, we will discuss the SymTFT for the recently widely studied non-invertible duality symmetries in both  $(1+1)d$  and  $(3+1)d$ . In particular, we will explain how the non-invertible fusion rules can be reproduced from the SymTFT, and will also comment on how one can use SymTFT to distinguish the intrinsically non-invertible symmetry from non-intrinsically non-invertible symmetry.

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

4:00pm **Shu-Heng Shao - SCGP 103**

**Speaker:** Shu-Heng Shao

**Title:** Non-invertible time-reversal symmetry

**Abstract:** In gauge theory, it is commonly stated that time-reversal symmetry only exists at  $\theta=0$  or  $\pi$  for a  $2\pi$ -periodic  $\theta$ -angle. In this paper, we point out that in both the free Maxwell theory and massive QED, there is a non-invertible time-reversal symmetry at every rational  $\theta$ -angle, i.e.,  $\theta = \pi p/N$ . The non-invertible time-reversal symmetry is implemented by a conserved, anti-linear operator without an inverse. It is a composition of the naive time-reversal transformation and a fractional quantum Hall state. We also find similar non-invertible time-reversal symmetries in non-Abelian gauge theories, including the  $\mathcal{N}=4$   $SU(2)$  super Yang-Mills theory along the locus  $|\tau|=1$  on the conformal manifold.

**Tuesday, September 20th**

9:30am **Justin Kaidi - Zoom**

**Speaker:** Justin Kaidi

**Title:** Non-Invertible Symmetries and Arithmetic

**Abstract:** I will begin by explaining how the spectrum of non-invertible symmetries in  $N=4$   $SU(p)$  SYM theory for prime  $p$  boils down to some simple statements in modular arithmetic. I will then generalize to an infinite family of  $4d$   $N=2$  theories obtained by compactifying the  $6d$   $(2,0)$  theory of type  $A_{p-1}$  on a genus  $g$  Riemann surface with no punctures. As a concrete example, I will provide a classification of all invertible and non-invertible symmetries descending from the modular group  $Sp(4, \mathbb{Z})$  at genus 2.

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

11:00am **Lakshya Bhardwaj - SCGP 102**

**Speaker:** Lakshya Bardwaj

**Title:** Universal Non-Invertible Symmetries

**Abstract:** It is well-known that gauging a finite 0-form symmetry group  $G$  in a quantum field theory leads to a dual symmetry generated by topological Wilson line defects. I will argue that one also obtains other dual symmetries described by higher-dimensional topological defects, which are generically non-invertible. The dual topological surface defects can all be shown to be condensation defects obtained by higher-gauging the dual topological Wilson line defects. The dual topological surfaces and lines form a 2-category  $2\text{Rep}(G)$  which is the 2-category of 2-representations of  $G$ . I will also discuss the dual symmetries obtained by gauging a finite 2-group symmetry. In this case, not all dual topological surface defects are condensation defects and the 2-category formed by dual topological surfaces and lines can be recognized as the 2-category of 2-representations of the 2-group. These 2-categories describe symmetries of gauge theories with continuous disconnected gauge groups in various spacetime dimensions.

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

1:15pm **Ibrahima Bah (SCGP Weekly Talk) - SCGP 102**

**Speaker:** Ibrahima Bah

**Title:** Symmetry structure from the bulk and holography

**Abstract:** Recently there has been a revival in the study of symmetries of physical systems due to the novel perspective that symmetries characterize topological aspects of quantum mechanical systems. Significant efforts by many researchers from condensed matter physics, to high energy physics and mathematics have been devoted to fully exploring the consequences of this perspective in physics. An important aspect to this is the understanding that symmetries, and their associated structures in a given quantum system, can be characterized in one dimension higher by a topological field theory via inflow mechanics. Such descriptions can naturally emerge whenever we can construct quantum field theories from decoupling limits of string theory or supergravity. In this talks I will review recent progress in these endeavors and discuss the critical questions that we hope to address.

2:30pm **Mathew Bullimore - SCGP 103**

**Speaker:** Mathew Bullimore

**Title:** Higher representations and BPS line operators

**Abstract:** The talk concerns generalised group-like symmetries in supersymmetric theories in three dimensions. I will explain how the category of BPS line defects supports a 2-representation of the symmetry category. I will also discuss a geometric formulation in terms of the moduli stack of vacua, which is an enhancement of the moduli space of vacua that captures topological sectors in the infrared. This could be seen as a small step towards the broader goal of understanding how categorical symmetries act on the extended operator spectrum of a general quantum field theory.

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

<b>Wednesday, September 21st</b>
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9:30am **Apoorv Tiwari - Zoom**

**Speaker:** Apoorv Tiwari

**Title:** Topological Holography: phase diagrams of generalized spin models from symmetry TFTs

**Abstract:** Owing to recent developments, it is increasingly clear that the finite symmetry of a  $d$ -dimensional quantum model can be encapsulated in a  $d+1$ -dimensional "symmetry topological field theory" (symmetry TFT). In this talk, I will describe how symmetry TFTs may be used to organize phase diagrams of generalized lattice spin systems.

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

11:00am **Christian Copetti - SCGP 102**

**Speaker:** Christian Copetti

**Title:** Self duality defects from holography.

**Abstract:** We explain how non invertible duality (and more generally  $n$ -ality) defects may emerge for theories with a dual holographic description. The key observation is that, at the self duality point, a discrete gauge field emerges in the bulk. We discuss its action through the example of  $N=4$  SYM and develop a formalism to describe the fusion of the ensuing non-invertible defects. Time permitting we mention generalizations to theories of class  $S$ .

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

2:30pm **Juven Wang - SCGP 103**

**Speaker:** Juven Wang

**Title:** Ultra Quantum Matter to Beyond the Standard Model Forecast

**Abstract:** Ideas developed from the quantum matter and quantum field theory frontier may guide us to explore new physics beyond the 4d Standard Model. I propose a few such ideas. First, new physics for neutrinos: right-handed neutrinos carry a  $Z_{16}$  class mixed gauge-gravitational global anomaly index, which could be replaced by 4d or 5d topological quantum field theory, or 4d interacting conformal field theory (CFT). These theories provide possible new neutrino mass mechanisms [arXiv:2012.15860]. Second, deconfined quantum criticality between Grand Unified Theories: dictated by a  $Z_2$  class global anomaly, a gapless quantum critical CFT region can happen between Georgi-Glashow and Pati-Salam models as deformation of the Standard Model, where Beyond the Standard Model physics and Dark Gauge sector occur as neighbor phases [arXiv:2106.16248, arXiv:2112.14765, arXiv:2204.08393]. I will also comment on the generalized higher symmetries and potential noninvertible symmetries pertinent to Grand Unified Theories. Third, the Strong CP problem may be solved by a new solution involving Symmetric Mass Generation [arXiv:2204.14271, arXiv:2207.14813, to appear]. The collaborators of these works include Yuta Hamada, Zheyang Wan, and Yizhuang You.

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

4:00pm **Gong Show - SCGP 103**

6:00pm **Banquet**

**Thursday, September 22nd**

9:30am **Ho Tat Lam - SCGP 102**

**Speaker:** Ho Tat Lam

**Title:** Exotic Theories with Dipole Symmetries

**Abstract:** I will discuss exotic theories with dipole global symmetries and dipole gauge symmetries. Examples of these theories include the compact Lifshitz theory and a tensor gauge theory that has fractons. To resolve various subtleties in the precise meaning of these global or gauge symmetries, we place these theories on a lattice and then take the continuum limit. Interestingly the continuum limit is not unique. Different limits lead to different continuum theories, whose operators, defects, global symmetries, etc., are different. Since these theories are non-relativistic, we need to distinguish global symmetries that act on defects and on operators. We refer to the global symmetries that act on defects as timelike global symmetries. Using these timelike global symmetries, we can phrase the mobility restrictions of defects (including those of fractons) as consequences of global symmetries.

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

11:00am **Fabio Apruzzi - SCGP 102**

**Speaker:** Fabio Apruzzi

**Title:** Non-Invertible Symmetries from Holography and Branes

**Abstract:** We propose a systematic approach to deriving symmetry generators of Quantum Field Theories in holography. Central to this are the Gauss law constraints in the Hamiltonian quantization of Symmetry Topological Field Theories (SymTFTs), which are obtained from supergravity. In turn we realize the symmetry generators from world-volume theories of D-branes in holography. Our main focus is on non-invertible symmetries, which have emerged in the past year as a new type of symmetry in  $d \geq 4$  QFTs. We exemplify our proposal in the holographic confinement setup, dual to 4d  $N=1$  Super-Yang Mills. In the brane-picture, the fusion of non-invertible symmetries naturally arises from the Myers effect on D-branes. In turn, their action on line defects is modeled by the Hanany-Witten effect.

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

2:30pm **Inaki Garcia-Extbarria - SCGP 103**

**Speaker:** Inaki Garcia-Extbarria

**Title:** Symmetries and branes for S-folds

**Abstract:** D3 brane stacks probing  $O3$  planes and its non-perturbative generalisations known as S-folds have a near horizon limit of the form  $AdS_5 \times (S^1/Z_k)$ , which describes the holographic dual of the SCFTs living on the D3 stack. I will describe various aspects of this class of systems, including how to extract the higher form symmetries (for arbitrary  $k$ ) and non-invertible symmetries (for  $k=2$ ).

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

4:00pm **Daniel Brennan - SCGP 103**

**Speaker:** Daniel Brennan

**Title:** Line Operator Quantum Numbers and Anomalies

**Abstract:** In this talk we will describe a new mechanism for studying anomalies of discrete symmetries in 4D gauge theories. This mechanism involves flowing to a pure abelian gauge theory where the anomaly can be computed in terms of the quantum numbers of electric and magnetic line operators. We demonstrate our program by computing the anomaly in  $SU(2)$  QCD with fundamental and adjoint fermions.

<b>Friday, September 23rd</b>
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10:30am **Coffee Break - SCGP Cafe**

11:00am **Jonathan Heckman - SCGP 102**

**Speaker:** Jonathan Heckman

**Title:** The Branes Behind Generalized Symmetry Operators

**Abstract:** We present a brane construction of generalized symmetry operators in supersymmetric QFTs engineered via string compactification. These branes link with defects, and the brane perspective allows us to read off various structures such as their fusion algebra. The stringy perspective also suggests various categorical generalizations of these objects, which we also discuss. Based on joint work with M. Hubner, E. Torres and H.Y. Zhang.

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

1:15pm **Zohar Komargodski - SCGP 102**

**Speaker:** Zohar Komargodski

**Title:** Line Operators, RG Flows, and One-Form Symmetry

**Abstract:** I will review general constraints on RG flows on line defects. The first constraint is from an inequality on a defect entropy and the second constraint is from one-form symmetry. We will apply these ideas to magnets and line defects in gauge theories.

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