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Higher Symmetry Topological Phases and Loop Braid Invariants

The non-Abelian exchange statistics of anyons in 2+1D topological phases of matter have received considerable interest in recent years due to the potential applications in topological quantum computation. Utilising the connection between topological phases of matter and extended Topological Quantum Field Theories (TQFT) has provided a powerful framework for understanding physically realistic models for realising anyons in condensed matter systems and providing representations of the braid group, describing the exchange of point particles.

In 3+1D it is well known that the exchange of point particles is necessarily described by Bosonic or Fermionic exchange statistics. However, it has been shown that many models of 3+1D topological phases of matter naturally support loop-like excitations. When one loop is passed through another, these excitations support possibly non-Abelian exchange statistics generating the so called loop-braid group.

In this talk I will outline a class of candidate 3+1D topological phases of matter arising from considerations in Higher Lattice Gauge Theory (HLGT)[1606.06639,1702.00868]. Such theories generalise Lattice Gauge Theories (LGT) with finite gauge group to the case of finite gauge 2-group which are described by crossed modules. I will then utilise this construction and ideas from extended TQFT to define representations of loop-braids within the HLGT framework.