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## Instanton Density Operator in Lattice QCD from Higher Category Theory

*Tuesday, November 12, 2024 3:30 PM (1 hour)*

A long standing problem in lattice QCD is to naturally define the Yang-Mills instanton on the lattice. I will show how this problem is, and has to be, resolved by higher category theory.

To resolve the problem, the notion of lattice Yang-Mills must be refined at a conceptual level, in a way similar to how Villainization refines XY model and  $U(1)$  lattice gauge theory. The remarkable point, however, is that it is mathematically impossible to achieve the needed refinement for lattice Yang-Mills using theoretical physicists' traditional toolbox of groups and fibre bundles, hence the more flexible language of categories becomes natural and necessary. While this might sound overly formal, the final construction admits very intuitive physical interpretation. It allows us to naturally define 3d Chern-Simons term, 4d instanton and 5d Yang monopole in lattice  $SU(N)$  Yang-Mills, as well as 2d Wess-Zumino-Witten term, 3d skrymion and 4d hedgehog in lattice  $S^3$  (pion) non-linear sigma model.

In a larger scope, higher category theory enables us to rethink what a "lattice QFT" really is, as well as its relation to continuum QFT. I will sketch a systematic program to naturally construct generic topological operators that we expect from a continuum QFT onto the lattice.

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