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School of Physical Sciences

Department of Physics

Centre Vortices Underpin Dynamical Chiral Symmetry Breaking in SU(3) Gauge Theory

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Abstract

The dynamical breaking of chiral symmetry is one of the key phenomena in QCD. It plays a vital role in explaining the QCD spectrum. The dynamical mass generation associated with the breaking of chiral symmetry is responsible for almost all of the mass of ground-state hadrons. The fundamental objects responsible for dynamical chiral symmetry breaking, however, remain elusive.

In this thesis, we investigate the role of a class of topological objects, centre vortices, in dynamical chiral symmetry breaking in SU(3) gauge theory using lattice gauge theory. We describe in detail an algorithm for identifying centre vortices on the lattice and isolating their effects. This allows us to define ensembles with centre vortices removed and ensembles consisting solely of centre vortices. We study the effects of smoothing algorithms on centre vortices, and find a strong connection to instantons, topological objects known to be important in dynamical chiral symmetry breaking. Then, we use the quark propagator to probe dynamical chiral symmetry breaking. We show a loss of dynamical chiral symmetry breaking after vortex removal, and correspondingly an ability to recreate it using the centre-vortex information alone. We then study the ground-state hadron spectrum, and show that the removal of centre vortices results in a spectrum consistent with restored chiral symmetry. Moreover, we show how chiral symmetry remains broken on the vortex-only ensembles.

Having examined multiple measures of dynamical chiral symmetry breaking and found them to be in agreement, we conclude that centre vortices are the fundamental objects underlying dynamical chiral symmetry breaking in SU(3) gauge theory.

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