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Zero modes of overlap fermions, instantons and monopoles

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Monopoles are considered that play the very important roles for the color confinement mechanism. University of Kanazawa and Pisa groups have shown a number of studies which support the confinement mechanism due to monopole condensations by the lattice simulations.
Instantons that are other topological objects found as solutions of QCD. The close relations to chiral symmetry breaking are theoretically explained, moreover, the relations are revealed by numerical simulations. The purpose of our study is to show that monopoles relate to instantons and chiral symmetry breaking by using the overlap fermions as an analytical tool.
To show the relations, first we generate SU(3) configurations for Wilson gauge action. We construct the overlap Dirac operator from link variables of the configurations, solve the eigenvalue problems by using of the subroutines (ARPACK), and find O(80) pairs of eigenvalues and eigenvectors each configurations. We count the number of the zero modes each ensemble. After analytical computations, we confirm that the instanton density is consistent with the instanton liquid model by E. V. Shuryak. Second, we add monopoles and antimonopoles with several charges to SU(3) configurations for Wilson gauge action by the monopole creation operator which is defined by the University of Pisa group. Third, we fix the maximally abelian gauge. After performed the abelian projection we localize the monopoles on the lattice. We measure the length of monopole loops and the monopole density to confirm that the monopoles are successfully added by the monopole creation operator. The last, we diagonalize the overlap Dirac operator deriving from the configurations which the monopoles are added. We try to quantitatively verify how many the monopoles with charges make the zero modes (instantons) in order to show the relations between them.
In my talk, I would like to present our preliminary results.

Primary author: Dr HASEGAWA, Masayasu (Bogoliubov Laboratory of Theoretical Physics, JINR)

Co-author: Prof. DI GIACOMO, Adriano (University of Pisa)

Presenter: Dr HASEGAWA, Masayasu (Bogoliubov Laboratory of Theoretical Physics, JINR)

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