



Contribution ID: 134

Type: **Talk**

Phase diagram of non-degenerate twisted mass fermions

Monday, 23 June 2014 14:35 (20 minutes)

In this talk, I will summarize recent work with Prof. Stephen Sharpe in mapping out the phase diagram and pion spectrum for chiral perturbation theory with twisted-mass fermions in the presence of non-degeneracy between the up and down quark and discretization errors. I will show how the CP-violating phase of the continuum theory, which occurs for sufficiently large non-degeneracy, is continuously connected to the Aoki-phase found in the lattice theory with degenerate quarks. Both for the Aoki-phase and first-order scenarios, this results in a critical surface along which at least one of the pions is massless. In the pion spectrum, I will focus mainly on the maximal twist case, where there is competition between the effects of non-degeneracy and twist-dependent discretization errors, resulting in a complete breakdown of isospin symmetry with all three pions having different masses. This breakdown of isospin symmetry should be a useful indicator of the size of discretization errors as simulations with twisted-mass fermions move to non-degenerate masses. Lastly, I will show numerical results for the effects of higher order terms on the phase diagram and the pion spectrum.

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Session Classification: Chiral Symmetry

Track Classification: Chiral Symmetry