Influence of the $U(1)_A$ Anomaly on the QCD Phase Transition

Jonathan Lenaghan [a]

[a] *Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark*

Presented by: Jonathan Lenaghan

Abstract

The $SU(3)_r \times SU(3)_\ell$ linear sigma model is used to study the chiral symmetry restoring phase transition of QCD at nonzero temperature. The line of second order phase transitions separating the first order and smooth crossover regions is located in the plane of the strange and nonstrange quark masses. It is found that if the $U(1)_A$ symmetry is explicitly broken by the $U(1)_A$ anomaly then there is a smooth crossover to the chirally symmetric phase for physical values of the quark masses. However, if the $U(1)_A$ anomaly is restored at T_c, the region of first order phase transitions is significantly enlarged and it is found that there is a phase transition for physical values of the quark masses provided that the σ meson mass is at least 600 MeV. In both cases, the region of first order phase transitions in the quark mass plane is enlarged as the mass of the σ meson is increased.

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