

Hadron Structure, Hadronic Matter, and Lattice QCD

Phases of QCD, topology and axions - I

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I Symmetries and phases
of QCD in the
Temperature, N_f space

II Results on the phase diagram

III Topology - broken phase

IV Topology - hot QCD & axions

Phases of QCD, topology and axions

I Symmetries and phases of QCD

QCD Lagrangian & Symmetries

Pseudoscalar spectrum and $U_A(1)$ puzzle

Simpler case: $SU(2) \times SU(2)$

$SU(N) \times SU(N) \times SU_{\text{gauge}}(N_c)$: running coupling, beta function, chiral breaking

The $T=0$ axis: Infrared fixed points at large N_f , essential singularity, conformal window

Fixed N_f axis: Finite temperature transition, Landau-Ginzburg scenario, magnetic EoS, Universal properties of chiral symmetry breaking

Columbia plot - infinite mass limit and confinement in YM

The phase diagram of QCD in the T, N_f plane

please see notes with
bibliography

Pseudoscalar spectrum, and $U_A(1)$ puzzle

Particle name	Particle symbol \blacklozenge	Antiparticle symbol \blacklozenge	Quark content	Rest mass (MeV/c ²) \blacklozenge
Pion ^[6]	π^+	π^-	$u\bar{d}$	$139.570\,18 \pm 0.000\,35$
Pion ^[7]	π^0	Self	$\frac{u\bar{u}-d\bar{d}}{\sqrt{2}}$ [a]	134.9766 ± 0.0006
Eta meson ^[8]	η	Self	$\frac{u\bar{u}+d\bar{d}-2s\bar{s}}{\sqrt{6}}$ [a]	547.862 ± 0.018
Eta prime meson ^[9]	$\eta'(958)$	Self	$\frac{u\bar{u}+d\bar{d}+s\bar{s}}{\sqrt{3}}$ [a]	957.78 ± 0.06
Kaon ^[12]	K^+	K^-	$u\bar{s}$	493.677 ± 0.016
Kaon ^[13]	K^0	\bar{K}^0	$d\bar{s}$	497.614 ± 0.024

