2+1 Heavy Quark QCD Phase Transitions in Massive Landau-DeWitt Gauge

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Journee des doctorants

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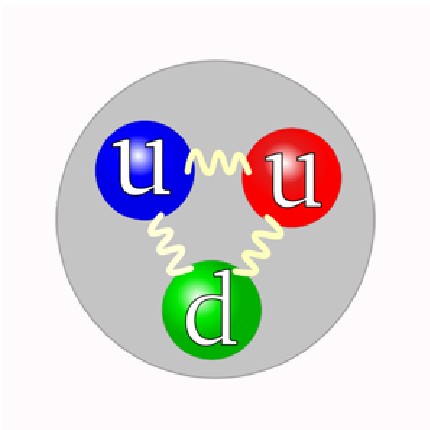
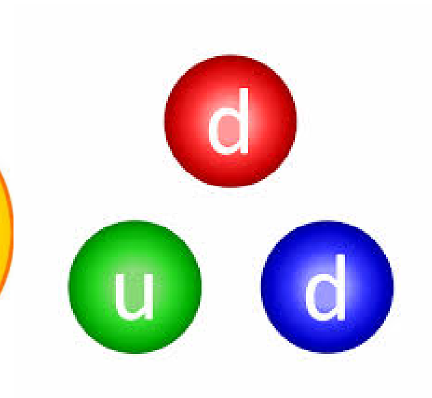
What do we study?

2+1 Heavy Quark QCD Phase Transitions in Massive Landau-DeWitt Gauge

Low E High E





1st/2nd order? Crossover? Critical T?

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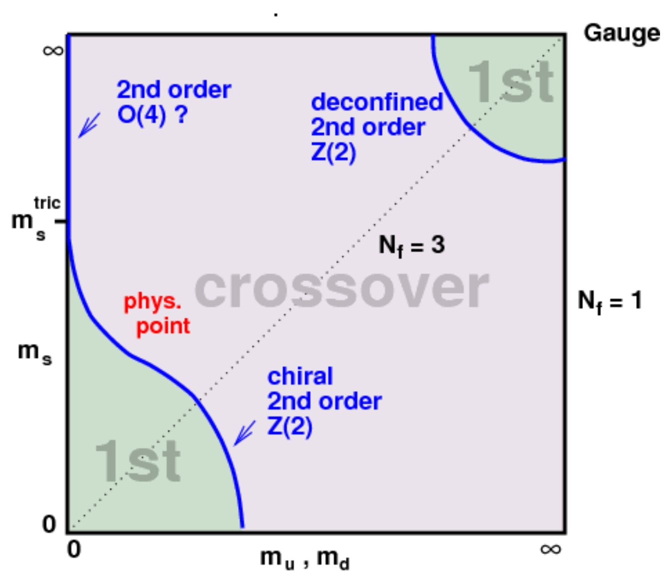

Will we be able to reproduce this picture with our approach?

QCD Action, FP Gauge Fixing, Gluon mass

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$$S = \int_x \Big\{ \frac{1}{4} F^a_{\mu\nu} F^a_{\mu\nu} + \sum_{f=1}^{N_f} \bar{\Psi}_f \big(\not{D} + M_f + \mu\gamma_0 \big) \Psi_f \Big\}$$

finite T: $\int_x = \int_0^\beta d\tau \int d^3x$

No lattice? → gauge fix → Fadeev-Popov → Gribov copies!!

Easy intuition: covariant g.f. cond:

$$\partial_\mu A_\mu = \omega$$

→ 1st order DE → 1 integration const. → ∞-many soln's $\hat{=}$ Gribov copies

QCD Action, FP Gauge Fixing, Gluon mass

What to do about it?

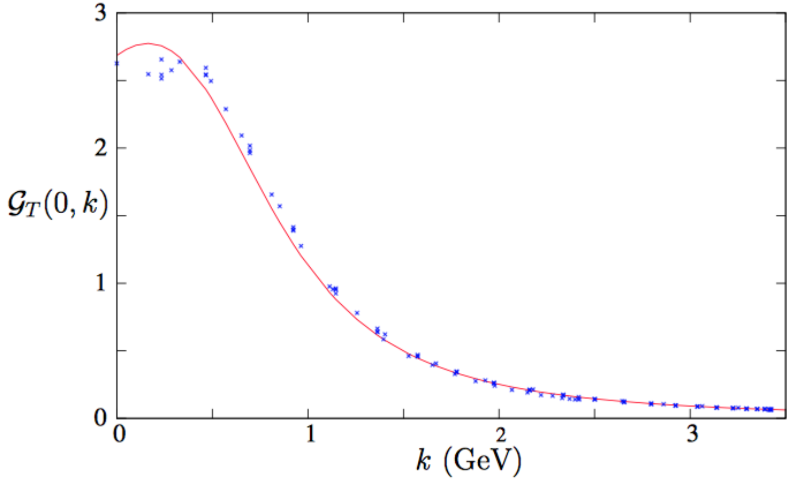
- ignore this → ”standard QCD”, Landau pole etc...
- Gribov ambiguity is a pure IR YM issue
  → How can we alter the IR YM sector in a minimal way without changing the UV at all?
  → eq. no new fields possible
  → simplest: effective gluon mass term

$$S = S_{QCD} + S_{GF} + \int_x \frac{1}{2} m^2 a_\mu^a a_\mu^a$$

QCD Action, FP Gauge Fixing, Gluon mass

Quick "proof":

- Landau gauge prop with mass term



- tree level prop:

$$\frac{1}{p^2 + m^2}$$

QCD Action, FP Gauge Fixing, Gluon mass

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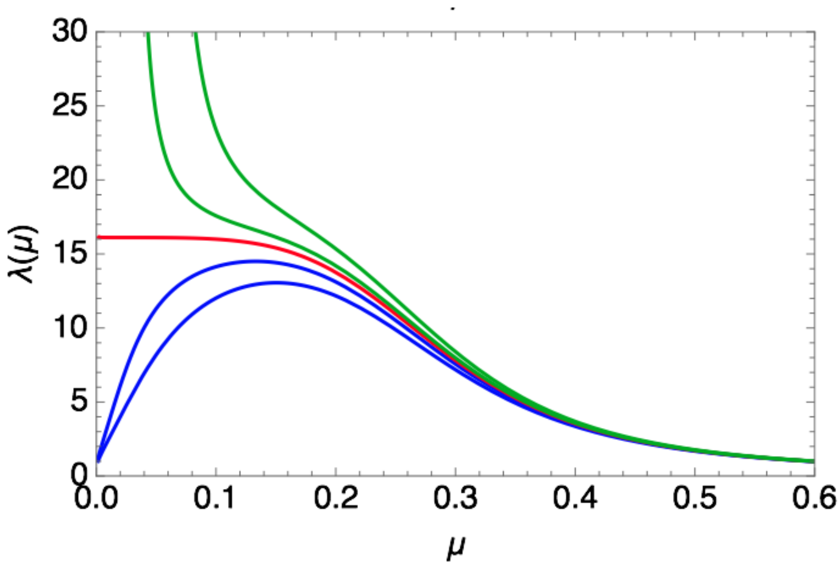
$$
\begin{aligned}
S &= \int_x \Big\{ \frac{1}{4} F^a_{\mu\nu} F^a_{\mu\nu} + \sum_{f=1}^{N_f} \bar{\Psi}_f \big(\not{D} + M_f + \mu\gamma_0 \big) \Psi_f \\
&+ (\bar{D}_\mu \bar{c})^a (D_\mu c)^a + i h^a (\bar{D}_\mu \bar{c})^a + \frac{1}{2} m^2 a^a_\mu a^a_\mu \Big\}
\end{aligned}
$$

with $\bar{A}_\mu = A_\mu - a_\mu$, $(\bar{D}_\mu a_\mu)^a = 0$ and $\bar{D}^{ab}_\mu = \delta^{ab}\partial_\mu + g f^{acb} \bar{A}^c_\mu$

→ Now you know all of the title of my presentation :)

RG flow of coupling

Difference to "standard QCD"?



→ perturbative access to observables! → systematic improvement!

Polyakov loop - Our order parameter

$$L(r) = \frac{1}{3}\mathrm{tr}\left\langle P \exp\Big(ig \int_0^\beta \mathrm{d}\tau\, A_0^a t^a\Big) \right\rangle$$

It is related to the free energy F_q necessary to bring a quark into a "bath" of gluons via $L = e^{-\beta F_q}$. Hence

$$L = 0 \leftrightarrow F_q = \infty \leftrightarrow \text{confinement}$$

and likewise

$$L \neq 0 \leftrightarrow F_q < \infty \leftrightarrow \text{deconfinement}$$

Likewise for an anti-quark

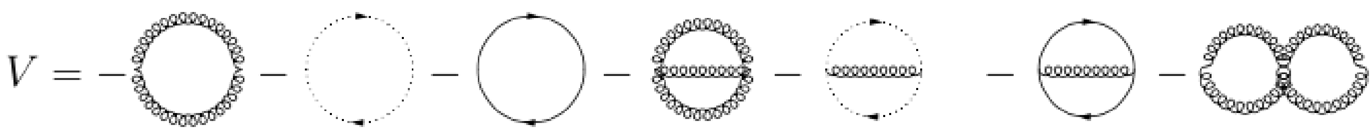
$$\bar{L}(r) = \frac{1}{3}\mathrm{tr}\left\langle \bar{P} \exp\Big(ig \int_0^\beta \mathrm{d}\tau\, A_0^a t^a\Big) \right\rangle$$

$L(r)$ and $\bar{L}(r)$ are functions of background $r \sim \bar{A}$

Effective Potential

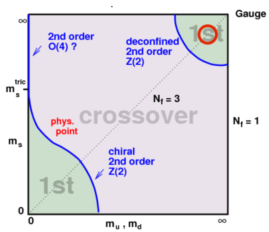
How to find r to be plugged in $L(r)$ and $\bar{L}(r)$?

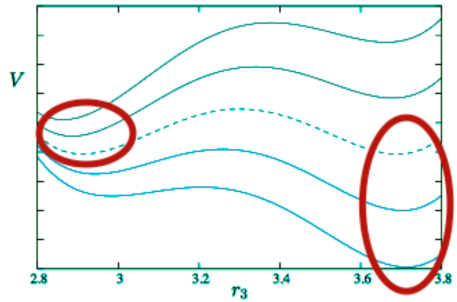
→ Minimize $V(r)$ to find the physical point:

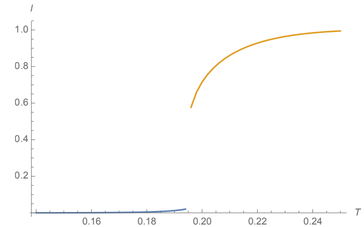


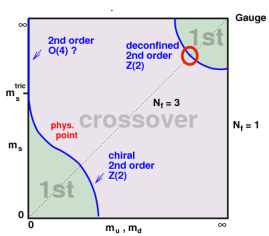
→ Then what would this look like in practice/in a simple example?

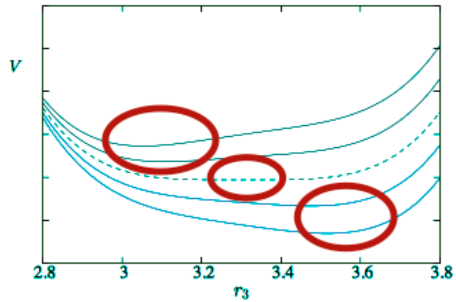
Minimization and Polaykov loops

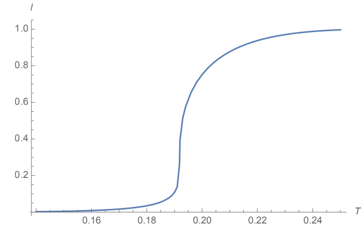


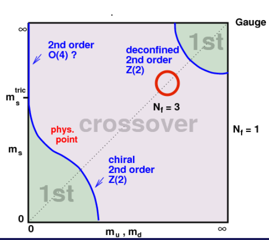


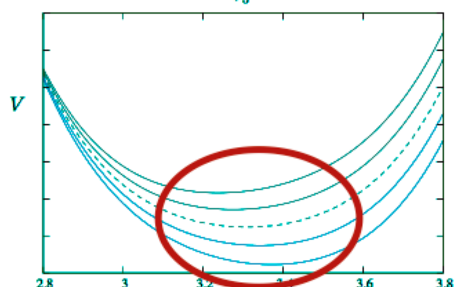


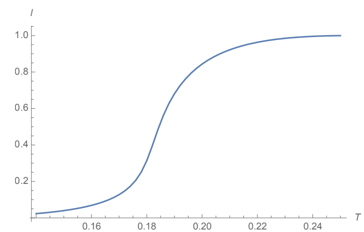












Real Chemical Potential