Interacting Ensemble of the Instanton-dyons and Deconfinement Phase Transition in the SU(2) Gauge Theory

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Overview

- Ensemble of Instanton-Dyons
- Explanation of Terms and setup
- Classical interaction
- Free Energy
- Results

Explanation of Terms

- Dyons
  - Magnetic and Electric Topological configuration, 2 in $SU(2)$ plus 2 anti-dyons
- Holonomy
  - The asymptotic value of the vector field, $A_4^3(\infty) = v = 2\pi\nu T$
  - Polyakov loop is $P = \cos(\pi\nu)$
- Temperature
  - Partition function is independent of temperature so distance is $x = Tr$
  - Temperature dependence hidden in g
- Debye Mass
  - Explains the exponential falloff of the fields

$$M_D^2 \equiv \frac{g^2}{2}\frac{\partial^2 f}{\partial^2 v} \tag{1}$$

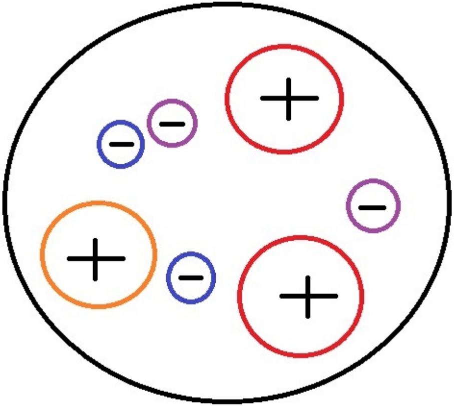
Ensemble

$$Z = \int Dx \exp(-S) \quad (2)$$

$$f = -\log(Z)/V \quad (3)$$

- Size of M dyons scales as $\frac{1}{\nu}$
- Size of L dyons scales as $\frac{1}{1-\nu}$
- Weight of M dyons are $8\pi^2\nu/g^2$
- Weight of L dyons are $8\pi^2\bar{\nu}/g^2$

	M	$\bar{M}$	L	$\bar{L}$
e	1	1	-1	-1
m	1	-1	-1	1



Free energy density

- In the infinite volume limit the dominating configuration is the parameters that minimizes free energy density

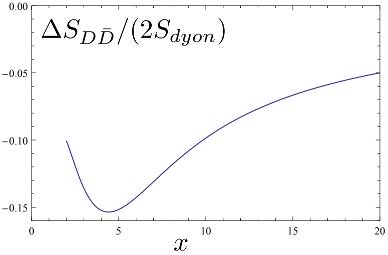
$$
\begin{aligned}
f &= \frac{4\pi^2}{3}\nu^2\bar{\nu}^2 - 2n_M \ln\left[\frac{d_\nu e}{n_M}\right] \\
&\quad -2n_L \ln\left[\frac{d_{\bar{\nu}} e}{n_L}\right] + \Delta f
\end{aligned} \tag{4}
$$

- Free energy density contains 3 items
  - The purturbative potential that prefer trivial Holonomy
  - The entropy due to the dyons moving around
  - (Δf) Correction to the energy due to the interaction of the dyons
- Δf contains
  - Classical 2-point interaction, with a core
  - Diakonov determinant to describe the moduli space

Classical interaction

- The dyon-antidyon classical interaction was found and parameterized using the streamline approach

$$\Delta S_{D\bar{D}} = -2\frac{8\pi^2\nu}{g^2}(\frac{1}{x} - 1.632e^{-0.704x})$$
$$x = 2\pi\nu r T \tag{5}$$



	M	$\bar{M}$	L	$\bar{L}$
e	1	1	-1	-1
m	1	-1	-1	1

- The rest was theorized and confirmed numerically to go as

$$\Delta S_{D\bar{D}} = \frac{8\pi^2\nu}{g^2}\left(-e_1 e_2\frac{1}{x} + m_1 m_2\frac{1}{x}\right)$$
$$x = 2\pi\nu r T \tag{6}$$

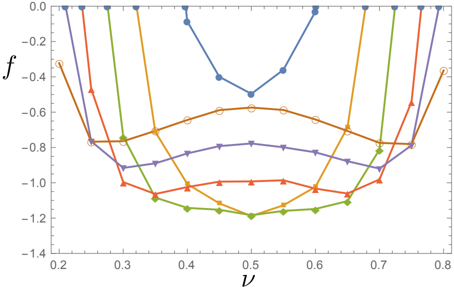
Ensemble of Dyons

- The free energy is found from

$$F(\lambda) = -\log(\int Dx \exp(-\lambda S)) \quad (7)$$

$$F(1) = \int_0^1 d\lambda < S(\lambda) > \quad (8)$$

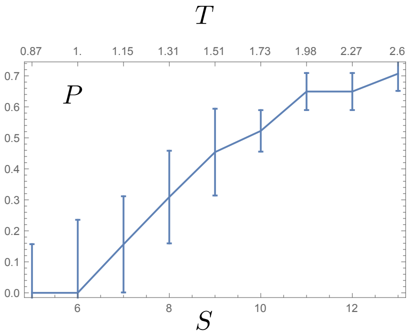
- Need to get the free energy of an ensemble of dyons as a function of
  - Coupling constant/Temperature
  - Density
  - Debye Mass
  - Holonomy

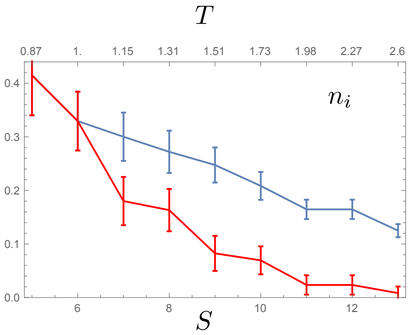


- Found using the Metropolis algorithm in c++ and Cuda that parallelized this ensemble

Results

- The main results are the Polyakov loop and the dyons density as a function of action/temperature





- Blue is density of M dyons and red is density of L dyons

Bibliography

1. R. Larsen and E. Shuryak, Classical interactions of the instanton-dyons with antidyons, arXiv:1408.6563 [hep-ph].
2. R. Larsen and E. Shuryak, Interacting Ensemble of the Instanton-dyons and Deconfinement Phase Transition in the SU(2) Gauge Theory, arXiv:1504.03341 [hep-ph].