PARITY DOUBLING STRUCTURE OF NUCLEON AT NON-ZERO DENSITY IN THE HOLOGRAPHIC MEAN FIELD THEORY

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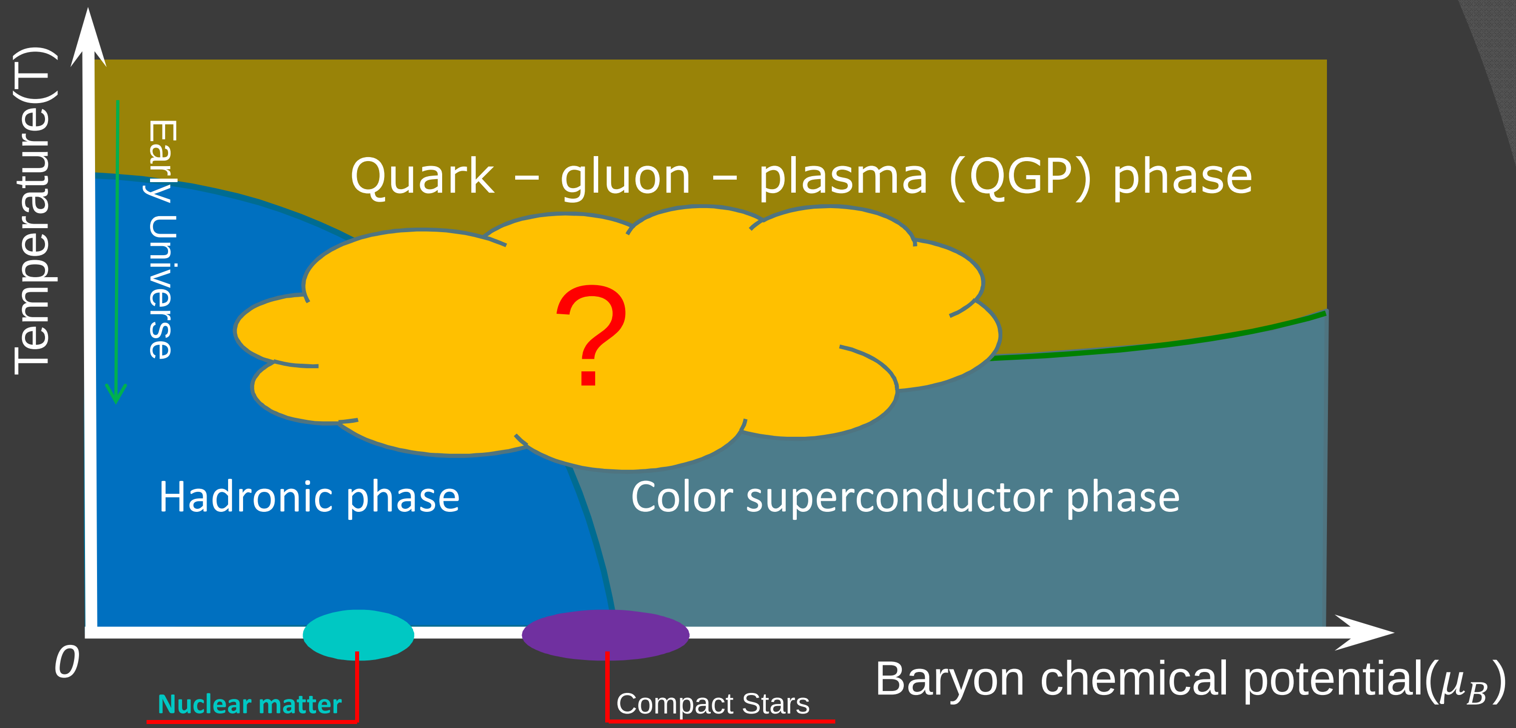
Motivation: QCD Phase Diagram

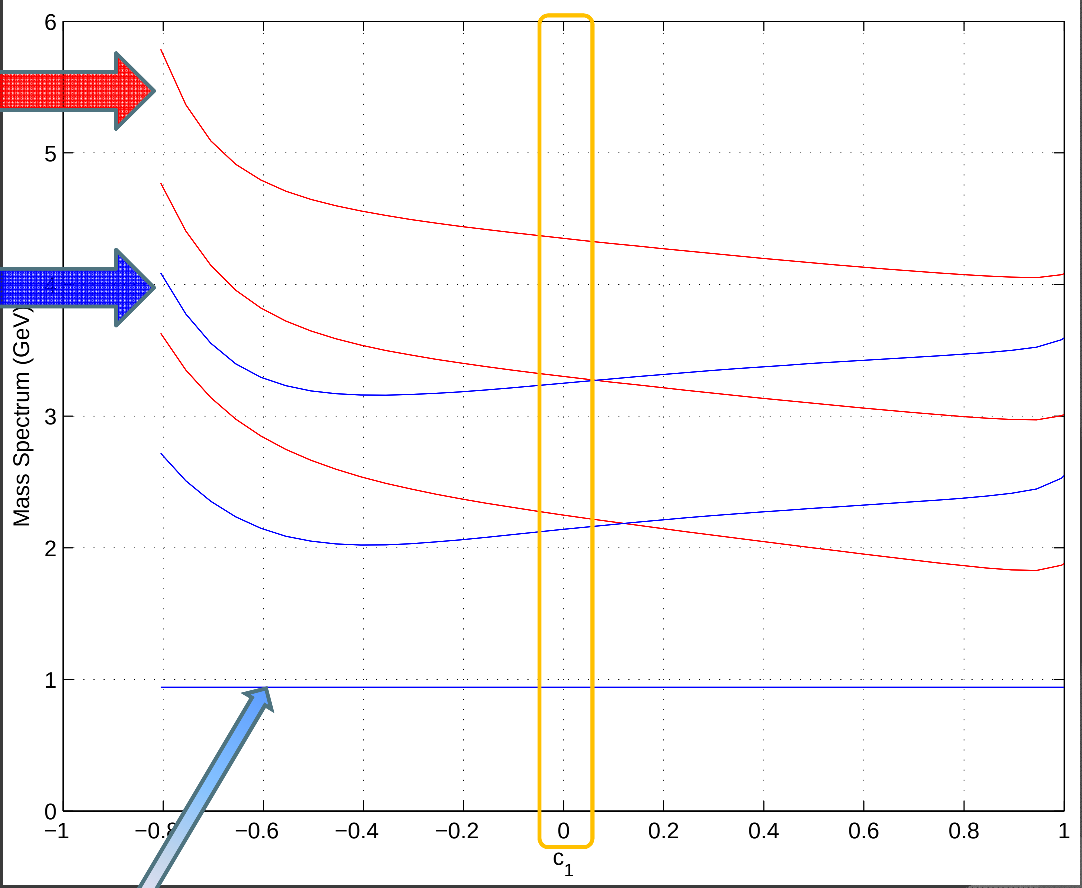


- Perturbative QCD, Lattice QCD methods are improper to study density matter
- What happens at high density place like compact stars?

Spin1/2 baryon mass spectrum @ $z_m = 1/0.33 (m_\rho = 780\text{MeV})$

Parity Odd

Parity Even



	Mass	Parity
p(n)	0.939	+
N(1440)	1.440	+
N(1535)	1.535	-
...		
N(2100)	2.100	+

$z_m(\text{GeV}^{-1})$	G	c_1	(p,n)(GeV)	N(1440)	N(1535)	3rd	4th	5th
$(0.33)^{-1*}$	8.67**	0	0.94*(+)	2.14(+)	2.24(−)	3.25(+)	3.30(−)	4.35(+)

m_ρ Auto Fixed $m_p(m_n)$

Parity coincides with Experiment

Deog Ki Hong, Takeo Inami, Ho-Ung Yee. Phys.Lett.B646, hep-ph/0609270

Holographic mean field theory

5D field decompose

$$\begin{cases} X(x,z) = X(z) + \cancel{x(x,z)} \\ V_M(x,z) = V_M(z) + \cancel{v_M(x,z)} \\ A_M(x,z) = \cancel{A_M(z)} + \cancel{a_M(x,z)} \\ N_1(x,z) = N_1(z) + \cancel{n_1(x,z)} \\ N_2(x,z) = N_2(z) + \cancel{n_2(x,z)} \end{cases}$$

Mean field

fluctuation

Masayasu Harada, Shin Nakamura, Shinpei Takemoto. Phys.Rev. D86 (2012) 021901

Mean field only distribution(depends) on the z coordinate, the other coordinates are flat(average) value. The mean field take the role of source.

ND - σ relation @ $z_m = 1/0.33(m_\rho = 780\text{MeV})$

Using:

$$\sigma \approx 2\frac{X(z)}{z^3}\Big|_{z\to 0}$$

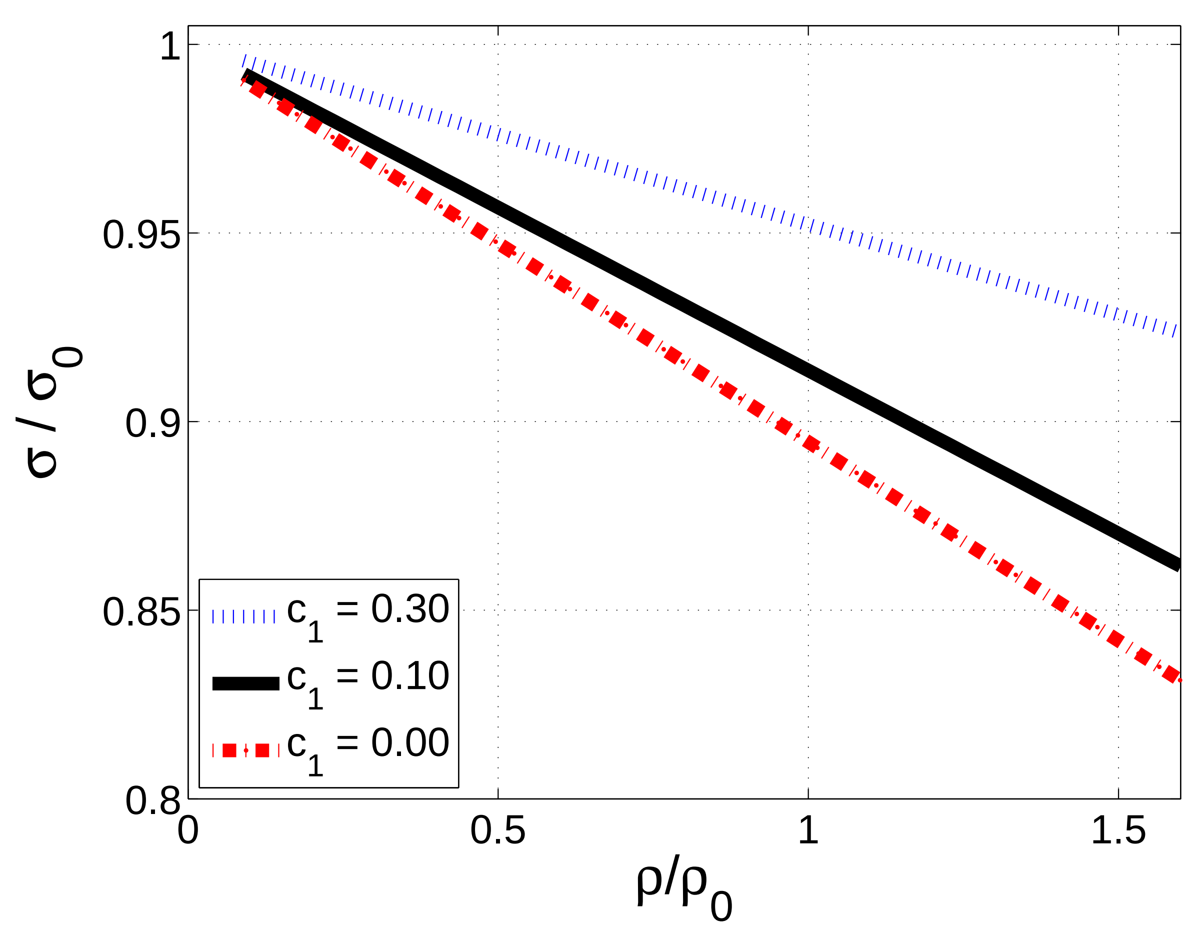
Boundary Condition

	UV	IR
N_1	0	c_2
N_2	0	$c_2 * c_1$

Physical meaning

c_2 ⟷ Number Density

c_1 ⟷ Chiral breaking



$\tilde{\sigma}/\sigma_0$ denote normalized σ by its value at zero density.

Youngman Kim, Chang-Hwan Lee, Ho-Ung Yee.
Phys.Rev.D77(2008)085030 arXiv:0707.2637

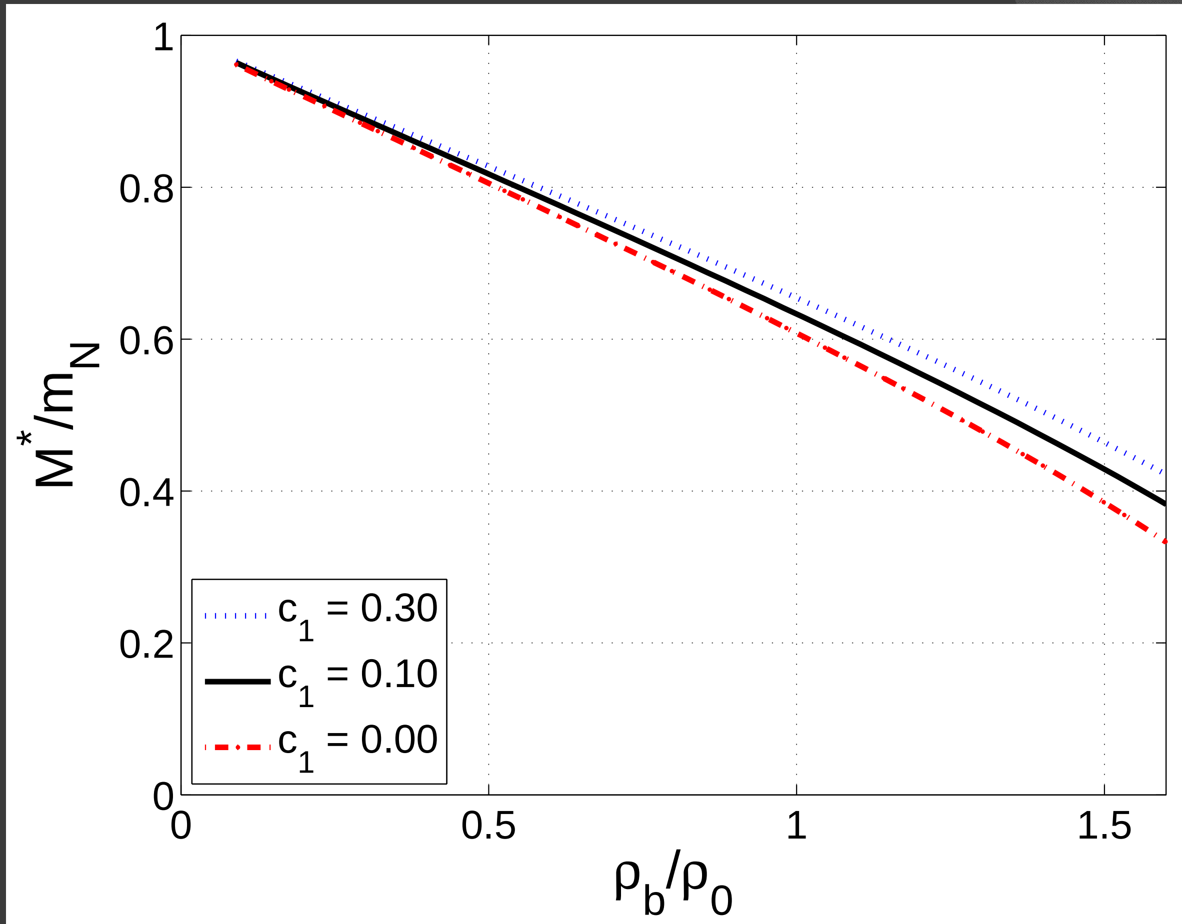
They only consider $c_1=0$,
In a same order with our results

ND - M^* relation @ $z_m = 1/0.33$(EKSS)

Walecka type model:

$$\mu = \sum_{n=1}^{\infty} \frac{g^2_{\omega^{(n)}NN}}{m^2_{\omega^{(n)}}} \rho_b + \sqrt{k_F^2 + M^{*2}}$$

(n)	$m_{\omega^{(n)}}$[GeV]	$g_{\omega^{(n)}NN}$
1	0.78	15.6
2	1.79	9.3
3	2.82	4.3



The decreasing of M^*at high density consistent with experiment result.

Summary

- We study the property of baryon at zero and finite density base on Holographic QCD models

- At zero density, we discuss a dynamical way to generate the nucleon mass and found a kind of chiral invariant mass
  - We discuss the relation between c_1 and chiral invariant mass

- At finite density, by adopting the holographic mean field theory, we discuses the quark condensate σ, chemical potential μ and effective mass M^* with their dependence of number density
  - We find that quark condensate σ will decrease at high density, which means chiral symmetry partially restored at high density
  - We find that effective mass M^* will decrease at high density, which consistent with experiment result

Thank you for your attention!