Magnetic moment of the baryon at finite density and temperature

Chang Ho Hyun
Daegu University

- Introduction
- Model
- Result
- Conclusion

Hyp-X 2009, Tokai
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INTRODUCTION

- High density and/or temperature
  - Nuclear interactions
  - Hadron properties
  - Symmetry restoration
  - Phase transition
- Probing tool
  - Neutron star observation
  - Relativistic heavy ion collisions

- Magnetic form factor in nuclei : finite density

- Recent experiment at JLab ~ 5% change in nuclei

S. Strauch, arXiv:0709.4034v1 [nucl-ex]

- Yet, old data are controversal

K.S.Kim, M.K. Cheoun, PRC67, 034603 (2003)

• Heavy ion collision : finite temperature

- Strong magnetic field in peripheral collision ~ 10^{18} G

D.E. Kharzeev, L.D. McLerran, H.J. Warringer, arXiv:0711.0950 [hep-ph]

- Strong magnetic field can change the properties of the baryon in free space

B.C. Tiburzi, NPA814, 74 (2009)

- Strong magnetic field can change the critical density and temperature for the phase transition

N.O. Agasian, S.M. Fedorov, PLB663, 445 (2008)

• Magnetic moment of the baryon at high density and temperature

- Probe the change of hadron properties

MODEL

- Quark-meson coupling model

- Baryons : MIT bags

- Interactions : Mean fields of σ and ω mesons

$$\left[i\gamma \cdot \partial - (m_q - g_\sigma^q \, \sigma) - g_\omega^q \, \gamma^0 \, \omega_0 \right] \, \psi_q = 0$$

$$m_B^* = \sqrt{E_B^2 - \sum_q \left(\frac{x_q}{R_B} \right)^2}$$

$$E_B \, = \sum_q \frac{\Omega_q}{R_B} - \frac{Z_b}{R_B} + \frac{4\pi R_B^3}{3} B_B$$

• Parameters

- Mass in free space : Bag constants (B_B), Phenomenological constants (Z_b)

- Nuclear saturation properties : quark-meson coupling constants ($g_\sigma{}^q$, $g_\omega{}^q$)

- QMC B_B = B_{B0}

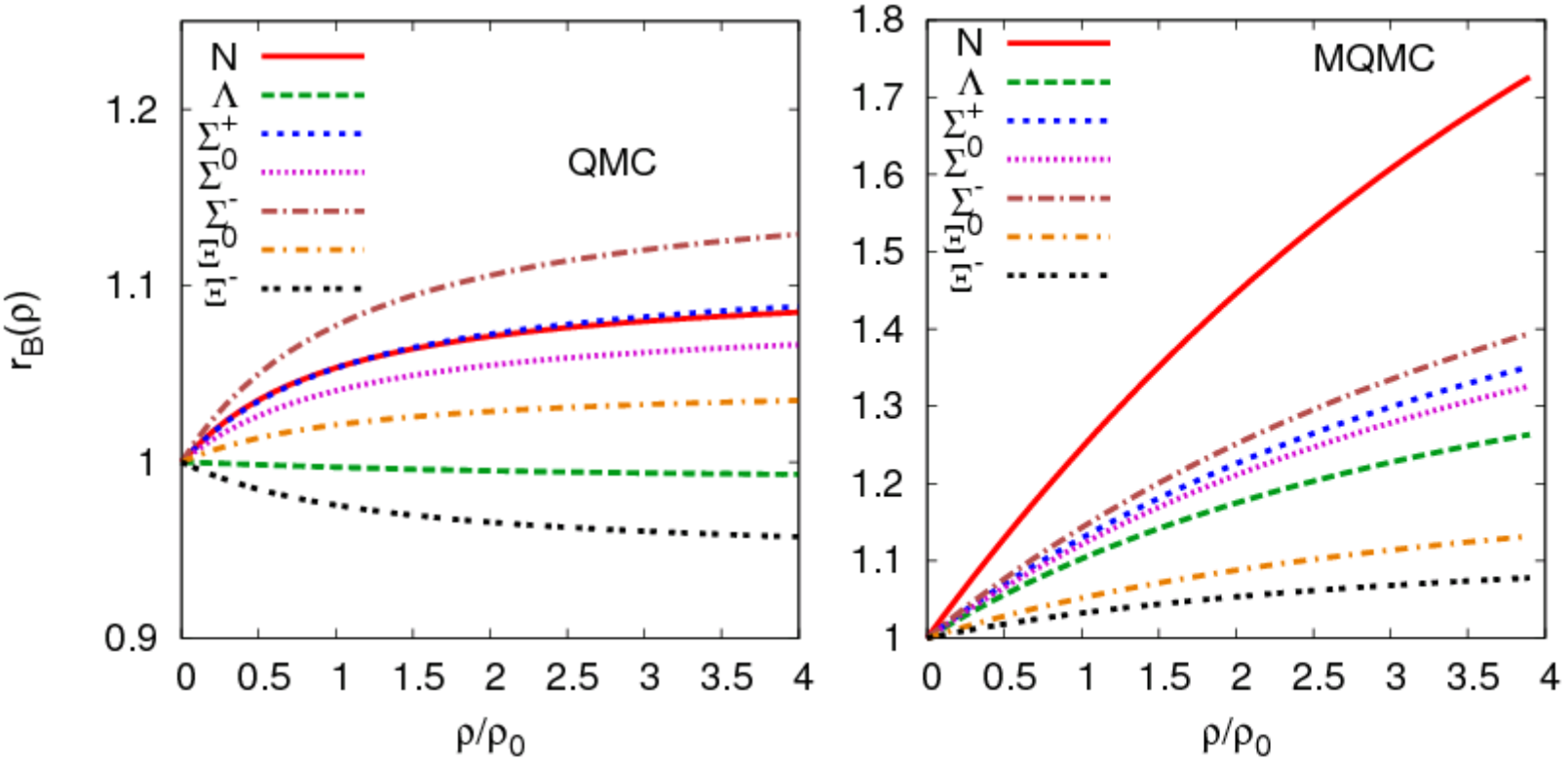
- MQMC B_B = $B_B(\sigma)$

$$B_B(\sigma) = B_{B0}\exp\left(-\frac{4g_\sigma^B\sigma}{M_N}\right)$$

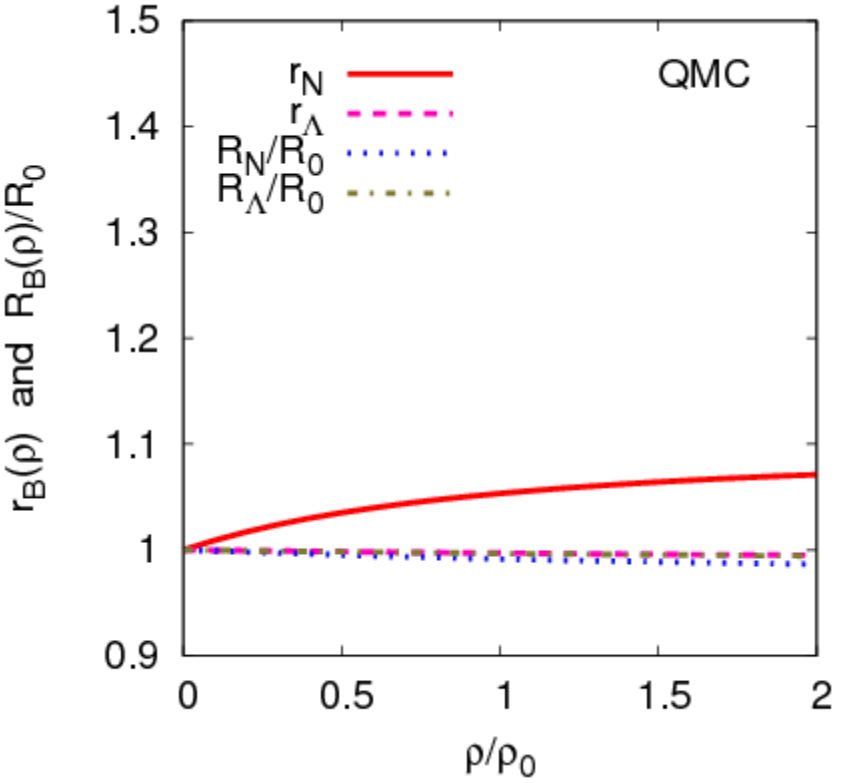
RESULTS

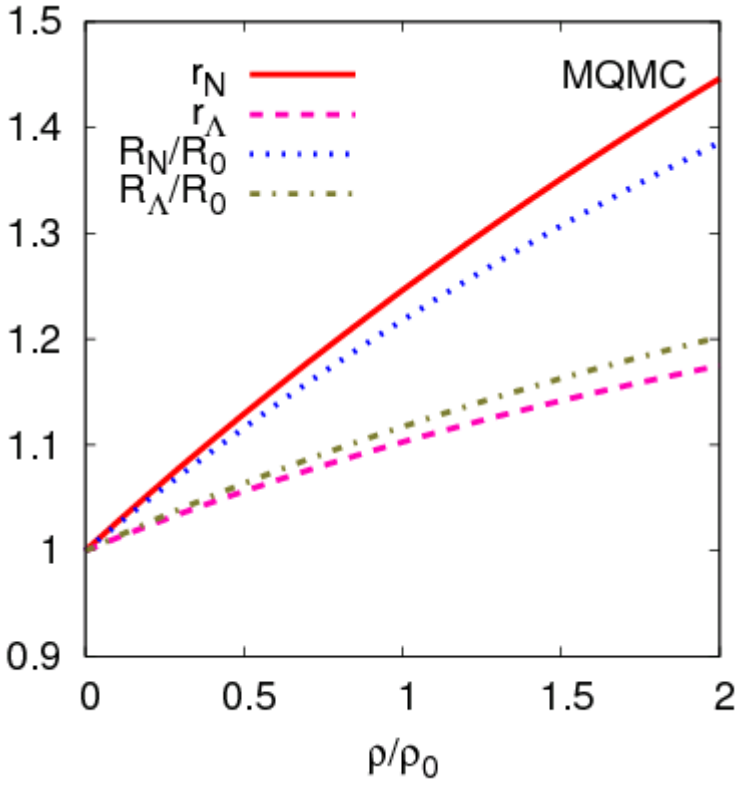
Magnetic moment ratio to free space value : $r_B = \mu_B^*/\mu_B$

- Finite density, T=0

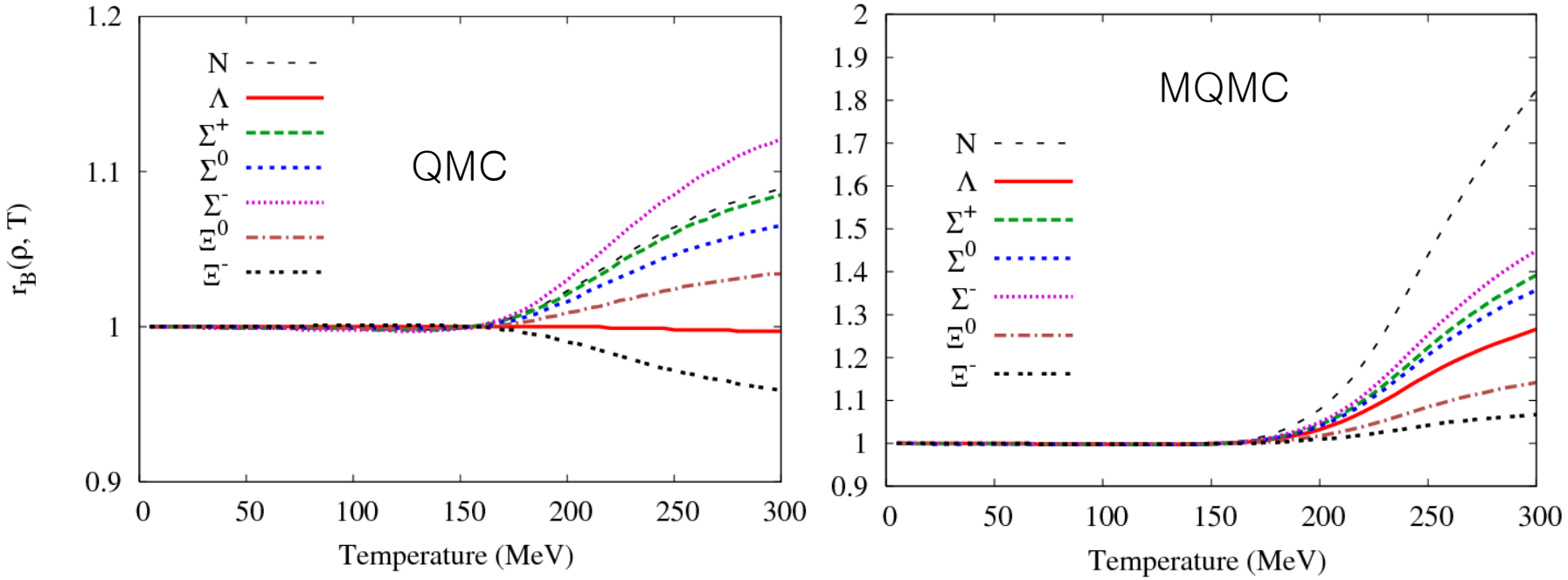


Explanation for the model dependence : $\mu_B \sim R_B$

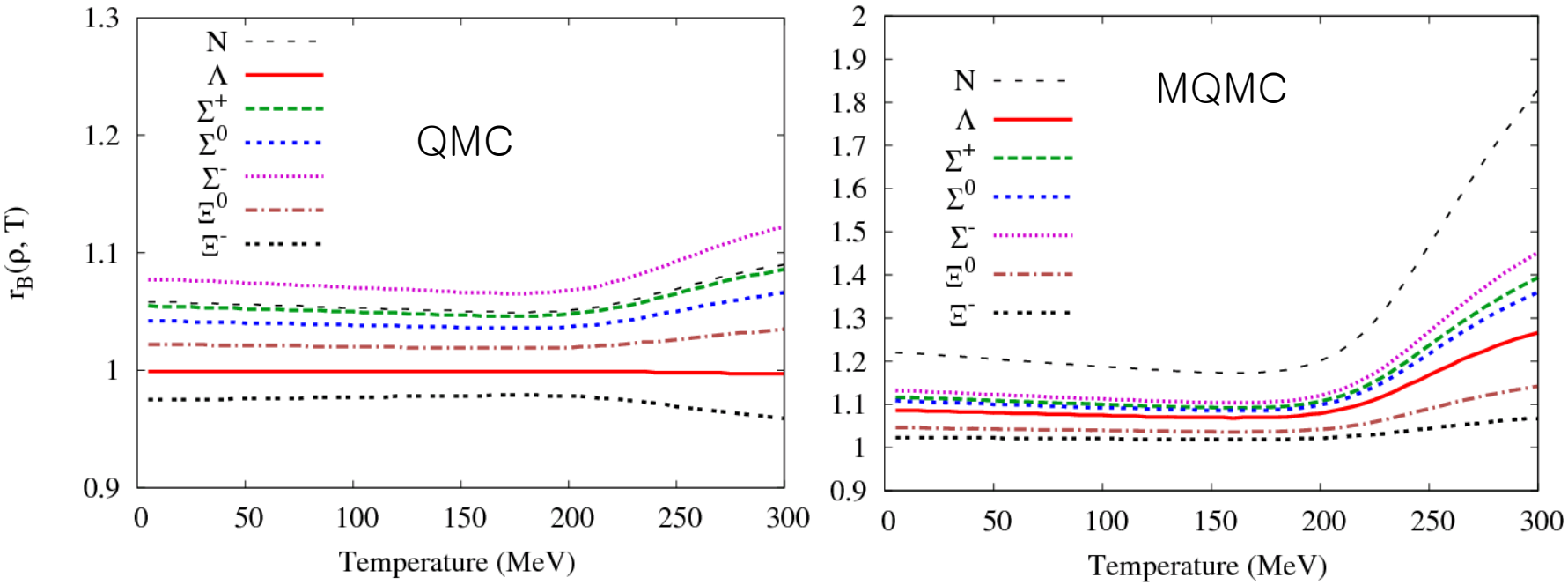




- Finite temperature, $\rho=0.1\rho_0$



- Finite temperature, $\rho=1.0\rho_0$



• The effect observable?

$$E_N = m_N - \mu_N \, eB/2m_N$$

$(eB)^{1/2}$ ~ 10^{18} G in peripheral heavy ion collision

- In free space

$\mu_p \, eB/2m_N$ ~ 3% of m_N

- For T=250MeV and ρ=0.1ρ_0 in the MQMC model

m_N^* ~ 0.7 m_N, μ_N^* ~ 1.5 μ_N

$\mu_p^* \, eB/2m_N^*$ ~ 10% of m_N^*

The effect is obvious

CONCLUSION

• Obvious change at finite density and temperature

• Density effect

- Neutron star phenomenology in combination with its strong magnetic field

• Temperature effect

-Baryon mass shift in relativistic heavy ion collisions

• Further investigations

- Relation to symmetry restoration

- Critical density and temperature for phase transition

- Magnetic moment at high density in the strong magnetic field in progress