Transition magnetic moments of transition in $\Delta \rightarrow p$ in asymmetric nuclear matter

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Outline

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   - Impact of Medium on Effective Baryon asses.
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QCD : Present theory of strong interactions

- Quantum Chromodynamics (QCD) provides a fundamental description of hadronic and nuclear structure and their dynamics.
- At high energies, (α_s is small), QCD can be used perturbatively.
- At low energies, (α_s becomes large), one has to use other methods such as effective Lagrangian models to describe physics.
- Many fundamental questions have not been resolved. The most challenging non-perturbative problem in QCD is to determine the structure and spectrum of hadrons in terms of their quark and gluon degrees of freedom.
- Knowledge has been rather limited because of **confinement** and it is still a big challenge to perform the calculations from first principles of QCD.

Fundamental Quantities

Electromagnetic Dirac and Pauli form factors: further related to the static low-energy observables

- **Structure :** Magnetic moments predicted by Dirac theory (1.0 μN) and experiment (2.5 μN).
  Proton is not an elementary Dirac particle but has an inner structure.
- **Size:** Spatial extension. Proton charge distribution given by charge radius r_p.
- **Shape:** Non-spherical charge distribution. Quadrupole moment of the transition $N \to \Delta$.
- **Relation between the properties??**

QCD : Present theory of strong interactions

- Wide range of applications ranging from the dynamics and structure of hadrons and nuclei to the properties and phases of hadronic matter at the earliest stages of the universe.
- New experimental tools are continually being developed to probe the non- perturbative structure of the theory, for example the hard diffractive reactions, semi-inclusive reactions, deeply virtual Compton scattering etc.

Proton spin Problem : The driving question

- Year 1988, European Muon Collaboration (EMC) discovered that Valence quarks carry 30% of proton spin.
- Naive Quark Model contradicts this results (Based on Pure valence description: $proton = 2u + d$).
  "Proton spin crisis"
- Confirmed by the measurements of polarized structure functions of proton in the deep inelastic scattering (DIS) experiments by SMC, E142-3 and HERMES experiments.
- Provides evidence that the valence quarks of proton carry only a small fraction of its spin suggesting that they should be surrounded by an indistinct sea of $q\bar{q}$ pairs.

Flavor Structure

- Year 1991, NMC result: Asymmetric nucleon sea ($\bar{d} > \bar{u}$). Results confirmed by E866 and HERMES.
- Measured quark sea asymmetry established that the study of the structure of the nucleon is intrinsically a non-perturbative phenomena.
- Sum Rules :
  - Bjorken Sum Rule: $\Delta_3 = \Delta_u - \Delta_d$
  - Ellis-Jaffe Sum Rule: $\Delta_8 = \Delta_u + \Delta_d - 2\Delta_s$ (Reduces to $\Delta_8 = \Delta\Sigma$ when $\Delta_s = 0$)
  - Strange quark fraction: $f_s \simeq 0.10$
  - Gottfried Sum Rule: $I_G = \frac{1}{3} + \frac{2}{3}\int_0^1 \left[\bar{u}(x) - \bar{d}(x)\right] dx = 0.254 \pm 0.026$

Quark Sea

- Recently, a wide variety of accurately measured data have been accumulated for
  - **Static properties of hadrons**: masses, electromagnetic moments, charge-radii etc.
  - **Low energy dynamical properties**: scattering lengths and decay rates etc.
- These lie in the non perturbative range of QCD.
- Flavor and spin structure of the nucleon is not limited to u and d quarks only.
- Non-perturbative effects explained only through the generation of "quark sea".

Nonperturbative regime

- The direct calculations of these quantities form the first principle of QCD are extremely difficult, because they require non-perturbative methods.
- **Naive Quark Model** is able to provide a intuitive picture and successfully accounts for many of the low-energy properties of the hadrons in terms of the valence quarks.
- **Techniques such as lattice gauge theory, QCD sum rules, and a wide variety of models have been developed to study this extremely interesting energy regime.**

Importance of studying the properties of hadrons in medium

Studying the medium modifications hadron properties is important

1. Understanding the Quark Gluon Plasma's (QGP) characteristics and behavior.
2. Understand the nuclear matter under extreme conditions such as neutron stars or during heavy-ion collisions.
3. To make QCD predictions under the extreme conditions and guide the experimental search.
4. MAMI and Jefferson lab experiments found the signatures of medium modification in Electro-magnetic properties of hadrons.
5. KEK-E325, sPrings8 facility, ANKE-COSY collaborations observed the modification in mass and decay width of ϕ meson mass.
6. Many theoretical studies like QMC model, Chiral SU(3) mean field model etc have been used to study the effective masses and magnetic moments of hadrons.

Chiral Quark Mean Field Model: Introduction

- Based on consideration of quarks and mesons as degrees of freedom.
- Baryons are formed via the confinement of quarks by an effective potential ($\mathcal{L}_c$).
- The interactions between quarks and mesons ($\mathcal{L}_{qm}$) and scalar & vector meson self interactions ($\mathcal{L}_{VV}, \mathcal{L}_{\Sigma\Sigma}$) are based on $SU(3)$.
- Constituent quarks and mesons obtain their masses through spontaneous symmetry breaking ($\mathcal{L}_{\chi SB}$).
- The total effective Lagrangian density in chiral SU(3) model

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{q0} + \mathcal{L}_{qm} + \mathcal{L}_{VV} + \mathcal{L}_{\Sigma\Sigma} + \mathcal{L}_{\chi SB} + \mathcal{L}_{\Delta m} + \mathcal{L}_c$$

- The term $\mathcal{L}_{q0}$ represents the free part of mass-less quarks.

Masses of quarks in Chiral Mean Field Model

- Interactions among quarks are mediated through non-strange scalar-isoscalar field (σ), strange scalar-isoscalar field (ζ) and scalar-isovector field (δ).
- The vector fields (ω, ρ, ϕ) are also incorporated which represent repulsive interactions.
- The in-medium constituent quark mass (m_i^*) and effective quark energy (e_i^*) are defined in terms of above fields

$$m_q^* = -g_\sigma^q \sigma - g_\zeta^q \zeta - g_\delta^q I^{3q} \delta + m_{q0} \quad (1)$$

$$e_q^* = e_q - g_\omega^q \omega - g_\rho^q I^{3q} \rho - g_\phi^q \phi \quad (2)$$

- Here, g^q are coupling constants of quarks withe respective fields while I^{3q} is the third component of isotopic spin.
- Parameters of the model are fitted to obtain the binding energy value of -16 MeV at the nuclear saturation density ($\rho_0 = 0.16 fm^{-3}$).

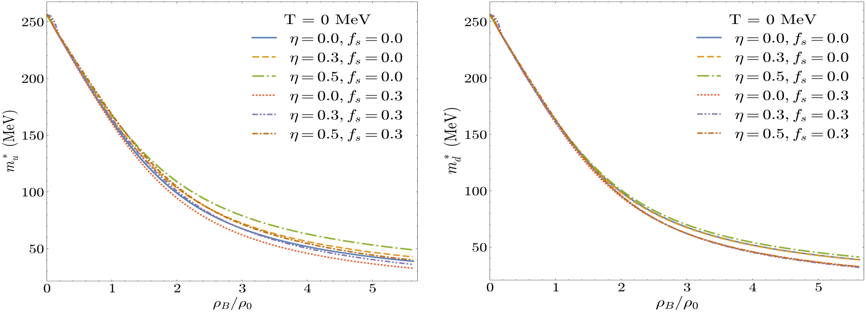
Masses of Baryons in Chiral Mean Field Model

- The in-medium mass of a baryon is expressed in terms of its effective energy E_i^* and spurious center of mass momentum p_{icm} as,
  $M_i^* = \sqrt{E_i^{*2} - < p_{icm}^{*2} >}$.
- $E_i^* = \sum_q n_{qi} e_q^* + E_{ispin}$: where E_{ispin} is a correction term in the effective energy of a baryon.
- $< p_{icm}^{*2} > = \frac{(11 e_q^* + m_q^*)}{6(3 e_q^* + m_q^*)}(e_q^{*2} - m_q^{*2})$;
- To obtain the density and temperature dependent values of scalar and vector fields, the strange isospin asymmetric thermodynamic potential is minimized with respect to these fields.

$$\frac{\partial \Omega}{\partial \sigma} = \frac{\partial \Omega}{\partial \zeta} = \frac{\partial \Omega}{\partial \delta} = \frac{\partial \Omega}{\partial \omega} = \frac{\partial \Omega}{\partial \rho} = \frac{\partial \Omega}{\partial \phi} = \frac{\partial \Omega}{\partial \chi} = 0$$

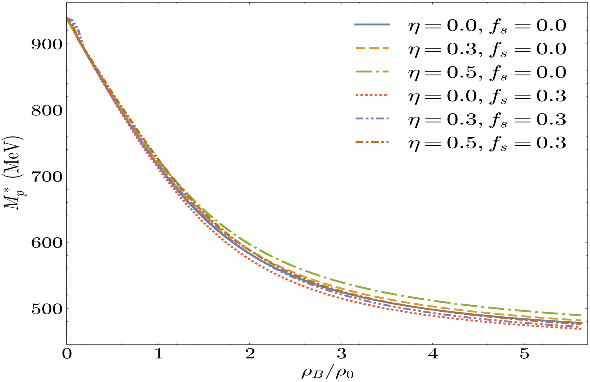
- The above equations are solved for different values of baryonic density (ρ_B), temperature, isospin asymmetry (η) and strangeness fraction (f_s) to obtain the values of meson fields and hence the in-medium masses of quarks and baryons.

In-Medium Masses of Light Quarks



- A decrease in masses is observed with ρ_B at isospin asymmetry $\eta = 0$ and strangeness fraction, $f_s = 0$.
- At fixed value of ρ_B and η, there is further decrease in value of mass of light quarks with the increase in strangeness fraction (f_s).
- For fixed value of ρ_B and f_s, there is an increase in value of mass of light quarks with the increase in isospin asymmetry parameter, η.
- Difference in behavior b/w u,and d is attributed to difference in value of third component of isospin appearing in Eq. 1.

Modification in proton masses



- Using the effective/in-medium quark masses and fitting E_{ispin} value to vacuum mass of proton, the effective mass of proton (M_p^*) is obtained as varying values of ρ_B, η, f_s and T.
- Similar features as discussed for quarks are observed. Values of m_u^*, m_d^* & M_p^* are used in the calculations for effective transition magnetic moments.

Chiral Constituent Quark Model

- χCQM initiated by Weinberg and developed by Manohar and Georgi to explain the successes of NQM.
- The fluctuation process describing the effective Lagrangian is

$$q \uparrow\downarrow \rightarrow \mathrm{GB} + q\prime \downarrow\uparrow \rightarrow (q\bar{q}') + q' \downarrow\uparrow$$

$q\bar{q}' + q'$ constitute the sea quarks.

- Incorporates *c*onfinement and *c*hiral symmetry breaking.
- "Justifies" the idea of constituent quarks.

Pion Cloud Mechanism

- Quark sea is believed to originate from process such as virtual pion production.
- It is suggested that in the deep inelastic lepton-nucleon scattering, the lepton probe also scatters off the pion cloud surrounding the target proton. The $\pi^+(\bar{d}u)$ cloud, dominant in the process $p \rightarrow \pi^+ n$, leads to an excess of $\bar{d}$ sea.
- However, this effect should be significantly reduced by the emissions such as $p \rightarrow \Delta^{++} + \pi^-$ with $\pi^-(\bar{u}d)$ cloud.Therefore, the pion cloud idea is not able to explain the significant $\bar{d} > \bar{u}$ asymmetry.
- This approach can be improved upon by adopting a mechanism which operates in the *interior* of the hadron.

- The effective interaction Lagrangian between GBs and quarks from in the leading order can now be expressed as

$$\mathcal{L}_{\rm int} = -\frac{g_A}{f_\pi}\bar{\psi}\gamma^\mu\gamma^5\psi,$$

which using the Dirac equation $(\gamma^\mu\partial_\mu - m_q)q = 0$ can be reduced to

$$\mathcal{L}_{\rm int} \approx i\sum_{q=u,d,s}\frac{m_q + m_{q'}}{f_\pi}\bar{q}\gamma^5 q = i\sum_{q=u,d,s} c_8\bar{q}\gamma^5 q.$$

- $c_8\left(=\frac{m_q+m'_q}{f_\pi}\right)$ is the coupling constant for the octet of GBs and m_q (m'_q) is the quark mass parameter.

- The Lagrangian of the quark-GB interaction, suppressing all the space-time structure to the lowest order, can now be expressed as

$$\mathcal{L}_{\rm int} = c_8 \bar{\psi} \Phi \psi.$$

- The QCD Lagrangian is also invariant under the axial $U(1)$ symmetry, which would imply the **existence of the ninth GB**. This breaking symmetry picks the η' as the ninth GB.
- The effective Lagrangian describing interaction between quarks and a nonet of GBs, consisting of octet and a singlet, can now be expressed as

$$\mathcal{L}_{\rm int} = c_8 \bar{\psi} \Phi \psi + c_1 \bar{\psi} \frac{\eta'}{\sqrt{3}} \psi = c_8 \bar{\psi} \left(\Phi + \zeta \frac{\eta'}{\sqrt{3}} I \right) \psi = c_8 \bar{\psi} \left(\Phi' \right) \psi,$$

where $\zeta = \frac{c_1}{c_8}$, c_1 is the coupling constant for the singlet GB, and I is the 3×3 identity matrix.

Successes of χCQM

- "Proton spin problem" including quark spin polarizations, orbital angular momentum of quarks etc.
- Quark flavor distributions, fraction of a particular quark (antiquark) present in a baryon, flavor structure functions, the Gottfried integral and the meson- baryon sigma terms.
- Magnetic moments of octet and decuplet baryons including their transi tions and the Coleman-Glashow sum rule.
- Axial-vector form factors of the low lying octet baryons, singlet (g_0^A) and nonsinglet (g_3^A and g_8^A) axial-vector coupling constants.
- The spin independent (F_1^N and F_2^N) and the spin dependent (g_1^N) structure functions, longitudinal spin asymmetries of nucleon (A_1^N).

Contd...

- Hyperon β decay parameters including the axial-vector coupling parameters F and D.
- Magnetic moments of octet baryon resonances well as Λ resonances .
- Charge radii and quadrupole moment of the baryons.
- **The model is successfully extended to predict the important role played by the small intrinsic charm content in the nucleon spin in the SU(4) χCQM and to calculate the magnetic moment and charge radii of charm baryons including their radiative decays.**

- The GB field can be expressed in terms of the GBs and their transition probabilities as $\Phi' =$

$$\begin{pmatrix} \frac{P_\pi \pi^0}{\sqrt{2}} + \frac{P_\eta \eta}{\sqrt{6}} + \frac{P_{\eta'} \eta'}{4\sqrt{3}} - \frac{P_D \eta_c}{4} & P_\pi \pi^+ & P_K K^+ & P_D \bar{D}^0 \\ P_\pi \pi^- & -\frac{P_\pi \pi^0}{\sqrt{2}} + \frac{P_\eta \eta}{\sqrt{6}} + \frac{P_{\eta'} \eta'}{\sqrt{3}} - \frac{P_D \eta_c}{4} & P_K K^0 & P_D D^- \\ P_K K^- & P_K \bar{K}^0 & -\frac{2 P_\eta \eta}{\sqrt{6}} + \frac{p_{\eta'} \eta'}{4\sqrt{3}} - \frac{P_D \eta_c}{4} & P_D D_s^- \\ P_D D^0 & P_D D^+ & P_D D_s^+ & -\frac{3 p_{\eta'} \eta'}{4\sqrt{3}} + \frac{3 P_D \eta_c}{4} \end{pmatrix}$$

- The chiral fluctuations $u(d) \to d(u) + \pi^{+(-)}$, $u(d) \to s + K^{+(0)}$, $u(d,s) \to u(d,s) + \eta$, $u(d,s) \to u(d,s) + \eta'$ and $u(d) \to c + \bar{D}^0(D^-)$ are given in terms of the transition probabilities P_π, P_K, P_η, $P_{\eta'}$ and P_D respectively.

Transition Magnetic Moments

- The transition magnetic moments for the the spin $\frac{3}{2}^+ \rightarrow \frac{1}{2}^+$ transitions from the radiative decays $B_i \rightarrow B_f + \gamma$, where B_i and B_f are the initial and final baryons.
- The magnetic moment of a given baryon in the χCQM receives contribution from the valence quark spin, sea quark spin and sea quark orbital angular momentum

$$\mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_{Total} = \mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_V + \mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_S + \mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_O$$

$$\mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_V = \sum_{q=u,d,s} \Delta q\left(\frac{3}{2}^+ \rightarrow \frac{1}{2}^+\right)_V \mu q$$

$$\mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_S = \sum_{q=u,d,s} \Delta q\left(\frac{3}{2}^+ \rightarrow \frac{1}{2}^+\right)_S \mu q$$

$$\mu\left(B_{\frac{3}{2}^+} \rightarrow B_{\frac{1}{2}^+}\right)_O = \sum_{q=u,d,s} \Delta q\left(\frac{3}{2}^+ \rightarrow \frac{1}{2}^+\right)_V \mu(q_+ \rightarrow)$$

- The quark magnetic moments are given as $\mu_d^* = -\left(1 - \frac{\Delta M}{M_B^*}\right)$ and $\mu_u^* = -2\mu_d^*$ in the units of μ_N (nuclear magneton).
- $\Delta q\left(\frac{3}{2}^+ \rightarrow \frac{1}{2}^+\right)_V$ & $\Delta q\left(\frac{3}{2}^+ \rightarrow \frac{1}{2}^+\right)_S$ represent valance and sea quark spin polarizations respectively.
- $\mu(q_+ \rightarrow)$ is the orbital moment for any chiral fluctuation, M_B^* is the effective mass of baryon and $\Delta M = M_B^* - M_{vac}$

- The spin structure of a decuplet to octet transition matrix element is defined as

$$\left\langle B_{\frac{1}{2}^+}, S_z = \frac{1}{2} \middle| N(B_{\frac{3}{2}^+} \to B_{\frac{1}{2}^+}) \middle| B_{\frac{3}{2}^+}, S_z = \frac{1}{2} \right\rangle$$

- The number operator measures the number of quarks with spin up ($\uparrow$) or down ($\downarrow$) in the transition ($\frac{3}{2}^+ \to \frac{1}{2}^+$)

$$N\left(B_{\frac{3}{2}^+} \to B_{\frac{1}{2}^+}\right) = \sum_{q=u,d,s} \left(N_{q\uparrow\left(B_{\frac{3}{2}^+} \to B_{\frac{1}{2}^+}\right)} + N_{q\downarrow\left(B_{\frac{3}{2}^+} \to B_{\frac{1}{2}^+}\right)} \right)$$

- The magnetic moment contribution of the angular momentum of a given sea quark

$$\langle L_q \rangle = \frac{M_{GB}}{M_q + M_{GB}} \quad \text{and} \quad \langle L_{GB} \rangle = \frac{M_q}{M_q + M_{GB}}.$$

- The general orbital moment for any quark (q) is given as

$$\mu(q^{\uparrow} \rightarrow q'^{\downarrow}) = \frac{e_{q'}}{2M_q} \langle L_q \rangle + \frac{e_q - e_{q'}}{2M_{GB}} \langle L_{GB} \rangle \,.$$

- The magnetic moment arising from all the possible transitions of a given valence quark to the GBs is obtained by multiplying the orbital moment of each process to the probability for such a process to take place.

- The orbital moments of u, d, s and c quarks after including the transition probabilities P_π, P_K, P_η, $P_{\eta'}$ and P_D as well as the masses of GBs M_π, M_K, M_η, $M_{\eta'}$, M_D, M_{D_s}, and M_{η_c}can be expressed as (in the units of μ_N)

$$[\mu^*(u_\uparrow \rightarrow)] = a\left[\frac{3m_u^{*2}}{2M_\pi(m_u^*+M_\pi)} - \frac{P_\pi^2(M_K^2-3m_u^{*2})}{2M_K(m_u^*+M_K)} + \frac{P_\eta^2 M_\eta}{6(m_u^*+M_\eta)} + \frac{P_{\eta'}^2 M_{\eta'}}{48(m_u^*+M_{\eta'})} + \frac{P_D^2 M_{\eta_c}}{16(m_u^*+M_{\eta_c})} + \frac{P_D^2 M_D}{m_u^*+M_D}\right]\mu_N,$$

$$[\mu^*(d_\uparrow \rightarrow)] = a\frac{m_u^*}{m_d^*}\left[\frac{3(M_\pi^2-2m_d^{*2})}{4M_\pi(m_d^{*2}+M_\pi)} - \frac{P_\pi^2 M_K}{2(m_d^*+M_K)} + \frac{P_D^2(2M_D^2-3m_d^*)}{2M_D(m_d^*+M_D)} - \frac{P_\eta^2 M_\eta}{12(m_d^*+M_\eta)} - \frac{P_{\eta'}^2 M_{\eta'}}{96(m_d^*+M_{\eta'})} + \frac{P_D^2 M_{\eta_c}}{32(m_d^*+M_D)}\right]\mu_N,$$

$$[\mu^*(s_\uparrow \to)] = a\frac{m_u^*}{m_s^*}\left[\frac{P_\pi^2\left(M_K^2 - 3m_s^{*2}\right)}{2M_K\left(m_s^* + M_K\right)} - \frac{P_\eta^2 M_\eta}{3\left(m_s^* + M_\eta\right)} + \frac{P_D^2\left(2M_{D_s}^2 - 3m_s^{*2}\right)}{2M_D\left(m_s^* + M_{D_s}^2\right)} - \frac{P_{\eta'}^2 M_{\eta'}}{96\left(m_s^* + M_{\eta'}\right)} - \frac{P_D^2 M_{\eta_c}}{32\left(m_s^* + M_D\right)}\right]\mu_N,$$

$$[\mu^*(c_\uparrow \to)] = a\frac{m_u^*}{m_c}\left[\frac{P_D^2\left(M_D^2 + 3m_c^2\right)}{2M_D\left(m_c + M_D^2\right)} - \frac{P_D^2\left(M_{D_s}^2 + 3m_c^2\right)}{2M_d\left(m_c + M_{D_s}^2\right)} + \frac{P_{\eta'}^2 M_{\eta'}}{16\left(m_c + M_{\eta'}\right)} + \frac{9P_D^2 M_{\eta_c}}{16(m_c + M_{\eta_c})}\right]\mu_N$$

Valence and sea transition magnetic moments for $\Delta \to p$ transitions

- Valance contribution is given as

$$\mu(\Delta \to p)_V = \frac{2\sqrt{2}}{3}\mu_u^* - \frac{2\sqrt{2}}{3}\mu_d^*$$

- Sea contribution is given as

$$-\frac{2\sqrt{2}}{3}a\left[1 + P_\pi^2 + \frac{P_\eta^2}{3} + \frac{P_{\eta'}^2}{24} + \frac{17P_D^2}{16}\right]\mu_u^*$$

$$+\frac{2\sqrt{2}}{3}a\left[1 + P_\pi^2 + \frac{P_\eta^2}{3} + \frac{P_{\eta'}^2}{24} + \frac{17P_D^2}{16}\right]\mu_d^*$$

- The orbital contribution to the magnetic moment of the decuplet to octet transition $\mu\left(B^+_{\frac{3}{2}} \rightarrow B^+_{\frac{1}{2}}\right)$ for the baryon of the type $B(Q_1 Q_2 Q_3)$ is

$$\begin{aligned} B(Q_1 Q_2 Q_3) =& \Delta Q_1 \left(\frac{3^+}{2} \rightarrow \frac{1^+}{2}\right)_V \mu(Q_1^{\uparrow} \rightarrow) \\ &+ \Delta Q_2 \left(\frac{3^+}{2} \rightarrow \frac{1^+}{2}\right)_V \mu(Q_2^{\uparrow} \rightarrow) \\ &+ \Delta Q_3 \left(\frac{3^+}{2} \rightarrow \frac{1^+}{2}\right)_V \mu(Q_3^{\uparrow} \rightarrow). \end{aligned}$$

Orbital Contribution is given as

$$\frac{2\sqrt{2}}{3}\left[\mu_u^*(u\uparrow \rightarrow) - \mu_d^*(d\uparrow \rightarrow)\right]$$

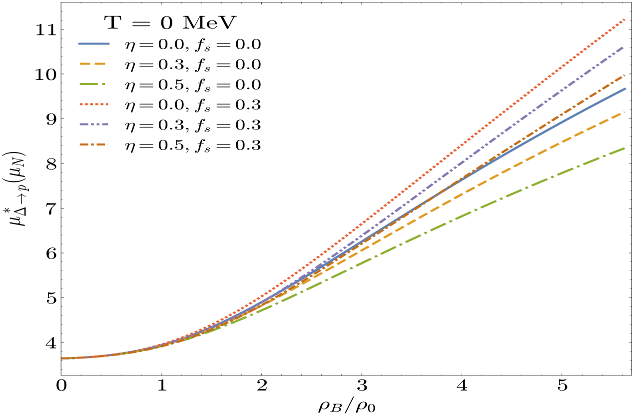
- Input parameters: transition probabilities $P_\pi, \quad P_K, \quad P_\eta, \quad P_{\eta'}, \quad P_D$ and masses of GBs $M_\pi, M_K, \quad M_\eta, M_{\eta'}, M_{\eta_c}$.
- Hierarchy followed by the probabilities of fluctuations of a constituent quark into pions, $K, \quad \eta, \quad \eta'$ and D mesons.

$$P_D < P_{\eta'} < P_\eta < P_K < P_\pi$$

- The transition probabilities are fixed by the experimentally known spin and flavor distribution functions measured from the DIS experiments. A detailed analysis leads to the following probabilities:

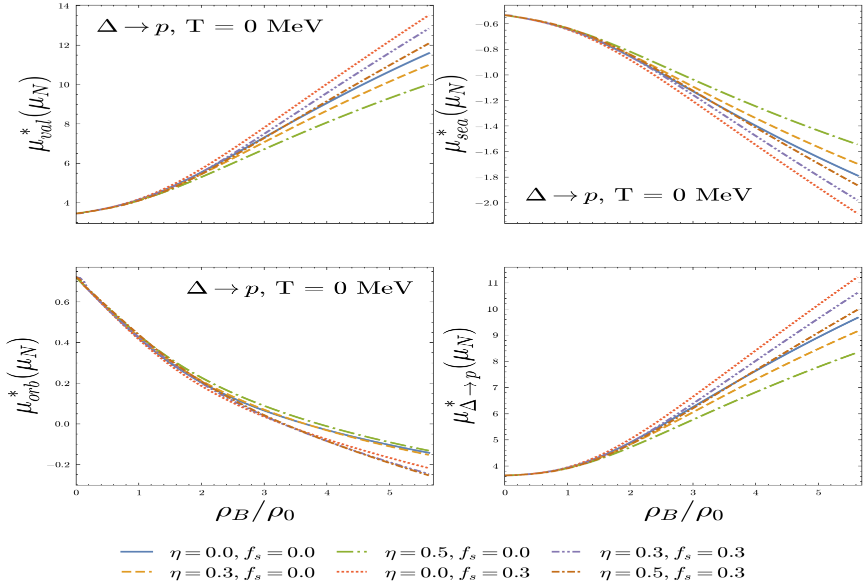
$$P_D = 0.01, P_{\eta'} = 0.03, \quad P_\eta = 0.04, \quad P_K = 0.06, \quad P_\pi = 0.12$$

- The on mass shell mass values can be used for the orbital angular momentum contributions characterized by the masses of quarks and GBs (M_q and M_{GB}).

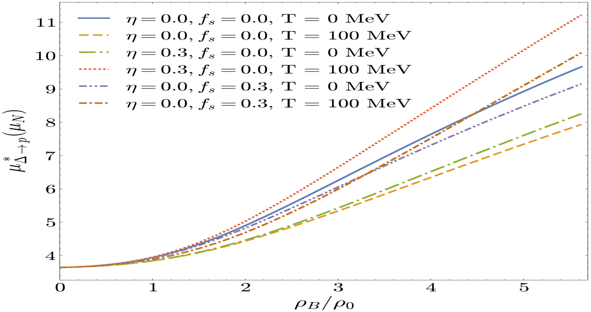


- Value of μ^* increases with the increase in ρ_B at η and f_s.
- The increase in f_s shows a increase in μ^* at same values of ρ_B and η.
- The increase in η shows a decrease in μ^* at same values of ρ_B and f_s.

Valance, Sea and Orbital Magnetic moments



Magnetic moments in for $\Delta \to p$ transitions at High Temperature



- For symmetric nuclear matter ($\eta = 0, f_s = 0$), μ^* decreases with increase in temperature.
- For isospin asymmetric nuclear matter ($\eta \neq 0$), large increase is observed with increase in temperature for all values of ρ_B.
- For symmetric strange matter, μ^* increases with increase in temperature

Summary

- Variation of Effective masses of quarks and hadrons with density studied for symmetric and asymmetric nuclear matter along-with in the asymmetric strange matter.
- Masses are found to decrease with density with sharp rate of decrease at lower density values.
- The increase in strangeness fraction decreases the mass while enhancement in the isospin asymmetry increases the mass at fixed density.
- The transition magnetic moment for $\Delta \to p$ transition also studied under the same conditions.
- The effective transition magnetic moments increase with the increase in density. At the fixed density, with η magnetic moments decrease while with f_s an increase is observed.
- The temperature also has a significant impact on the magnetic moment.

Thank You!