Towards a universal description of hadronic phase of QCD

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Outline

Motivation

- Finite temperature and finite density QCD explored using effective models such as PNJL, PQM, HRG, etc.
- Study in a purely hadronic model keeping confinement in mind.
- Nuclear mean field models well constrained from data.
- Learn what nuclear mean field models can tell us about finite temperature QCD.
- Universal hadronic interactions within the confined phase of QCD.

Nuclear Model

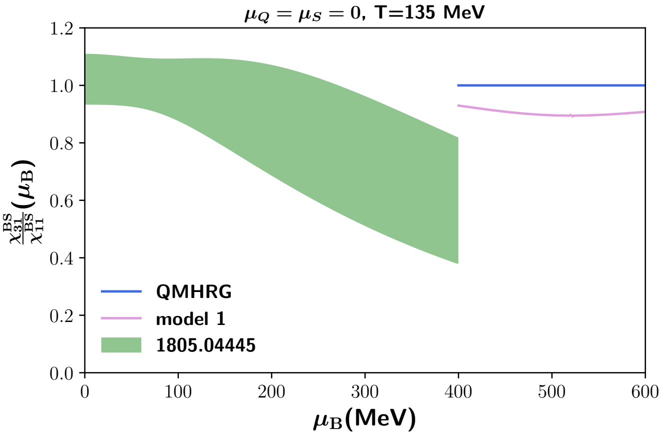
- Nuclear Models work well at high densities.
- Constrained from experiments such as neutron skin depth, maximum mass of neutron star, nuclear saturation properties, tidal deformability, etc.
- Consist of nucleons, hyperons interacting through sigma, omega, strange meson fields, etc.
- Have attractive and repulsive interactions built in.

Phys. Rev. C. 99, 052802, R. Nandi, P. Char, S. Pal

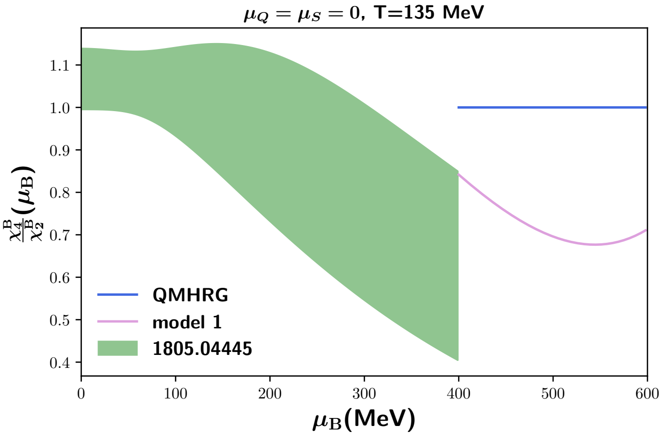
- Considered about 269 models.
- Three models were found to be best fit.
  - Greco-Liu : Doesn't have strange degrees of freedom.
  - NLρ : Couplings are density dependent.
  - Bunta-Gmuca : Contains strange degrees of freedom.

RESULTS

$\chi_{31}^{BS}/\chi_{11}^{BS}$ in Bunta-Gmuca model



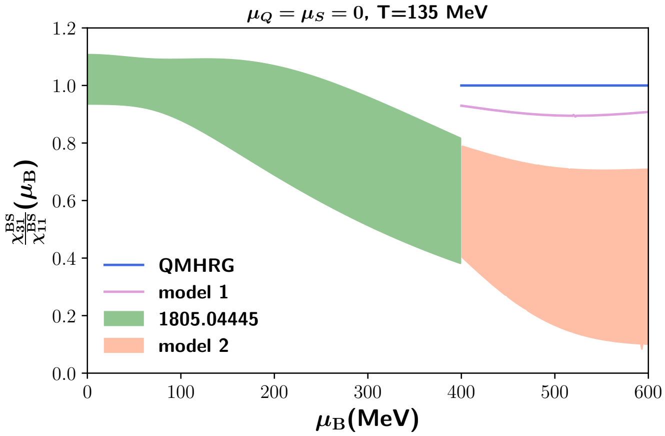
χ_4^B/χ_2^B in Bunta-Gmuca model



Extension to finite temperature

- Nuclear mean field models have too few degrees of freedom.
- Hadronic spectrum is known to be much larger.
- Couplings of heavier hadrons unknown, hence we introduce couplings
  - $g_{Non-strange} = \alpha_{NS}\ g_P$
  - $g_{strange} = \alpha_S\ g_\Lambda$.

$\chi_{31}^{BS}/\chi_{11}^{BS}$ in extended model

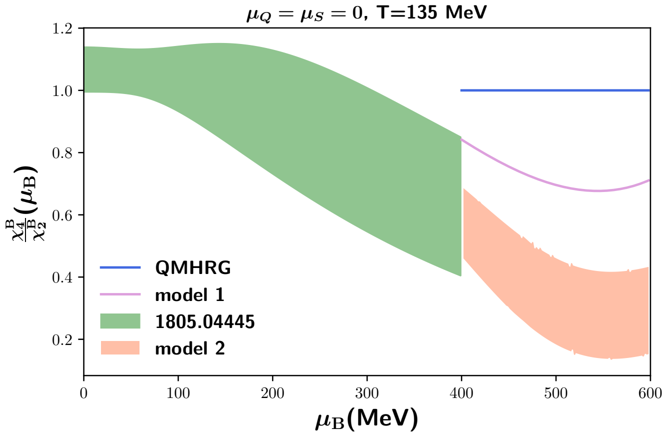


Fitting $\chi_{31}^{BS}/\chi_{11}^{BS}$

- To match upper boundary of lattice band in $\chi_{31}^{BS}/\chi_{11}^{BS}$
  - $\alpha_{NS} = 0.15$, $\alpha_S = 0.15$.

- To match lower boundary of lattice band in $\chi_{31}^{BS}/\chi_{11}^{BS}$
  - $\alpha_{NS} = 0.2$, $\alpha_S = 0.7$.

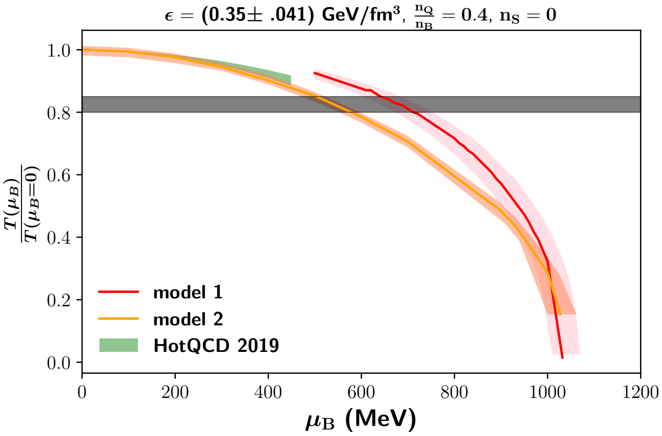
χ_4^B/χ_2^B in extended model



Few observations regarding couplings

- $\chi_{31}^{BS}/\chi_{11}^{BS}$ was found to be more sensitive to α_S.
- χ_4^B/χ_2^B was found to be more sensitive to α.
- Minimum value of α_{NS}=0.15 is needed to cover the lattice band.
- Value of $\alpha_{NS} > 0.2$ tends to overestimate lattice band in χ_4^B/χ_2^B.

Constraining the location of critical end point



Conclusions

- Extension of nuclear model and comparison with lattice gives better estimates of susceptibility.
- $\sigma - \omega$ interaction may be important.
- More precise lattice data in future can constrain nuclear models.

Future Directions

- A universal hadronic model can be constrained by both lattice QCD and high density data.
- If such a model is found it may also give reasonable estimate of CEP and first order line.
- Beyond mean field calculations are important.


Thank You!