A new RMF based quark-nuclear matter EoS for applications in astrophysics and heavy-ion collisions

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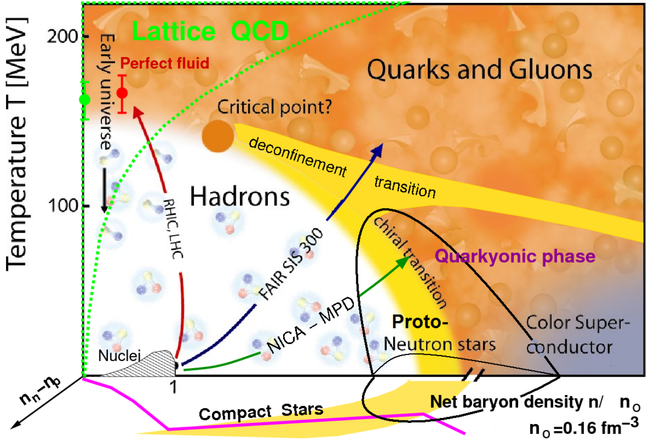
Comparition to current EOS[1] [2]



[1] A.S. Khvorostukhin, V.V. Skokov, V.D. Toneev, K. Redlich, Eur.Phys.J.C**48**:531-543,2006

[2] Y. B. Ivanov, V. N. Russkikh and V. D. Toneev, Phys. Rev. C **73** (2006) 044904

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- orientation on astrophysical constraints (e.g. two solar mass neutron stars)
- improvements in the low temperature / high density regime

density functional approach with tdyn consistency

- start with approach for grand canonical potential density

$$\omega = -U - \sum_i g_i \int \frac{\mathrm{d}^3 p}{(2\pi)^3} \left\{ T \ln[1 + \mathrm{e}^{(\tilde{E}_i^+ - \mu_i)/T}] + T \ln[1 + \mathrm{e}^{(\tilde{E}_i^- + \mu_i)}\right.$$

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- with the quasiparticle/antilparticle energy

$$\tilde{E}_i^{\pm} = \sqrt{p^2 + (m_i - S_i)^2} \pm V_i$$

one can introduce an effective mass $M_i = m - S$ and an effective chemical potential $\tilde{\mu}_i = \mu_i - V_i$ with self-energies

$$S_i = \Delta m_i + m_i^{\mathrm{R}} \qquad V_i = \Delta E_i + E_i^{\mathrm{R}}$$

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- rearrangement contributions $U, m_i^{\mathrm{R}}, E_i^{\mathrm{R}}$ ensure consistency

density functional approach with tdyn consistency

derivation of rearrangement

- to preserve thermodynamical consistency the definition of the particle density

$$n_i = \frac{\partial p}{\partial \mu_i} = g_i \int \frac{\mathrm{d}^3 p}{(2\pi)^3} \frac{1}{1 + \mathrm{e}^{(\sqrt{p^2 - M_i} - \tilde{\mu}_i)/T}}$$

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- this leads us to the differential equation

$$\frac{\partial U}{\partial \mu_i} = \sum_j \left\{ n_j \frac{\partial \Delta E_j}{\partial \mu_i} + n_j \frac{\partial E_j^{\mathrm{R}}}{\partial \mu_i} - n_j^{\mathrm{s}} \frac{\partial \Delta m_j}{\partial \mu_i} - n_j^{\mathrm{s}} \frac{\partial m_j^{\mathrm{R}}}{\partial \mu_i} \right\}$$

density functional approach with tdyn consistency

derivation of rearrangement

- one solution,provided by Stefan Typel (but slightly altered), is

$$E_i^{\mathrm{R}} = \sum_j n_j \frac{\partial \Delta E_j}{\partial n_i} - \sum_j n_j^{\mathrm{s}} \frac{\partial \Delta m_j}{\partial n_i}$$

$$m_i^{\mathrm{R}} = -\sum_j n_j \frac{\partial \Delta E_j}{\partial n_i^{\mathrm{s}}} + \sum_j n_j^{\mathrm{s}} \frac{\partial \Delta m_j}{\partial n_i^{\mathrm{s}}}$$

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- now we are coming to an concrete example

Stringflip modell

- confinement potential with effects of pauli quenching[3,4]

$$\Delta m_i = -C^{\mathrm{q}} \cdot (n^{\mathrm{s}})^{1/3} - D^{\mathrm{q}} \cdot (n^{\mathrm{s}})^{-1/3} \quad \Delta E_i = a^{\mathrm{q}} n + b^{\mathrm{q}} n^3$$

with the density dependent $D^{\mathrm{q}} = D^{\mathrm{q}}(n^{\mathrm{s}})$.

[3] G. Ropke, D. Blaschke and H. Schulz, Phys. Rev. D **34** (1986) 3499.

[4] Yukalov, Yukalova, Physica A 243 (1997) 382-414

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- The rearrangement contributions

$$E_i^{\mathrm{R}} = \left(a^{\mathrm{q}} + 3b^{\mathrm{q}} n^2\right) n = E^{\mathrm{R}}$$

$$m_i^{\mathrm{R}} = \left(-\frac{C^{\mathrm{q}}}{3}(n^{\mathrm{s}})^{-2/3} + \frac{D^{\mathrm{q}}}{3}(n^{\mathrm{s}})^{-4/3} - D^{\mathrm{q}\prime} \cdot (n^{\mathrm{s}})^{-1/3}\right) n^{\mathrm{s}} = m^{\mathrm{R}}$$

$$U = nE^{\mathrm{R}} - n^{\mathrm{s}} m^{\mathrm{R}}$$

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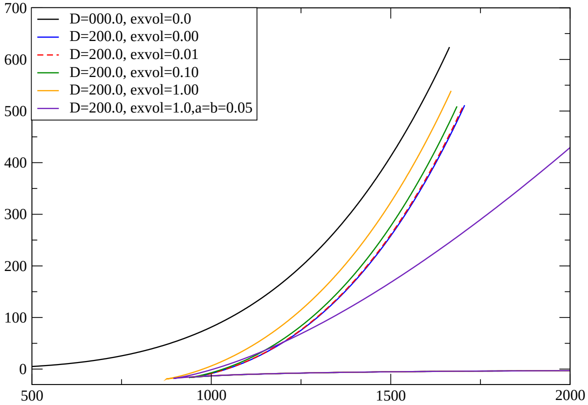
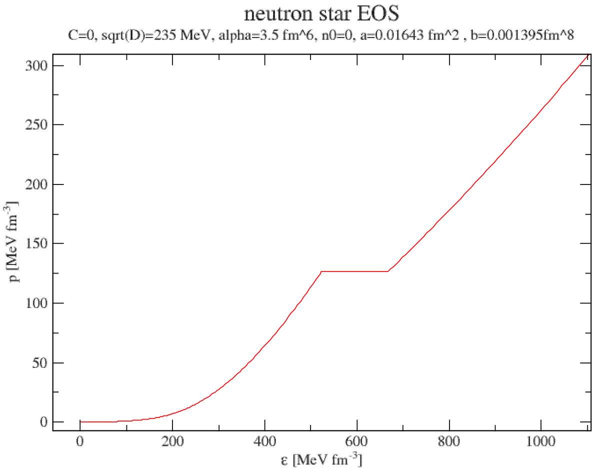
resulting eos

pressure over baryon chemical potential

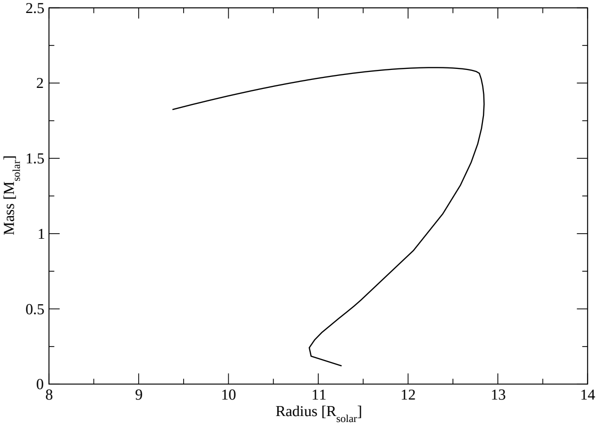


resulting eos
neutron star eos



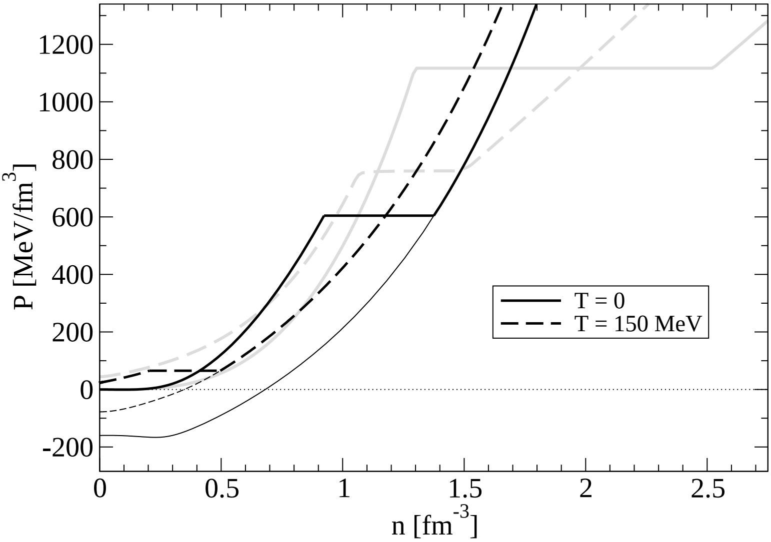
resulting eos

neutron star configurations



resulting eos

symmetric matter



Outlook

what to do next?

- systematic calculation and analysis of the current eos'

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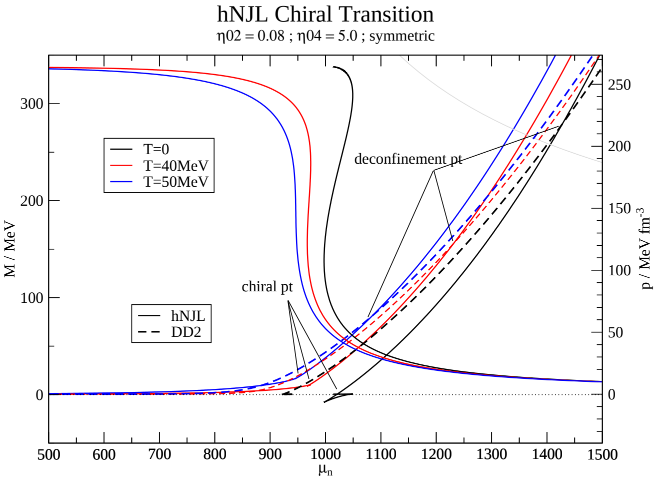
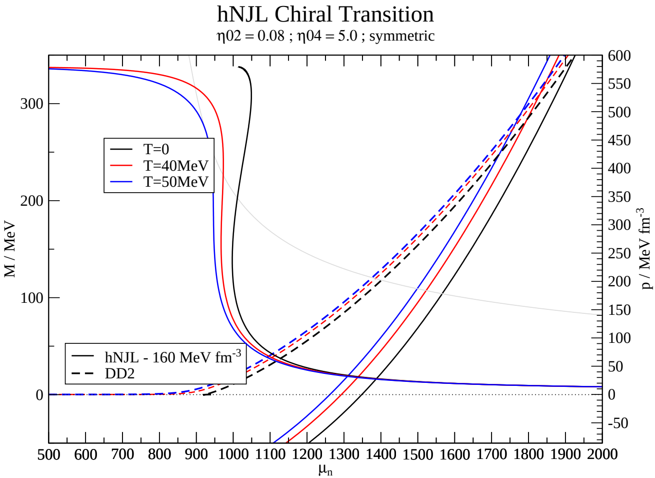
- thank you for your attention!

Phase transition
bare models

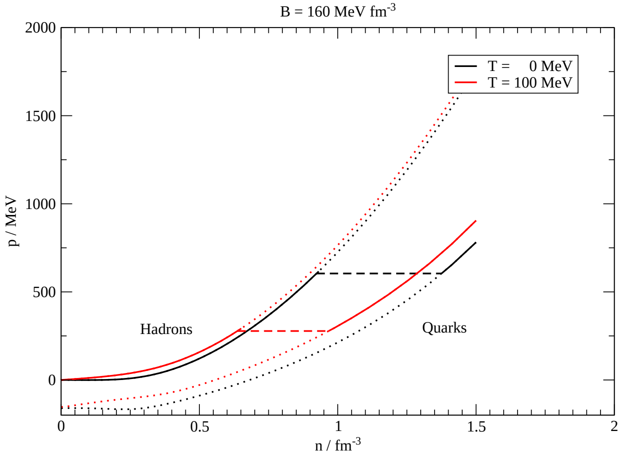


Phase transition

including bag constant



Phase transition
over density



Phase transition
phase diagram