Nuclear matter EOS with light clusters within mean-field approximation

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Compact Stars in the QCD Phase Diagram III

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Objective

How do we

1. construct an EOS that contains light clusters?
2. parametrize them?

1. We use the relativistic mean-field model:
$$\mathcal{L} = \mathcal{L}_{NLWM} + \mathcal{L}_t + \mathcal{L}_h + \mathcal{L}_d + \mathcal{L}_\alpha$$

Fermions (t, h): $\mathcal{L}_j = \bar{\psi}_j \left[\gamma_\mu i D_j^\mu - M_j^*\right] \psi_j$

with $iD_j^\mu = i\partial^\mu - g_v^j \omega^\mu - \frac{g_\rho^j}{2} \boldsymbol{\tau} \cdot \mathbf{b}^\mu$ and $M_j^* = M_j - g_s^j \sigma, \quad j = t, h$

$$\text{Spin 0 boson: } \mathcal{L}_\alpha = \frac{1}{2}(iD_\alpha^\mu \phi_\alpha)^*(iD_{\mu\alpha}\phi_\alpha) - \frac{1}{2}\phi_\alpha^* \left(M_\alpha^*\right)^2 \phi_\alpha,$$

$$\text{Spin 1 boson: } \mathcal{L}_d = \frac{1}{4}(iD_d^\mu \phi_d^\nu - iD_d^\nu \phi_d^\mu)^*(iD_{d\mu}\phi_{d\nu} - iD_{d\nu}\phi_{d\mu}) - \frac{1}{2}\phi_d^{\mu *} \left(M_d^*\right)^2 \phi_{d\mu}$$

Conclusions

- To constrain the meson-cluster i coupling constants (g_σ^i, g_ω^i and g_ρ^i) we use
  - ✓ The dissolution density at $T = 0$
  - ✓ The medium binding energy at finite T

- The dissolution density is mainly determined by the isoscalar part of the EOS
- The $B_i(\rho)$ does not depend much on T
  - ✓ To obtain a realistic description of light clusters within a RMF approach
    - A temperature dependence must be introduced in the cluster coupling constants: $g_v^i(T)$ and $g_s^i(T)$