Yang-Mills deconfinement transition from 1-loop potential

Tomas Mari Surkau and Urko Reinosa

Can we describe the YM-phase diagram with a perturbative approach?

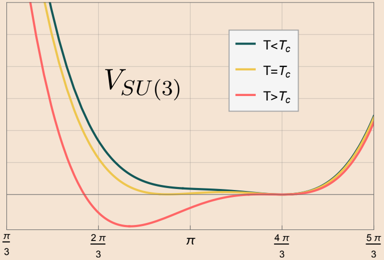
$$\mathcal{L} = \quad \frac{1}{4}F^a_{\mu\nu}F^a_{\mu\nu} \quad + \quad \bar{D}_\mu \bar{c}^a D_\mu c^a + ih^a \bar{D}_\mu (A^a_\mu - \bar{A}^a_\mu) \quad + \quad \frac{1}{2}m^2(A^a_\mu - \bar{A}^a_\mu)^2$$

Center-symmetry
→ Polyakov Loop ℓ

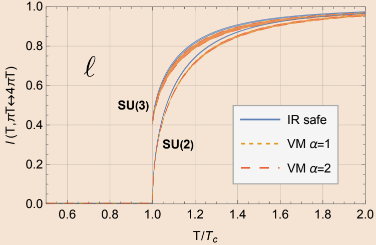
Background gauge $(\bar{A}^a_\mu)$
→ access SSB

Curci-Ferrari gauge (m^2)
→ regulate IR

Use quantum effective potential to determine the order parameter ℓ:



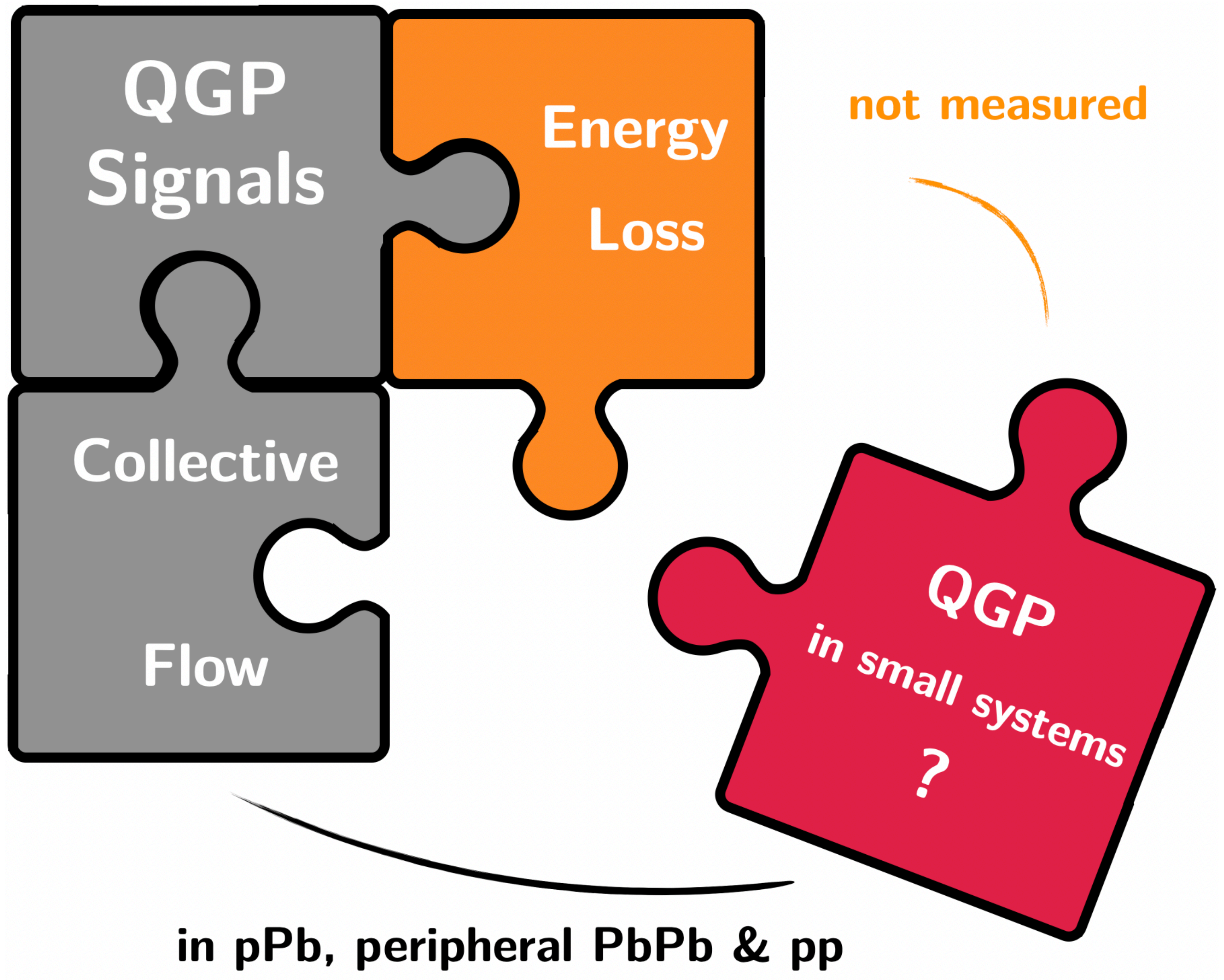
$\rightarrow T_c,\ \ell$



Finding Energy-Loss in Small Systems

Jannis Gebhard, Aleksas Mazeliauskas and Adam Takacs (in preparation)

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386



precise **no-quenching baseline**
+
study of systematic uncertainties

Inclusive (R_{AA}) and semi-inclusive (I_{AA}) nuclear modification factors in **oxygen-oxygen** collisions

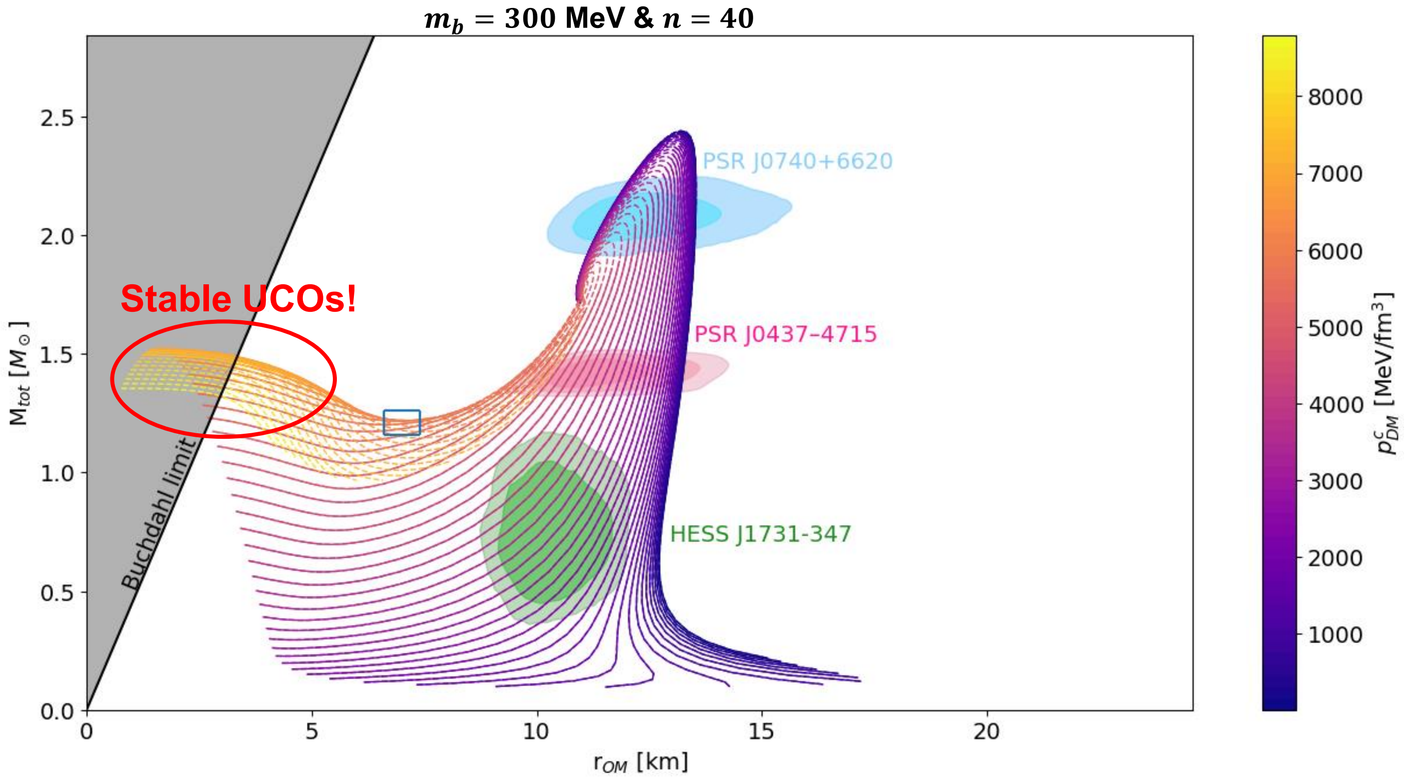
Major limitation: **Uncertainties** from **nuclear parton distribution functions**

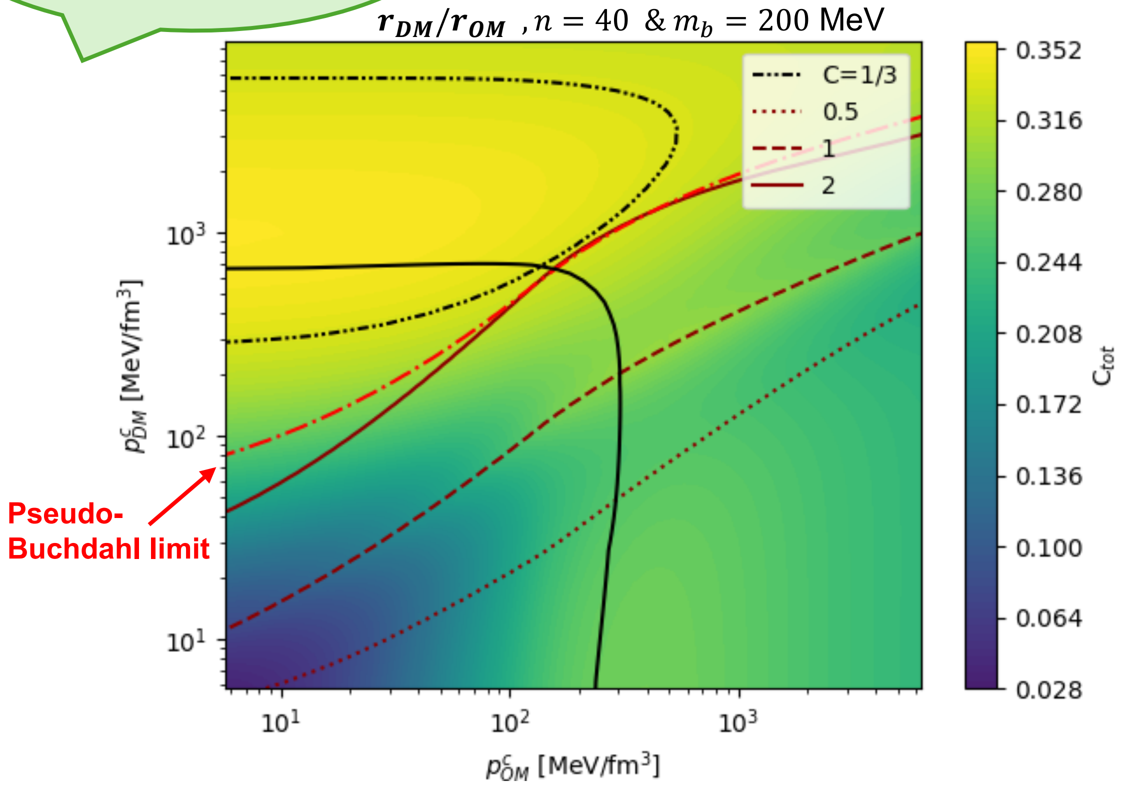
Ultra-compact neutron stars with dark matter – Sarah Pitz & Jürgen Schaffner-Bielich

Goethe Universität Frankfurt am Main Germany, pitz@itp.uni-frankfurt.de & schaffner@astro.uni-frankfurt.de

- Two-fluid NS with scalar, bosonic DM
- **Stiff self-interaction** potential: $V = \frac{\lambda}{2^{n/2}} (\phi^* \phi)^{n/2}$
- Stability analysis: radial density perturbations

HESS, XTE J1814-338, GW230529? OM or DM? Causality!





- Stable NS with $\boldsymbol{M_{tot} \leq 1.5\, M_\odot}$ $(m_b = 300$ MeV) or $\boldsymbol{M_{tot} \geq 3.4\, M_\odot}$ $(m_b = 200$ MeV) and $\boldsymbol{R_{OM} < 8}$ **km**!
- Compact enough to have a light-ring ⇒ black hole mimicker
- Model describes HESS J1731-347, XTE J1814-338 and GW230529

⇒ could be smoking gun signal for DM

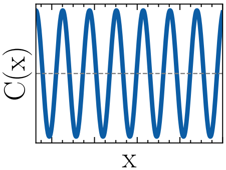
Check out my poster for the other plots

Exotic phases in finite density QCD?
The Quantum Pion Liquid using lattice field theory

- At intermediate μ and T: Explore phases with spatial modulated (mesonic) quantities

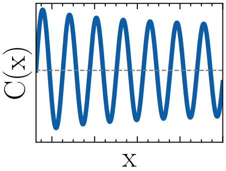
Inhomogeneous phase(IP)

- $\langle \phi_j \rangle \sim \langle \bar{\psi} \Gamma_j \psi \rangle = f_{\text{os}}(\mathbf{x})$ with, e.g., $f_{\text{os}} \sim \cos(kx)$
- $\langle \phi(x)\phi(0) \rangle \sim C_{\text{osc}}(x)$
- Translational SSB!



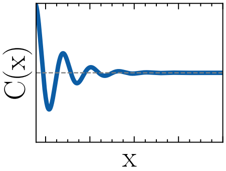
Liquid crystal

- $\langle \phi_j \rangle \sim \langle \bar{\psi} \Gamma_j \psi \rangle = \text{const.}$
- Disordering through phonon fluctuations
- $\langle \phi(x)\phi(0) \rangle \sim C_{\text{osc}}(x)|x|^{-\beta}$



Quantum π liquid(QπL)

- $\langle \phi_j \rangle \sim \langle \bar{\psi} \Gamma_j \psi \rangle = \text{const.}$
- Disordering through Goldstones of chiral SSB
- $C(x) \sim \mathrm{e}^{-mx} C_{\text{osc}}(x)$



- (Model) evidence for QπL instead of, e.g., IP from two different approaches

Electric field effects on hot and dense media

Osvaldo Ferreira* and Eduardo Souza Fraga

$$\xi = \frac{1}{2e^2} \lim_{k\to 0} \lim_{k_0 \to 0} \frac{\partial^2 \Pi_{00}^{T\neq 0}(k_0, k)}{\partial k^2}$$

$$\chi = \frac{1}{2e^2} \lim_{k\to 0} \lim_{k_0 \to 0} \frac{\partial^2 \Pi_{S}^{T\neq 0}(k_0, k)}{\partial k^2}$$

(Endrődi and Markó, JHEP, 2022)

↔

(OF and Eduardo S. Fraga, PRD, 2024)

The susceptibilities are associated to **power corrections** to the photon polarization tensor.

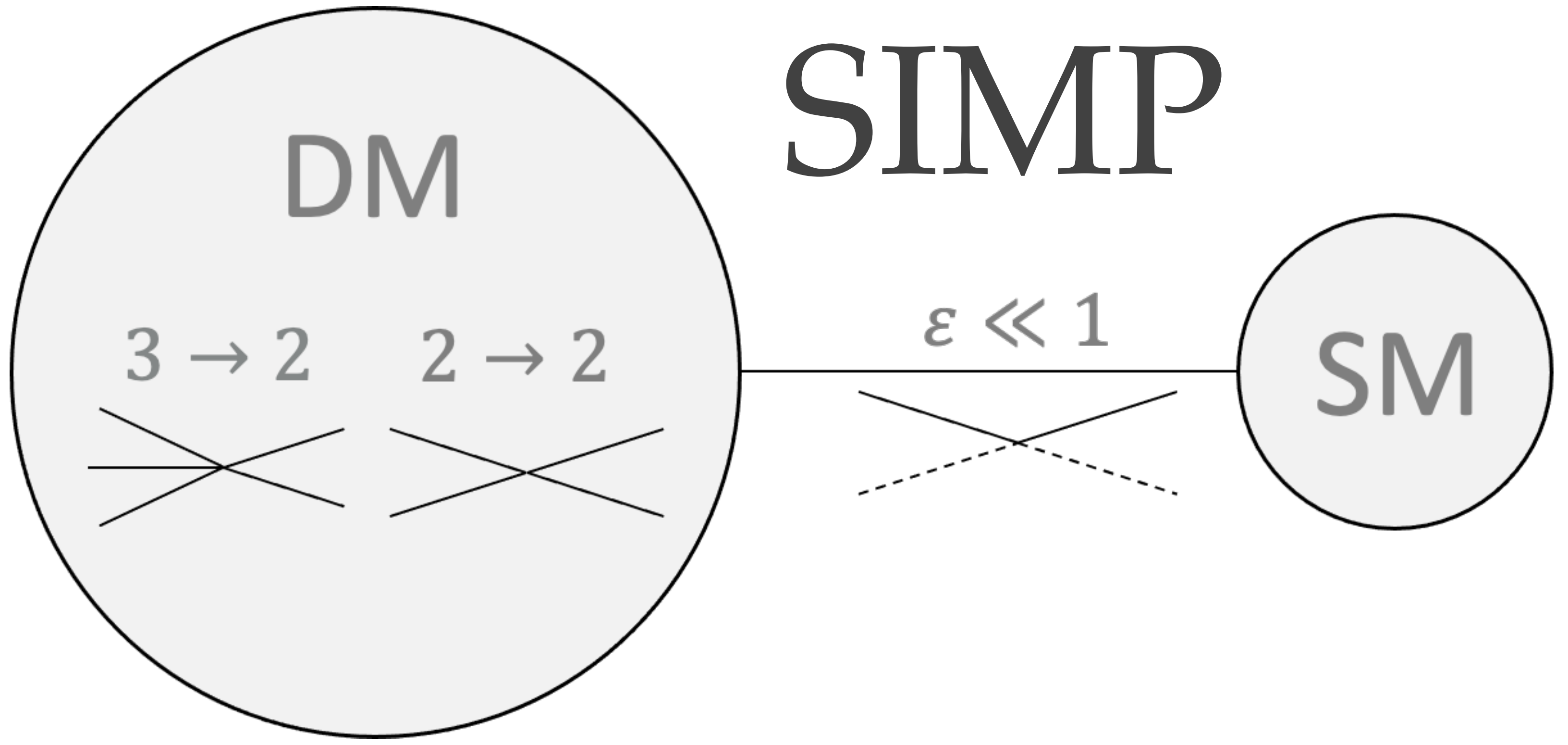
↓

HTL methods for finite temperature and density calculations.
(Gorda et al, PRD, 2023)
(Carignano et al,Phys.Lett.B, 2018),
(Manuel et al, PRD, 2016)
and references therein.

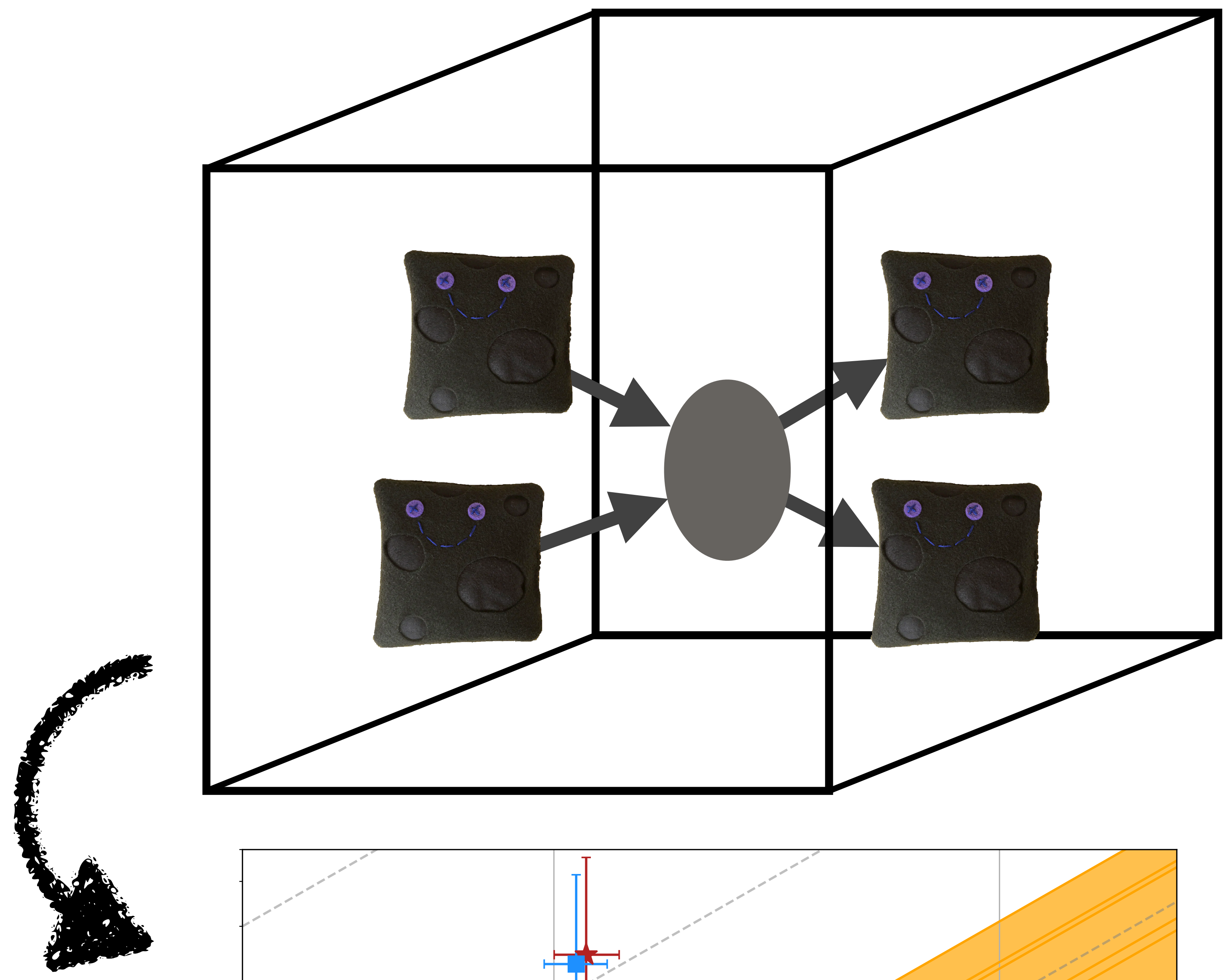
Dark Matter Scattering on the lattice

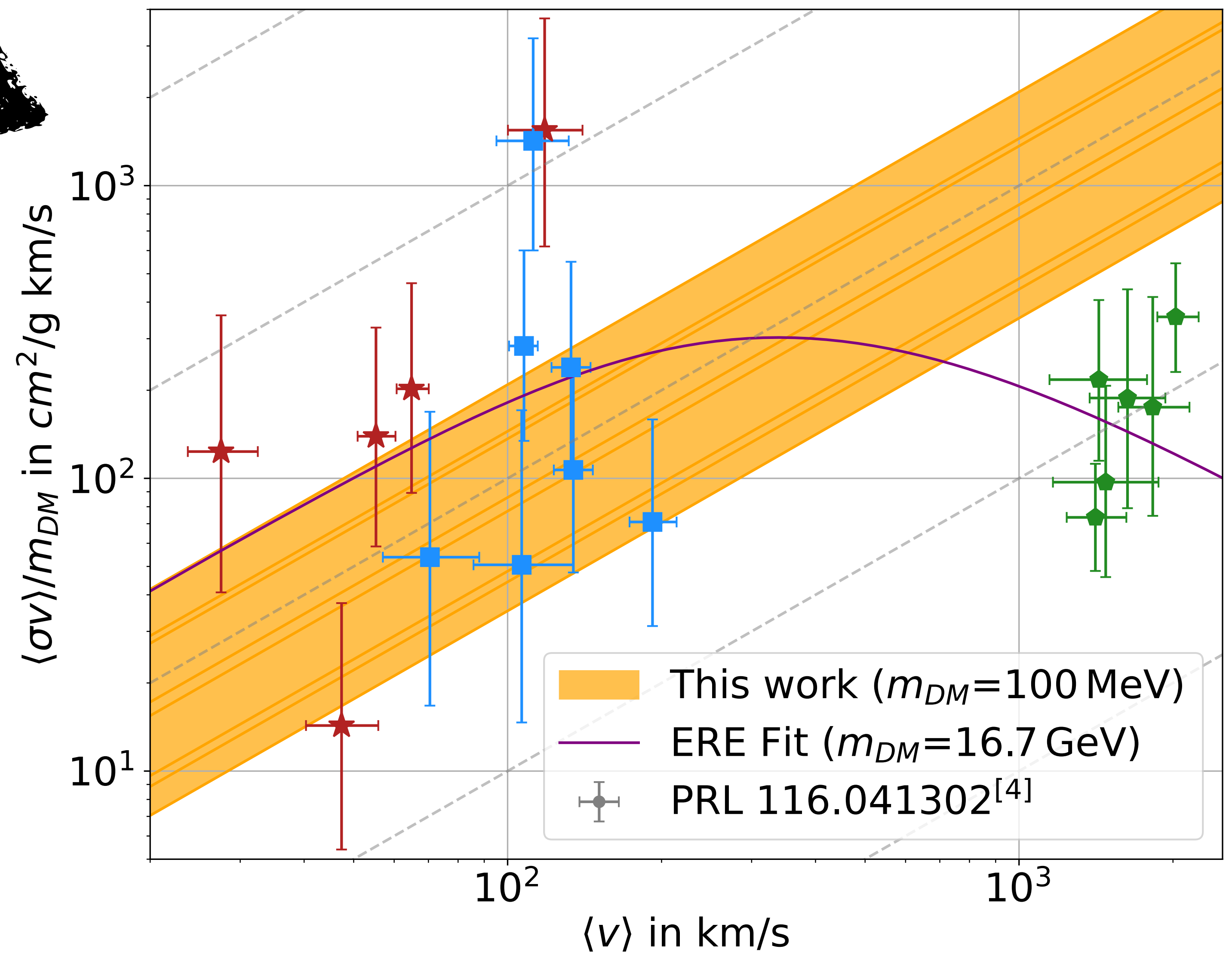
Yannick Dengler, Axel Maas & Fabian Zierler

SIMP



- Freeze-out
- Self-interaction
- Detectability





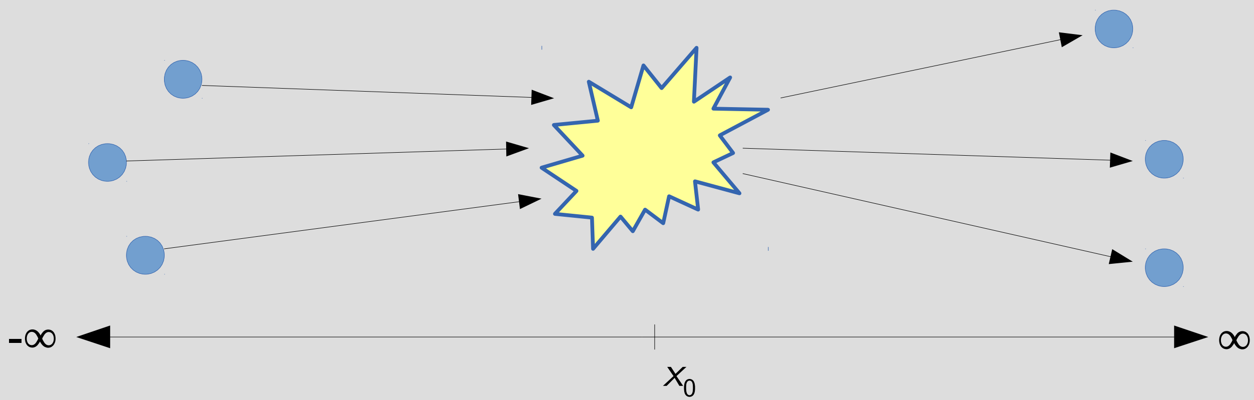
- Sp(4) is a minimal realisation
  - Rich Hadron Sector
  - Dark matter candidates are the Pions
- Lattice results can be directly compared to astro-data

Non-perturbative constraints on perturbation theory at finite temperature

(Based on: P. Lowdon*, O. Philipsen, *JHEP* 08, 167 (2024) [2405.02009])

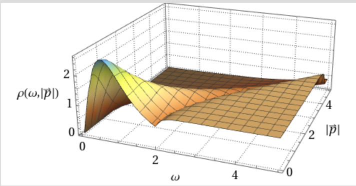
Problem: Perturbation theory is known to break down when $T > 0$

Why? Non-trivial physics cannot occur when $T > 0$ if the scattering states have purely real dispersion relations $\omega = E(\boldsymbol{p})$: dissipative effects of the thermal medium are ***everywhere***, need to take these into account in the definition of these states!



→ This is a consequence of a non-perturbative QFT constraint: the *Narnhofer-Requardt-Thirring Theorem* [Commun. *Math. Phys.* 92, 247 (1983)]

Solution: perform $T > 0$ perturbation theory with propagators that have non-real dispersion relations from the outset! → **"Thermoparticles"**



Adjoint correlator(s) of Chromoelectric fields at NLO in Finite T

1. Motivation: Evolution of heavy quarkonium in QGP

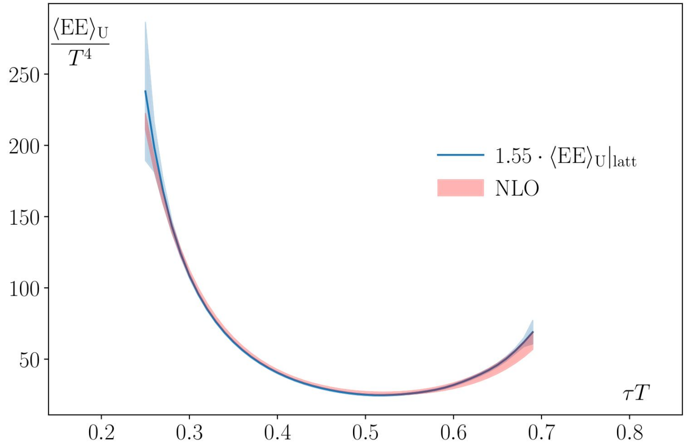
OQS + pNRQCD

2. Evolution quantified by two transport coefficients: **κ** and γ

$$\kappa = \frac{g^2}{6N_c}\mathrm{Re}\int_{-\infty}^{\infty} dt \langle \mathcal{T} E_i^a(t) U^{ab}(t,0) E_i^b(0)\rangle \qquad \gamma = \frac{g^2}{6N_c}\mathrm{Im}\int_{-\infty}^{\infty} dt \langle \mathcal{T} E_i^a(t) U^{ab}(t,0) E_i^b(0)\rangle$$

3. **κ** and γ depend on Chromoelectric correlators:

$$\langle EE\rangle_U \equiv \langle E_a^i(0) W^{ab}(0,\tau) E_b^i(\tau)\rangle$$



Determining proto-neutron stars‘ minimal mass with a chirally constrained nuclear equation of state

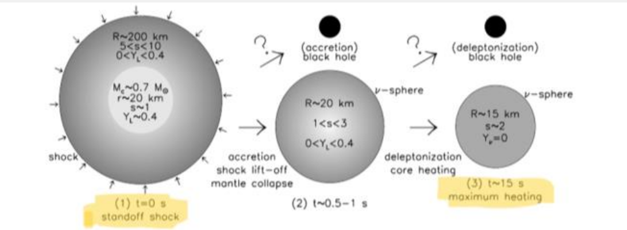
Selina Kunkel, Stephan Wystub and Jürgen Schaffner-Bielich

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

CRC-TR 211 Strong-interaction matter under extreme conditions

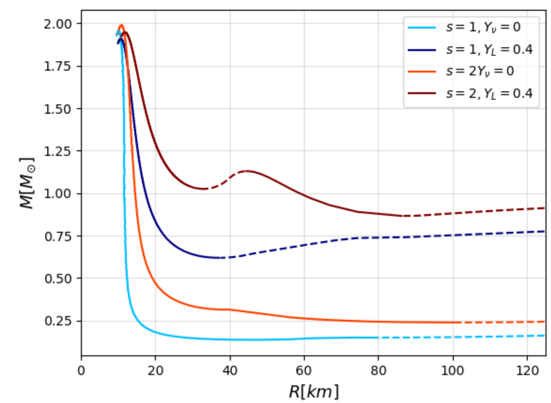
Proto-neutron star:

- Hot!
- Constant entropy per baryon
- Constant lepton fraction



Variation of constant S/N and Y_L leads to different mass configurations for different evolution stages!

Mass-Radius Curve:

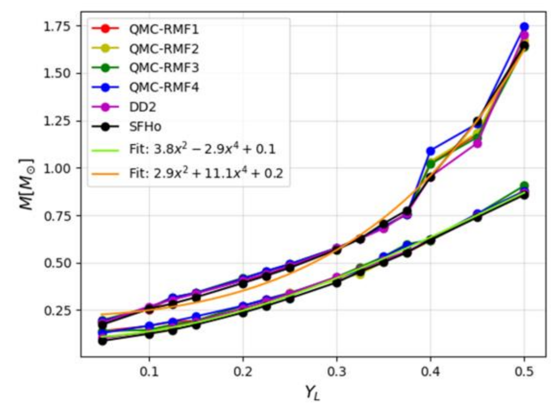


Chiral EFT:

- Effective Field Theory that includes chiral symmetry in terms of an expansion parameter Q/Λχ
- Relevant degrees of freedom are nucleons
  → Good for describing neutron matter!
- Limits of application: 0.5n_0 - (1n_0- 2n_0)
- Uncertainty estimates give constraints on equation of state

Similarities between equations of state which fulfill chiral EFT!

Minimal mass dependency on lepton fraction:

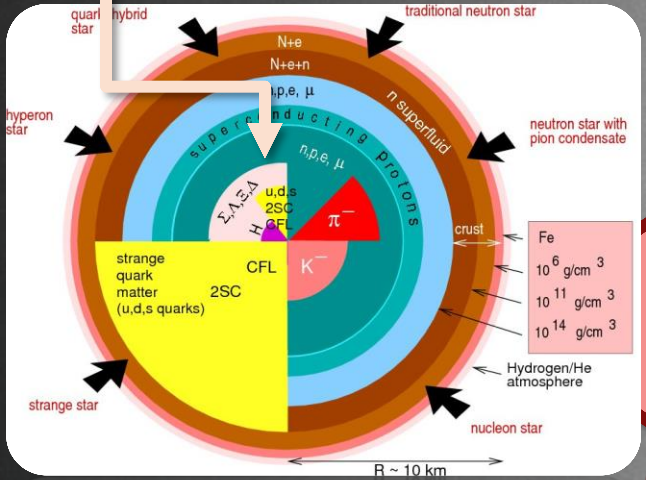


Constraining the deconfinement phase transition properties in hybrid stars with the fastest spinning millisecond pulsars

C.Gärtlein,
O.Ivanytskyi,
V.Sagun,
D. Blaschke,
I. Lopes

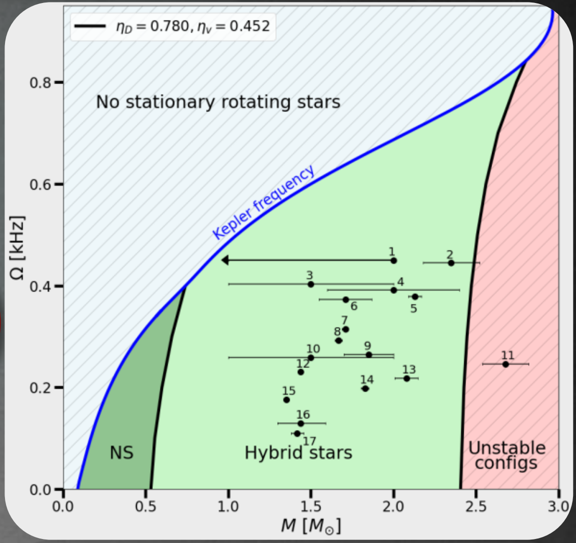
Hybrid neutron stars:

- First order phase transition
- Hadronic: DD2npY-T
- Quark matter:
  - RDF approach (Blaschke, Ivanytskyi)



Phase diagrams of rotating neutron stars

- predictions on composition of pulsars
- shows influence of rotation on M_{Max} and M_{onset}



Uniformly rotating hybrid stars

- **Tool: RNS code**
- rotations up to Kepler frequency

Kepler frequency

- universal relation

$$f_K = C\left(\frac{M}{M_\odot}\right)^{1/2}\left(\frac{R}{10\mathrm{km}}\right)^{-3/2}$$

- C dependent on quark matter phase