Primordial Black-Holes (PBH) Formation and Heavy r-Process Element Synthesis from the Cosmological QCD Transition*

David Blaschke (Univ. Wroclaw & HZDR/CASUS Görlitz)

NARODOWE CENTRUM NAUKI
2021/43/P/ST2/03319

1. PBH formation from overcritical overdensities

2. Fate of undercritical overdensities: baryon droplets/Q-balls

- **a) Witten Scenario**
- **b) Boeckel & Schaffner Bielich**
- **c) Zhitnitsky et al.**

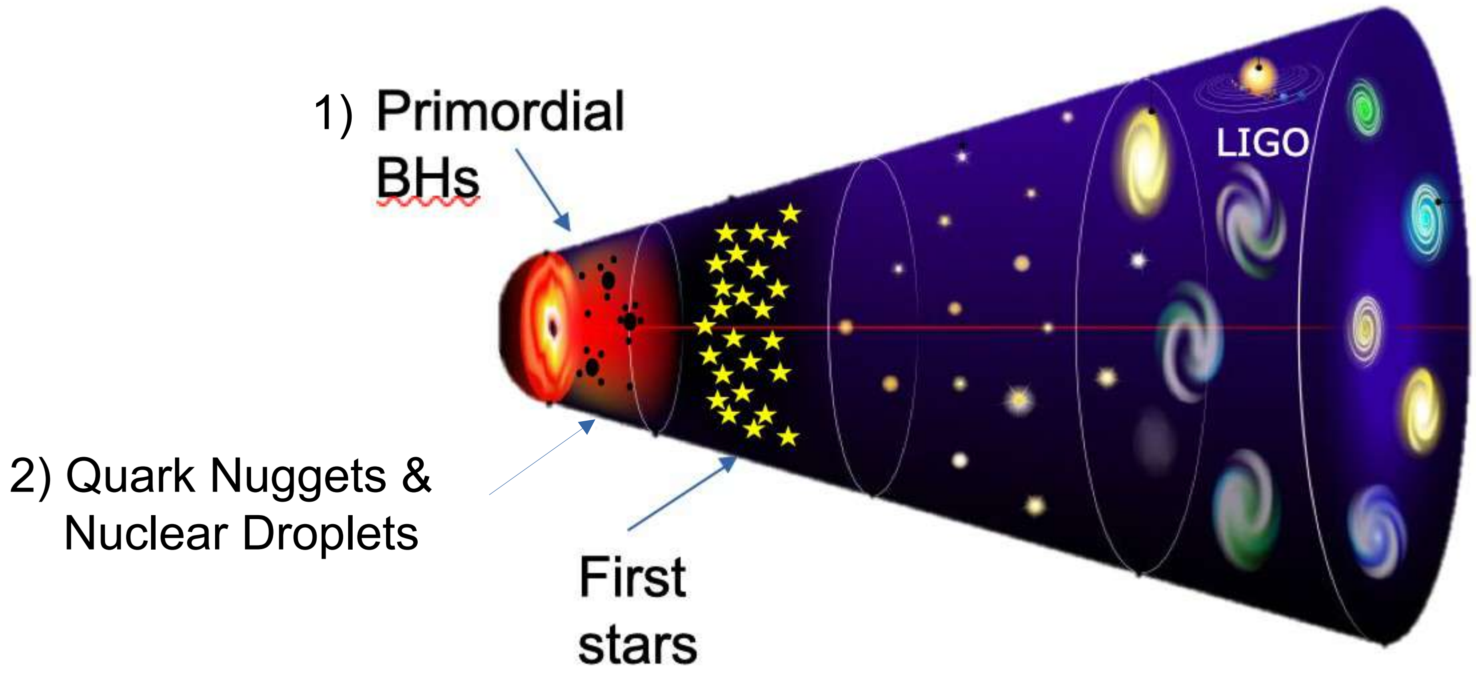
3. Freeze-out of heavy nuclear clusters from a thermal state

Uniwersytet Wrocławski
CASUS CENTER FOR ADVANCED SYSTEMS UNDERSTANDING
HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

* Gonin, Hasinger, D.B., Ivanytskyi and Röpke, EPJA 61 (2025) 170; arXiv:2505.05463

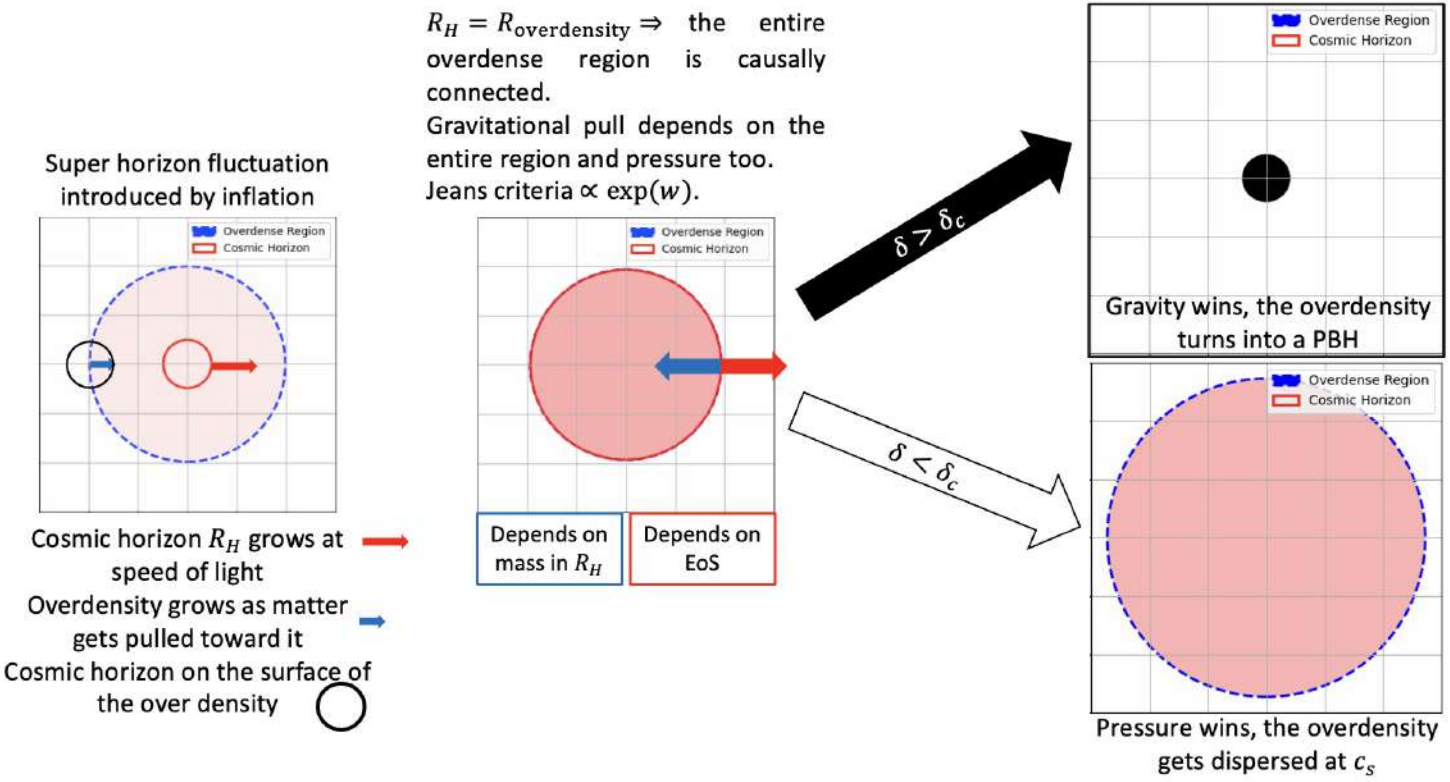
PBH Formation and CFO of heavy elements?

JWST results – primordial black holes !



QCD hadronization transition plays key role for PBH formation !

PBH Formation and Nuclear Droplets?



Two paths @ QCD hadronization: 1) PBH formation & 2) Nuclear droplets !

Cluster virial expansion for quark-hadron matter

The cluster decomposition of the thermodynamic potential is given as

$$\Omega_{\mathrm{total}}(T,\mu,\phi,\bar{\phi}) = \Omega_{PNJL}(T,\mu,\phi,\bar{\phi}) + \Omega_{\mathrm{pert}}(T,\mu,\phi,\bar{\phi}) + \Omega_{MHRG}(T,\mu,\phi,\bar{\phi}),$$

where the first two terms describe the quark and gluon degrees of freedom via the mean–field thermodynamic potential for quark matter in a gluon background field $\mathcal{U}$

$$\Omega_{PNJL}(T,\mu,\phi,\bar{\phi}) = \Omega_{Q}(T,\mu,\phi,\bar{\phi}) + \mathcal{U}(T,\phi,\bar{\phi})$$

with a perturbative correction $\Omega_{\mathrm{pert}}(T,\mu,\phi,\bar{\phi})$.
The Mott-Hadron-Resonance-Gas (MHRG) part for the multi-quark clusters is

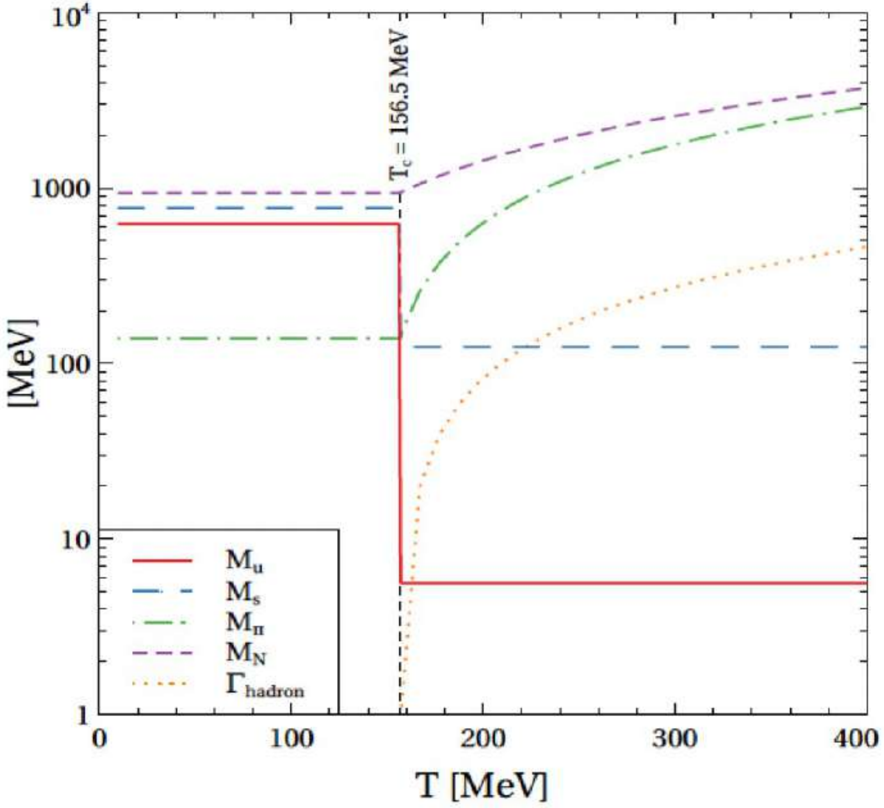
$$\Omega_{MHRG}(T,\mu,\phi,\bar{\phi}) = \sum_{i=M,B,\dots} \Omega_i(T,\mu,\phi,\bar{\phi}),$$

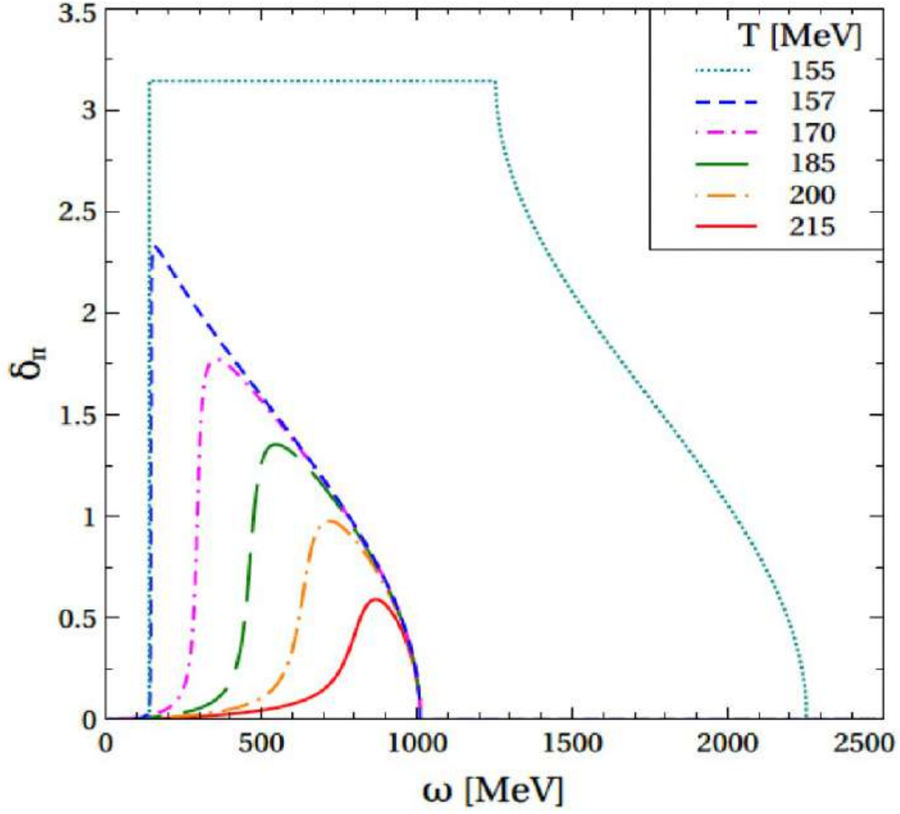
where the multi–quark states are described by the GBU formula:

$$\begin{aligned} n &= -\frac{\partial\Omega}{\partial\mu} = \sum_a a\, n_a(T,\mu) \\ &= \sum_a a\, d_a \int \frac{d\omega}{\pi} \int \frac{d^3q}{(2\pi)^3} \left\{ f_\phi^{(a),+} - \left[f_\phi^{(a),-} \right]^* \right\} 2\sin^2\delta_a(\omega,q) \frac{\partial\delta_a(\omega,q)}{\partial\omega}, \end{aligned}$$

where d_i is the degeneracy factor, a is the number of valence quarks in the cluster an $f_\phi^{(a),+}$, $\left[f_\phi^{(a),-}\right]^*$ are the Polyakov-loop modified distribution functions.
Analogous for the entropy density $s = -\partial\Omega/\partial T$.

Inputs: mass spectrum & phase shifts (models)





D.B., M. Ciernak, O. Ivanytskyi and G. Röpke, arXiv:2308.07950; EPJA 60 (2024) 14

Inputs: mass spectrum (Particle Data Tables)

Mesons

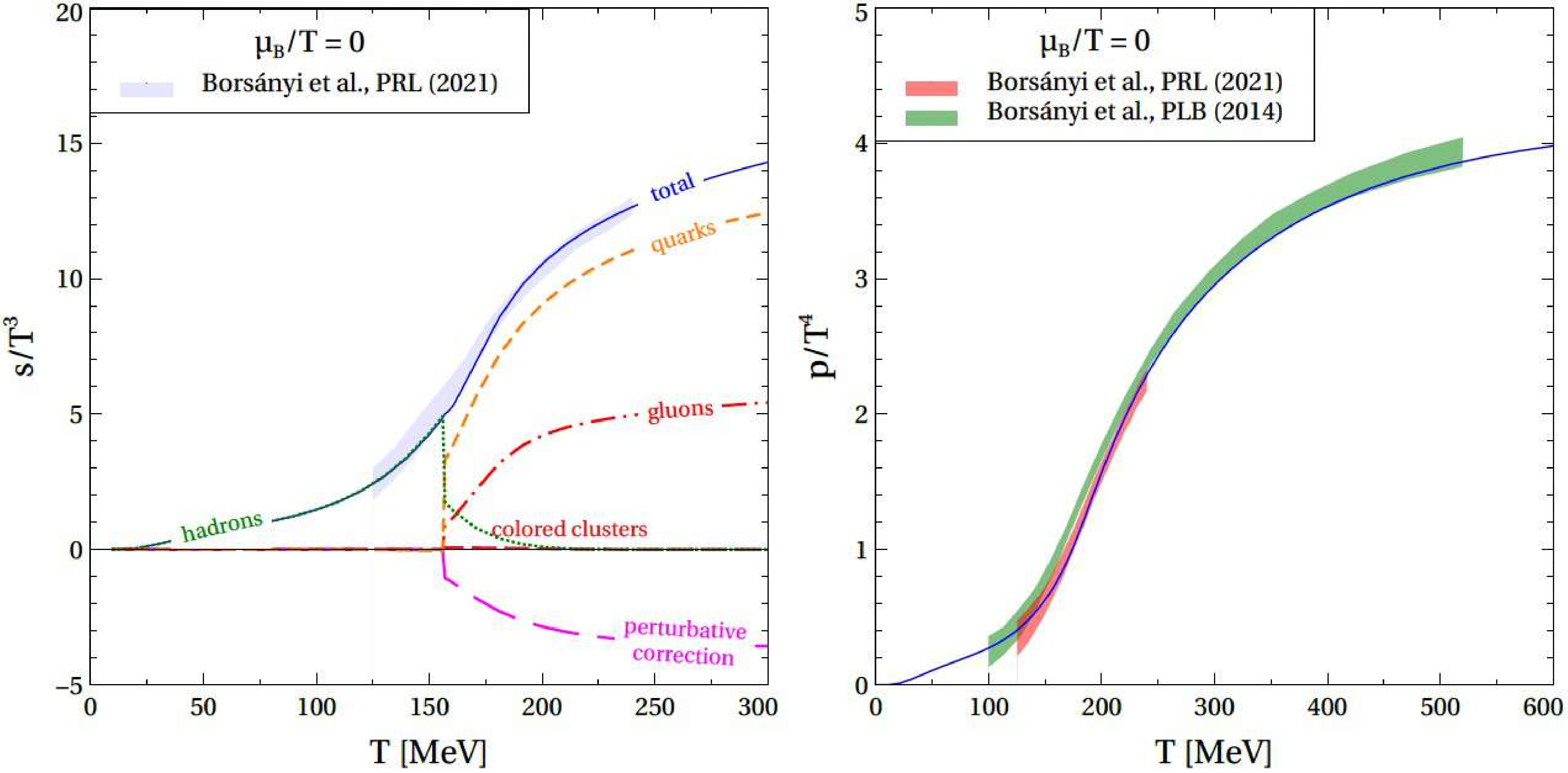
PDG mesons	d_i	M_{PDG} [MeV]	M_i [MeV]	$M^<_{th,i}$ [MeV]	$M^>_{th,i}$ [MeV]
π^+/π^0	3	140	140	1254	11.2
K^+/K^0	4	494	494	1397	129.6
η	1	548	878	1349	90.1
ρ^+/ρ^0	9	775	783	1254	11.2
ω	9	783	783	1254	11.2
K^{*+}/K^{*0}	12	895	$806^{*)}$	2651	140.8
η'	1	960	878	1349	90.1
a_0	3	980	$1095^{*)}$	2508	22.4
f_0	1	980	$1095^{*)}$	2508	22.4
ϕ	3	1020	1069	1540	248
..					
$\pi_2(1880)$	15	1895	$1095^{*)}$	2508	22.4
$f_2(1950)$	5	1944	$1095^{*)}$	2508	22.4
$a_4(2040)$	27	1996	$1095^{*)}$	2508	22.4
$f_2(2010)$	5	2011	$1095^{*)}$	2508	22.4
$f_4(2050)$	9	2018	$1095^{*)}$	2508	22.4
$K_4^*(2045)$	36	2045	$1238^{*)}$	2651	140.8
$\phi(2170)$	3	2175	$1381^{*)}$	2794	259.2
$f_2(2300)$	5	2297	$1095^{*)}$	2508	22.4
$f_2(2340)$	5	2339	$1095^{*)}$	2508	22.4

Baryons

PDG baryons	d_i	M_{PDG} [MeV]	M_i [MeV]	$M^<_{th,i}$ [MeV]	$M^>_{th,i}$ [MeV]
n/p	4	939	939	1881	16.8
Λ	2	1116	1082	2024	135.2
Σ	6	1193	1082	2024	135.2
Δ	16	1232	$1251^{**)}$	3135	28
Ξ^0	2	1315	1225	2167	253.6
Ξ^-	2	1322	1225	2167	253.6
$\Sigma(1385)$	6	1385	$1394^{**)}$	3278	146.4
$\Lambda(1405)$	2	1405	$1394^{**)}$	3278	146.4
$N(1440)$	4	1440	$1251^{**)}$	3135	28
..					
$N(2195)$	36	2220	$1251^{**)}$	3135	28
$\Sigma(2250)$	6	2250	$1394^{**)}$	3278	146.4
$\Omega^-(2250)$	2	2252	$1680^{**)}$	3564	383.2
$N(2250)$	20	2275	$1251^{**)}$	3135	28
$\Lambda(2350)$	10	2350	$1394^{**)}$	3278	146.4
$\Delta(2420)$	48	2420	$1251^{**)}$	3135	28
$N(2600)$	24	2600	$1251^{**)}$	3135	28

… and colored clusters (model) !

D.B., M. Ciernak, O. Ivanytskyi and G. Röpke, arXiv:2308.07950; EPJA 60 (2024) 14



$\mu_B/T = 0$
Borsányi et al., PRL (2021)
total
quarks
gluons
hadrons
colored clusters
perturbative correction
s/T^3
T [MeV]
$\mu_B/T = 0$
Borsányi et al., PRL (2021)
Borsányi et al., PLB (2014)
p/T^4
T [MeV]

„Sudden Switch“ from HRG to QGP

Chemical Freeze-out: „inverse“ Mott effect – hadron localization = collapse of the wave function

$$H_{\exp}(T_{\mathrm{cf},i}) = \tau_i^{-1}(T_{\mathrm{cf},i})$$

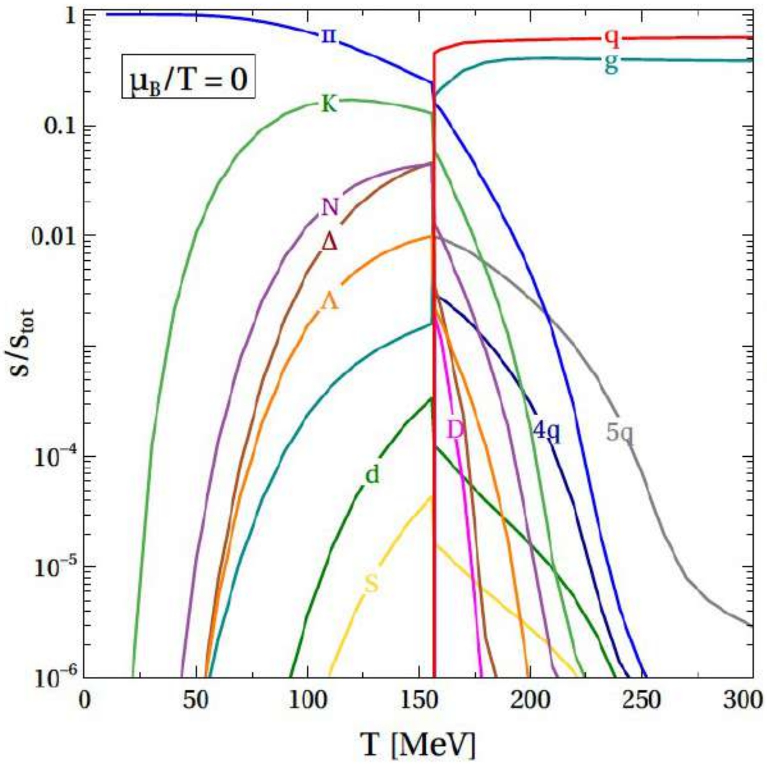
$$H_{\exp} = \frac{1}{\tau_{\exp}} = \frac{s^{1/3}}{a},$$

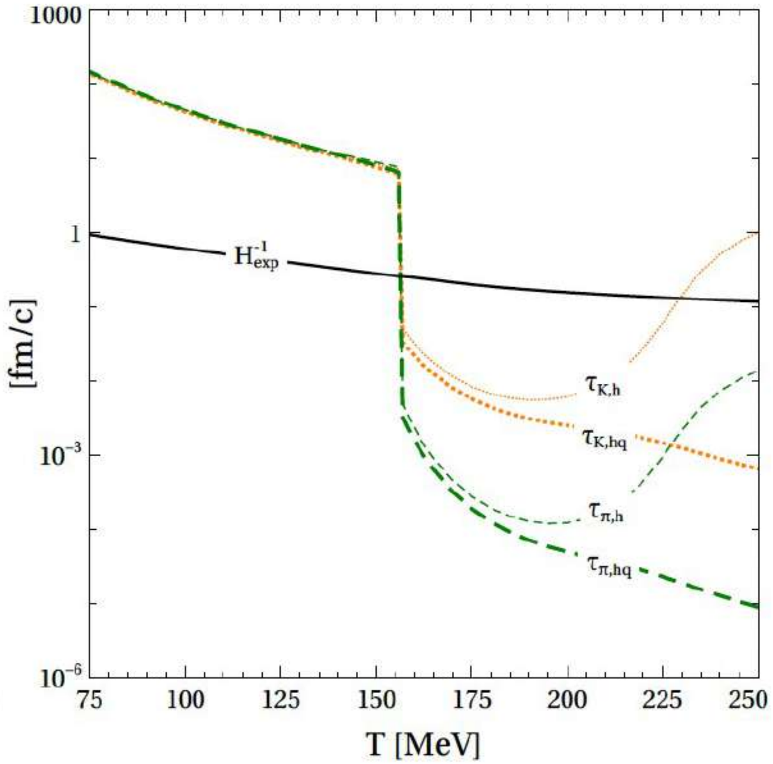
$$\tau_i^{-1} = \sum_j \sigma_{ij} v_{\mathrm{rel}} n_j,$$

$$\sigma_{ij} = \lambda \langle r_i^2 \rangle \langle r_j^2 \rangle,$$

$$\langle r^2 \rangle_\pi^{1/2} \sim |T - T_{\mathrm{Mott},\pi}|^{-1/2}$$

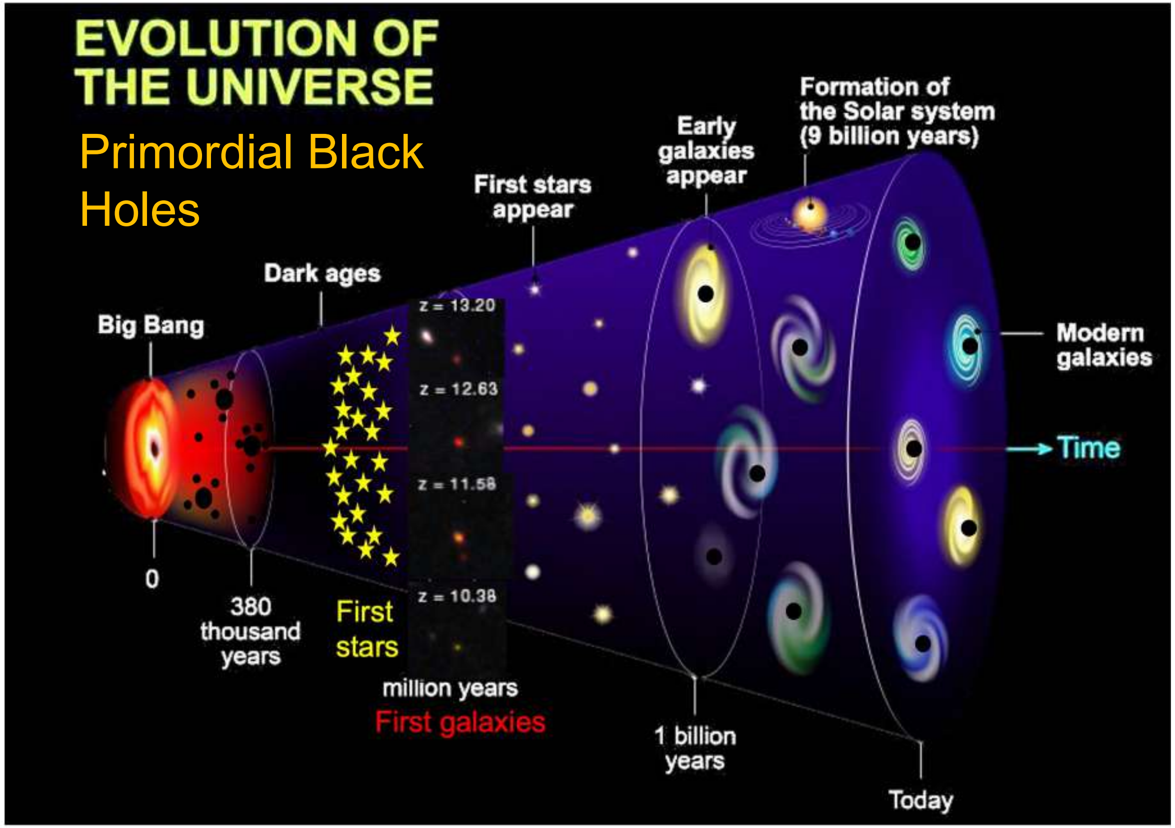
$$\langle r^2 \rangle_\pi \sim E_{B,\pi}(T)^{-1/2}$$

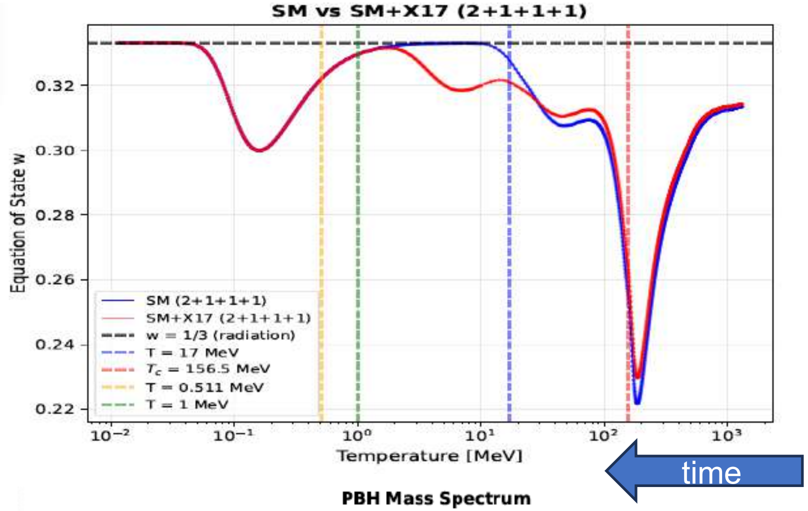


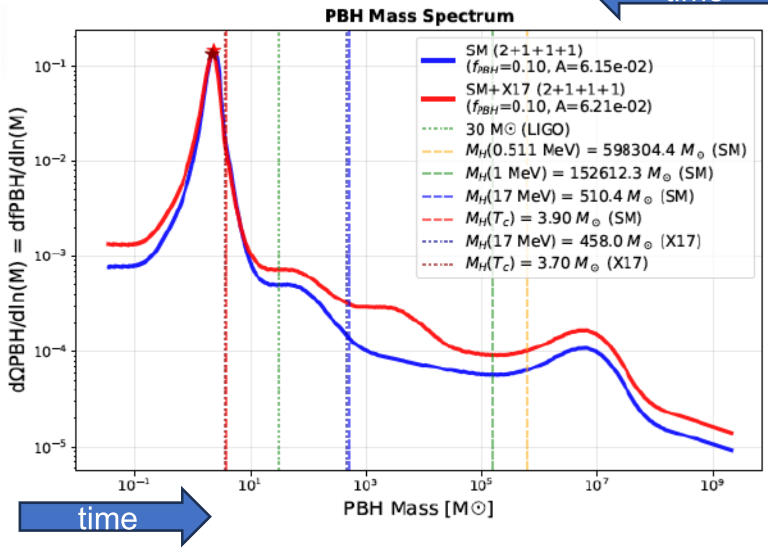


arXiv:2507.10497; PoS (QCHS2024) 247

PBH Formation and Nuclear Droplets?

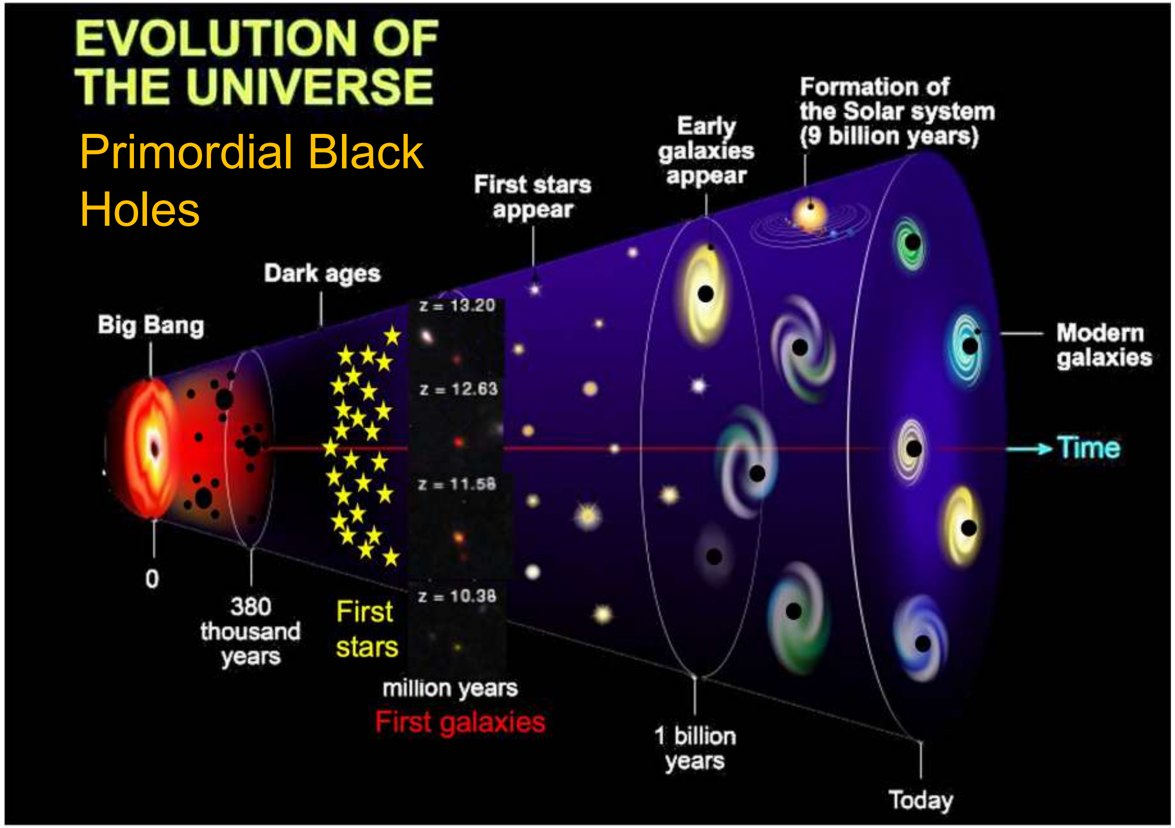


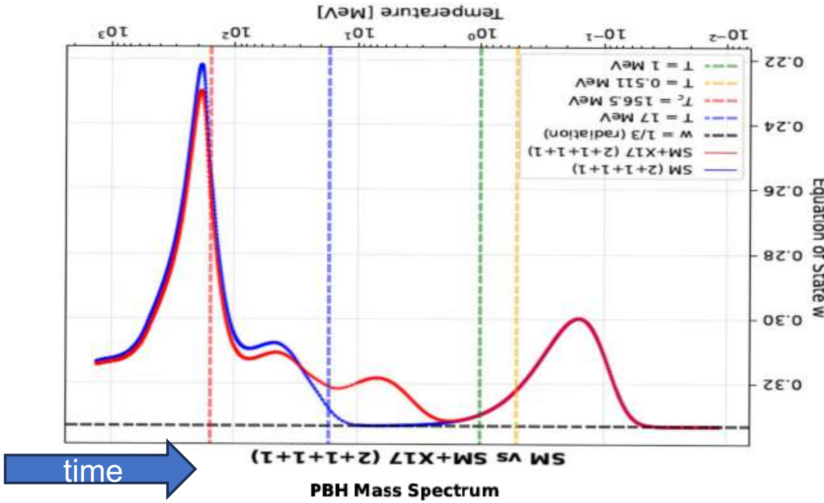


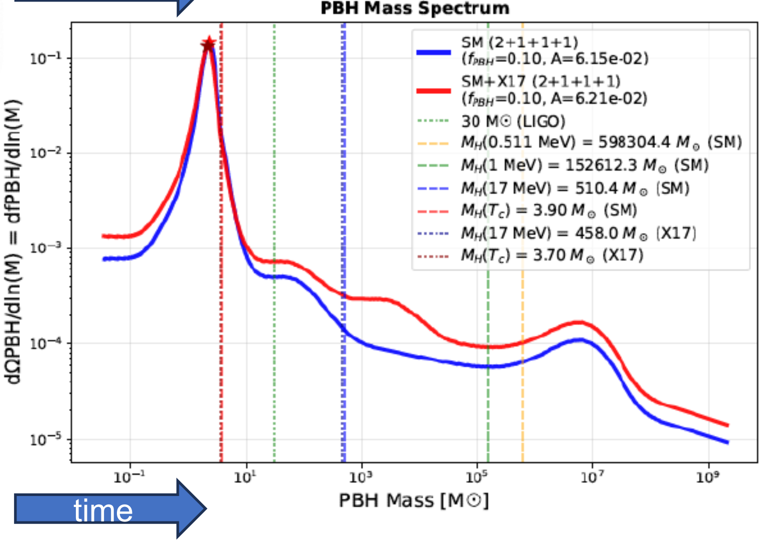


1) PBH formation & 2) Nuclear droplets !

PBH Formation and Nuclear Droplets?



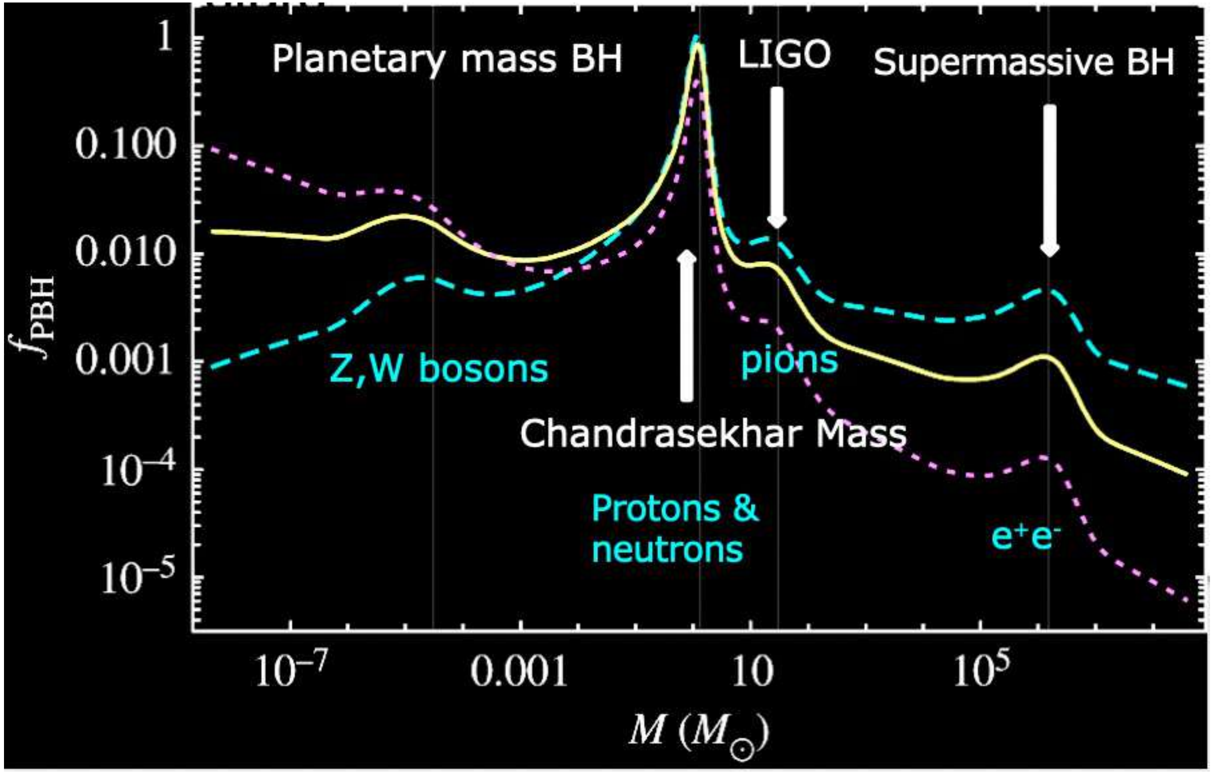




1) PBH formation & 2) Nuclear droplets !

PBH Formation and CFO of heavy elements?

JWST results – primordial black holes !



Different peaks correspond to different particles created at the early universe phase transitions and the corresponding reduction in the sound velocity.

BH mass corresponds to the horizon size at each time.

Only requirement is enough fluctuation power in a volume fraction of 10^{-9} of the early Universe.

Carr, Clesse, García-Bellido 2019

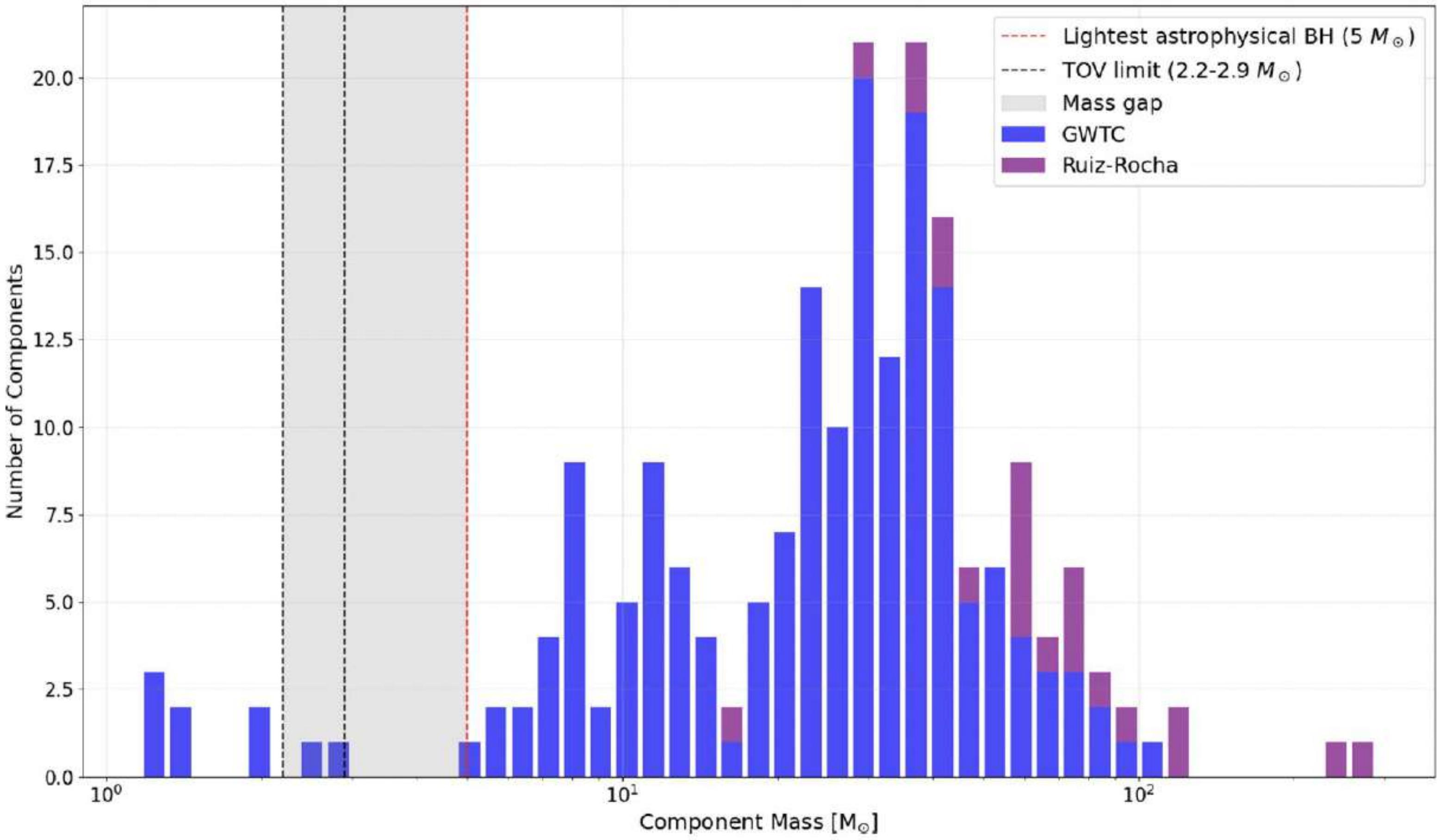
QCD hadronization transition plays key role plays for PBH formation !

PBH Formation and CFO of heavy elements?

LIGO BBH Merger Mass Distribution

Crazy conjecture:

Peak mass "measures" Cosmic QCD Transition Temperature T_H~50 MeV ?

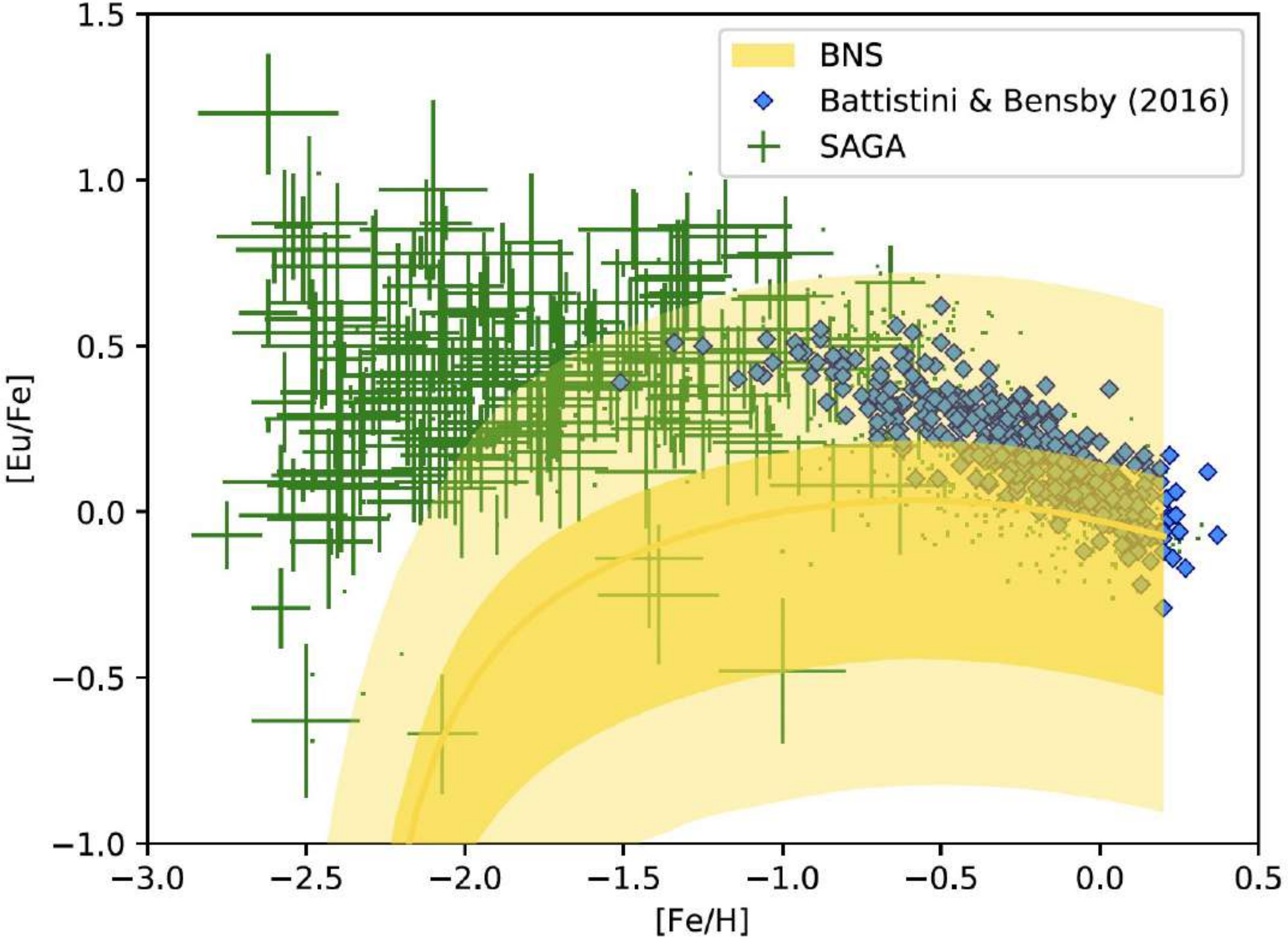


Unknown early source of heavy r-process elements!

Suggestion:

Freeze-out from a primordial dense, thermal source as the missing production site of heavy r-process elements.

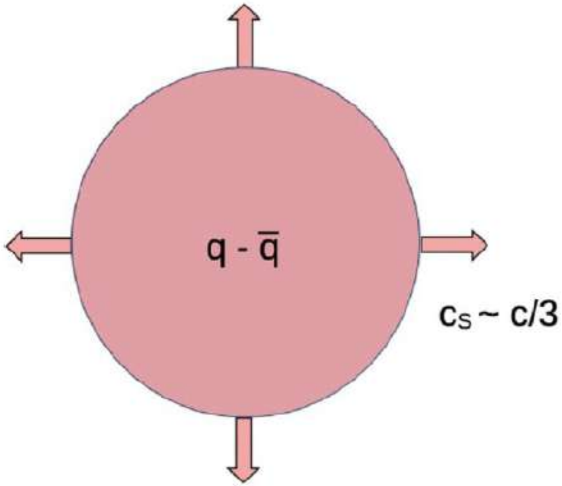
Gonin et al., EPJA 61 (2025)



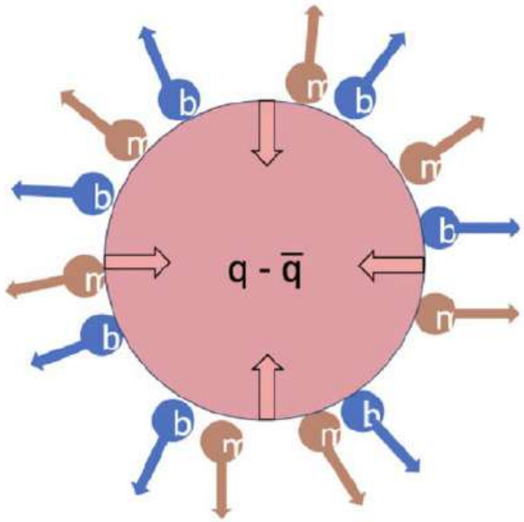
Chen et al., ApJ 985 (2025) 154

PBH Formation and CFO of heavy elements?

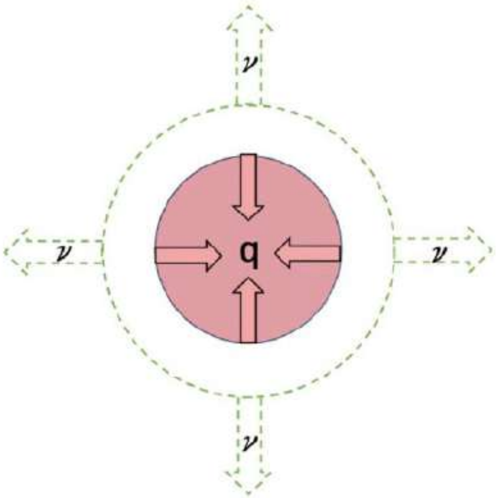
In this scenario the shrinking stops when the energy density gets to protons energy density.
This scenario requires $T > T_{QCD}$. It can be applied for pre-QCD transition failed collapse.



At first the overdensity expands at the speed of sound



Following Bjerrum-Bohr et al. 2012 and 2014. The quark plasma droplet shrinks by emitting baryons marked with b and mesons marked with m.



Following Witten 1984, the surplus quarks could be distilled by quark-antiquark annihilation to neutrinos being radiated off the glob.

QCD phase transition → Quark Matter nuggets

PHYSICAL REVIEW D VOLUME 30, NUMBER 2 15 JULY 1984

Cosmic separation of phases

Edward Witten*
Institute for Advanced Study, Princeton, New Jersey 08540
(Received 9 April 1984)

A first-order QCD phase transition that occurred reversibly in the early universe would lead to a surprisingly rich cosmological scenario. Although observable consequences would not necessarily survive, it is at least conceivable that the phase transition would concentrate most of the quark excess in dense, invisible quark nuggets, providing an explanation for the dark matter in terms of QCD effects only. This possibility is viable only if quark matter has energy per baryon less than 938 MeV. Two related issues are considered in appendices: the possibility that neutron stars generate a quark-matter component of cosmic rays, and the possibility that the QCD phase transition may have produced a detectable gravitational signal.

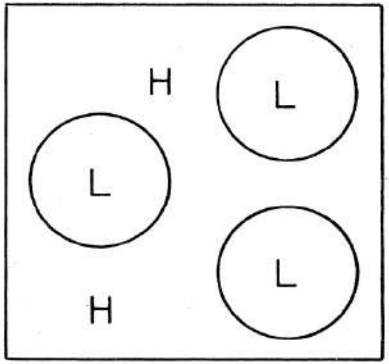


FIG. 1. Isolated expanding bubbles of low-temperature phase in the high-temperature phase.

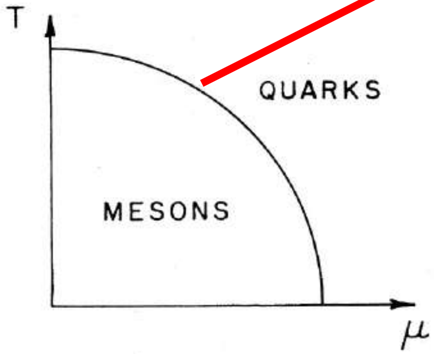
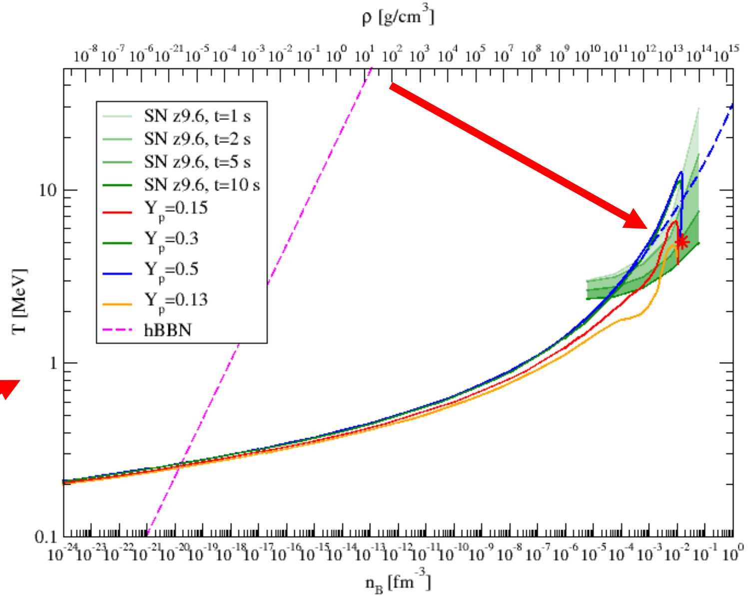


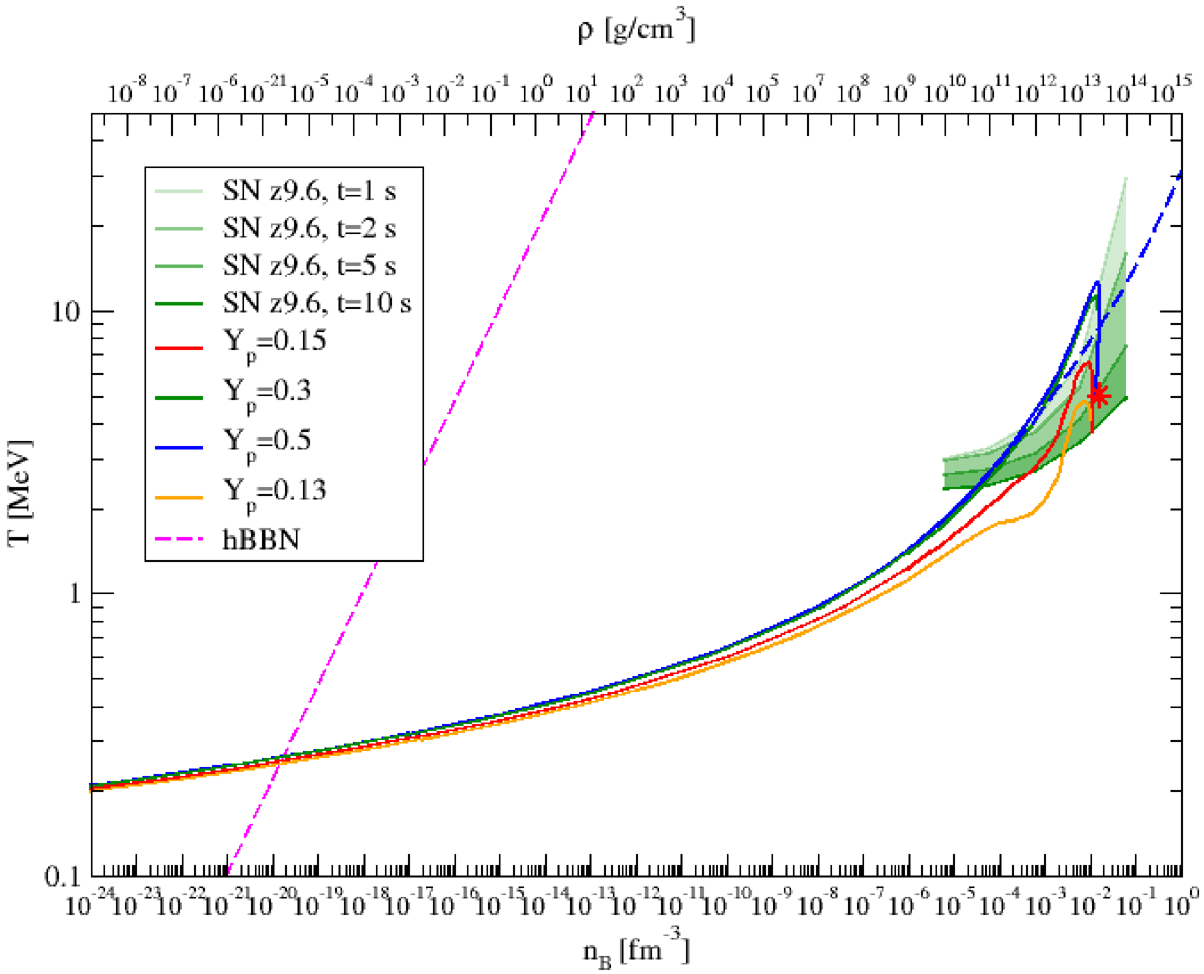
FIG. 4. A sketch of the coexistence temperature for quark matter of chemical potential μ coexisting with the meson-baryon phase of $\mu=0$. What is shown is the temperature, as a function of μ, at which the two phases exert equal pressure.



Accumulated mass fraction vs. mass number Â for solar element abundances compared with freeze-out model after neutron evaporation for T=5 MeV, μ_n=940.317 MeV, μ_p= 845.069 MeV

G. Röpke, D. Blaschke, F. Röpke, arXiv:2411.00535

PBH Formation and Nuclear Droplet Formation?



Can the primordial evolution of the Universe lead to these freeze-out Parameters (red star):

T=5 MeV,
μ_n=940.317 MeV,
μ_p= 845.069 MeV

Maybe inhomogeneous Big Bang?

The freeze-out point lies in the domain of supernova explosions and binary neutron star mergers

G. Röpke, D. Blaschke, F. Röpke, arXiv:2411.00535 and Universe (2025) accepted

Mott dissociation for bound states in a plasma

Effective wave equation for deuterons in nuclear matter

[Derivation of a „Plasma Hamiltonian“ from a Bethe-Goldstone Eq. for two-particle states]

In-medium two-particle wave equation in mean-field approximation

$$\left(\frac{p_1^2}{2m_1}+\Delta_1+\frac{p_2^2}{2m_2}+\Delta_2\right)\Psi_{d,P}(p_1,p_2)+\sum_{p_1',p_2'}(1-f_{p_1}-f_{p_2})V(p_1,p_2;p_1',p_2')\Psi_{d,P}(p_1',p_2')$$

$$= E_{d,P}\Psi_{d,P}(p_1,p_2)$$

Add self-energy

Pauli-blocking

[R. Zimmermann et al. (5-men-work), Phys. Stat. Sol. (b) 90 (1978) 175]

Thouless criterion

$$E_d(T,\mu)=2\mu$$

Fermi distribution function

$$f_p=\left[e^{(p^2/2m-\mu)/k_BT}+1\right]^{-1}$$

BEC-BCS crossover:
Alm et al.,1993

Mott dissociation for clusters in nuclear matter

Nuclear Physics A379 (1982) 536–552

PARTICLE CLUSTERING AND MOTT TRANSITIONS IN NUCLEAR MATTER AT FINITE TEMPERATURE
(I). Method and general aspects

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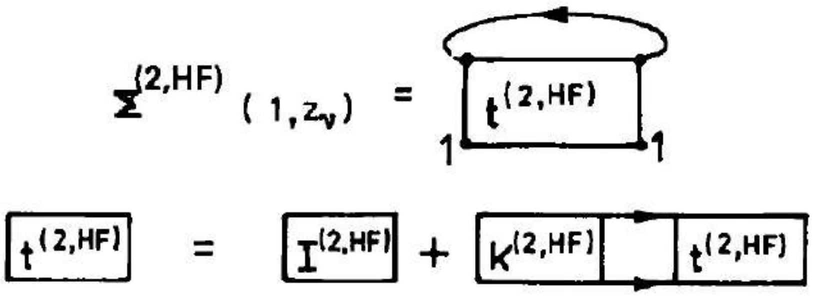
Received 18 May 1981
(Revised 17 September 1981)



$$t^{(2,\mathrm{HF})}(1234,\Omega_\lambda)=\sum_\alpha \frac{\phi_\alpha^{\mathrm{HF}}(12)\phi_\alpha^{\mathrm{HF}}(34)}{E_\alpha^{\mathrm{HF}}-\hbar\Omega_\lambda}(1+\tfrac{1}{2}(f(1)+f(2)+f(3)+f(4)))$$
$$\times(\hbar\Omega_\lambda-E(1)-\Delta^{\mathrm{HF}}(1)-E(2)-\Delta^{\mathrm{HF}}(2))$$
$$\times(E_\alpha^{\mathrm{HF}}-E(3)-\Delta^{\mathrm{HF}}(3)-E(4)-\Delta^{\mathrm{HF}}(4)),$$

$$\{E(1)+E(2)-E_\alpha^{\mathrm{HF}}\}\phi_\alpha^{\mathrm{HF}}(12)+\sum_{1'2'}V(12,1'2')\phi_\alpha^{\mathrm{HF}}(1'2')$$
$$=\sum_{1'2'}\{\tfrac{1}{2}(f(1)+f(2)+f(1')+f(2'))V(12,1'2')$$
$$-(\Delta^{\mathrm{HF}}(1)+\Delta^{\mathrm{HF}}(2))\,\delta_{11'}\,\delta_{22'}\}\phi_\alpha^{\mathrm{HF}}(1'2')$$
$$=-\sum_{1'2'}H^{(2,\mathrm{HF})}_{\mathrm{nucl.\,matter}}(12,1'2')\phi_\alpha^{\mathrm{HF}}(1'2').$$

Mott dissociation for clusters in nuclear matter

Present state-of-the-art:

G. Röpke, Nuclear matter equation of state including two-, three-, and four-nucleon correlations, Phys. Rev. C 92 (5) (2015) 054001, https://doi.org/10.1103/PhysRevC.92.054001, arXiv:1411.4593.

$$E_{A,\nu}(P) = E^0_{A,\nu}(P) + \Delta E^{\rm SE}_{A,\nu}(P) + \Delta E^{\rm Pauli}_{A,\nu}(P) + \Delta E^{\rm Coulomb}_{A,\nu}(P).$$

The cluster binding energies $E^{\rm bind}_{A,\nu}(P;T,n_B,Y_p,T_{\rm eff})$ are defined as

$$E^{\rm bind}_{A,\nu}(P;T,n_B,Y_p) = -[E_{A,\nu}(P;T,n_B,Y_p) - E^{\rm cont}_{A,\nu}(P;T,n_B,Y_p)]$$

$$E^{\rm cont}_{A,\nu}(P;T,n_B,Y_p) = N E_n(P/A;T,n_B,Y_p) + Z E_p(P/A;T,n_B,Y_p)$$

the in-medium dispersion relations for nucleons ($\tau = n, p$) are defined as

$$E_\tau(p;T,n_B,Y_p) = \sqrt{\left[m_\tau c^2 - S(T,n_B,Y_p)\right]^2 + \hbar^2 c^2 p^2} + V_\tau(T,n_B,Y_p) - m_\tau c^2$$

$$S_i(T,n_B,Y_p) = (4463 - 6.610\,T - 0.1703\delta^2 + 4.112\delta^4) n_B \times \frac{1 + c_1 n_b + c_2 n_B^2}{1 + c_3 n_b + c_4 n_B^2},$$

$$V_p(T,n_B,Y_p) = (3403 + 0.000052\,T - 486.6\,\delta - 2.420\,\delta^2) n_B \times \frac{1 + d_1 n_b + d_2 n_B^2}{1 + d_3 n_b + d_4 n_B^2}$$

Scalar and vector mean fields from RDF EoS DD2
S. Typel et al., Phys. Rev. C 81, 015803 (2010)

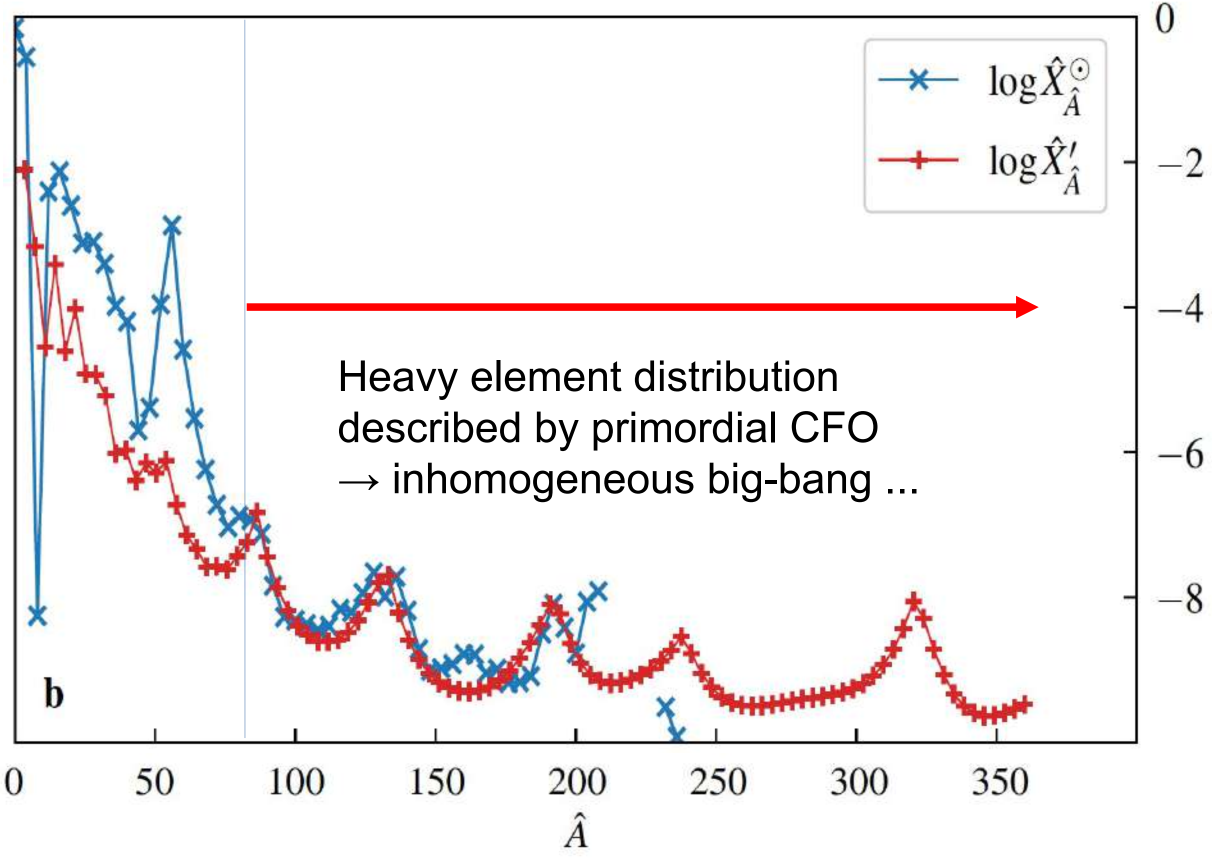
Parameter fit provided by G. Röpke et al.,
Phys. Part. Nucl. Lett. 15, 225 (2018)

$$c_1 = 20.56 - 0.04099\,T - 0.3394\,\delta^2 + 0.9972\,\delta^4,$$
$$c_2 = 15.98 + 0.8664\,T - 2.020\,\delta^2 - 3.018\,\delta^4,$$
$$c_3 = 24.27 - 0.07417\,T - 0.5427\,\delta^2 + 1.196\,\delta^4,$$
$$c_4 = 114.6 + 1.350\,T + 2.674\,\delta^2 + 0.7268\,\delta^4,$$

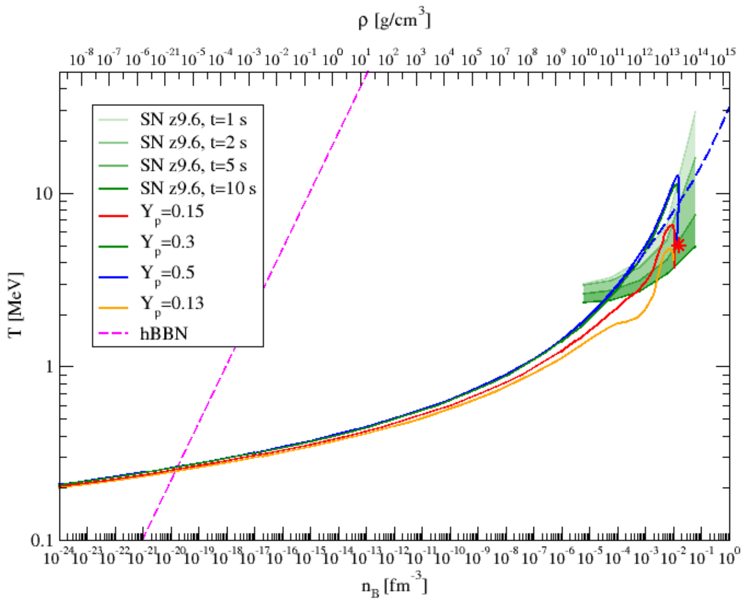
$$d_1 = 0.6629 - 0.006142\,T - 1.141\,\delta - 0.7176\,\delta^2,$$
$$d_2 = 10.7780 + 0.004432\,T + 0.8020\,\delta + 0.4576\,\delta^2,$$
$$d_3 = 3.433 + 0.000104\,T - 1.549\,\delta - 0.3360\,\delta^2,$$
$$d_4 = 23.01 - 0.03302\,T - 5.923\,\delta + 0.05090\,\delta^2,$$

with the isospin asymmetry $\delta = (1 - 2Y_p)$

PBH Formation and CFO of heavy elements?



Heavy element distribution described by primordial CFO → inhomogeneous big-bang ...



Accumulated mass fraction vs. mass number Â for solar element abundances compared with freeze-out model after neutron evaporation for T=5 MeV, μ_n=940.317 MeV, μ_p= 845.069 MeV

G. Röpke, D. Blaschke, F. Röpke, arXiv:2411.00535

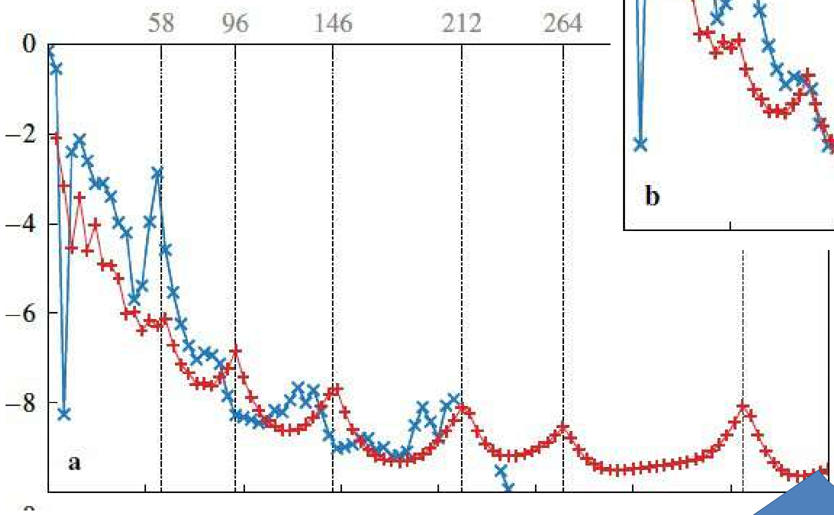
Primordial black-hole formation and heavy r-process element synthesis from the cosmological QCD transition

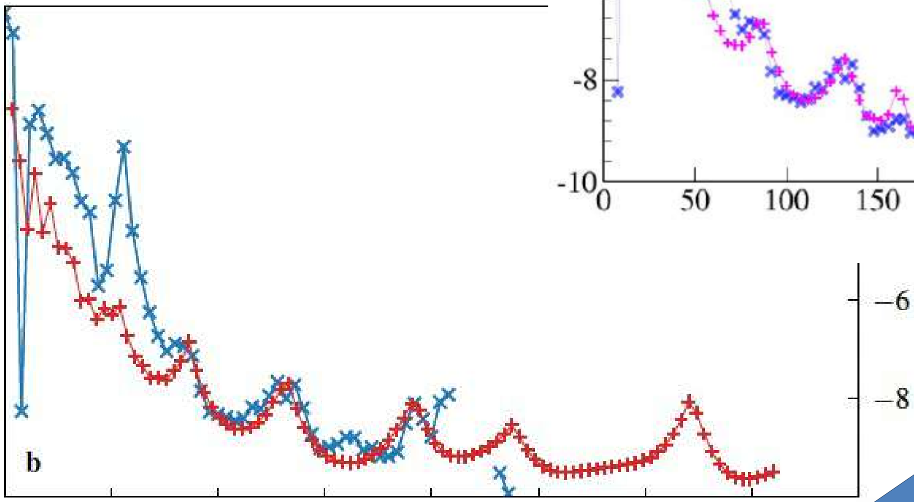
Two aspects of an inhomogeneous early Universe

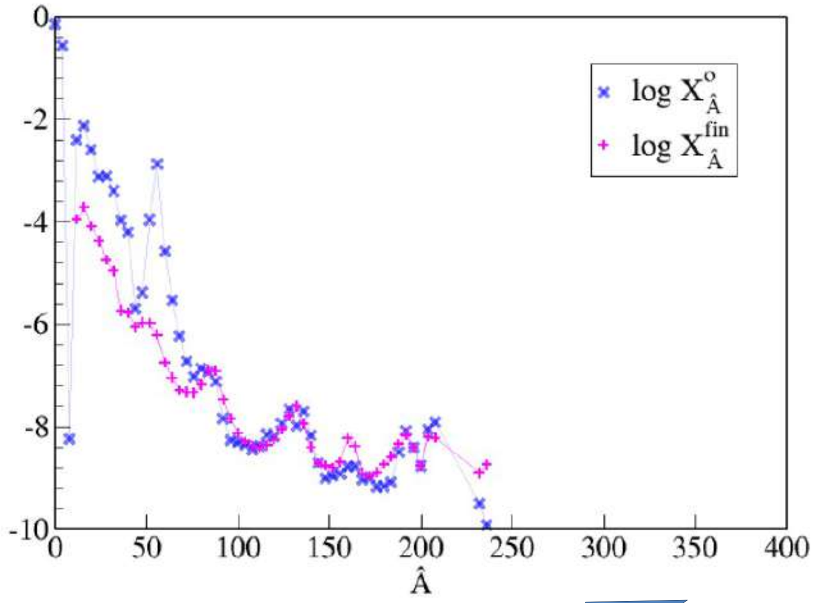
Maël Gonin[1,2], Günther Hasinger[1,2,3], David Blaschke[4,5,6], Oleksii Ivanytskyi[7], and Gerd Röpke[8]

EPJA 61 (2025) 170; arXiv:2505.05463

Primordial accumulated mass fraction (red plusses) compared to the solar one (blue crosses)



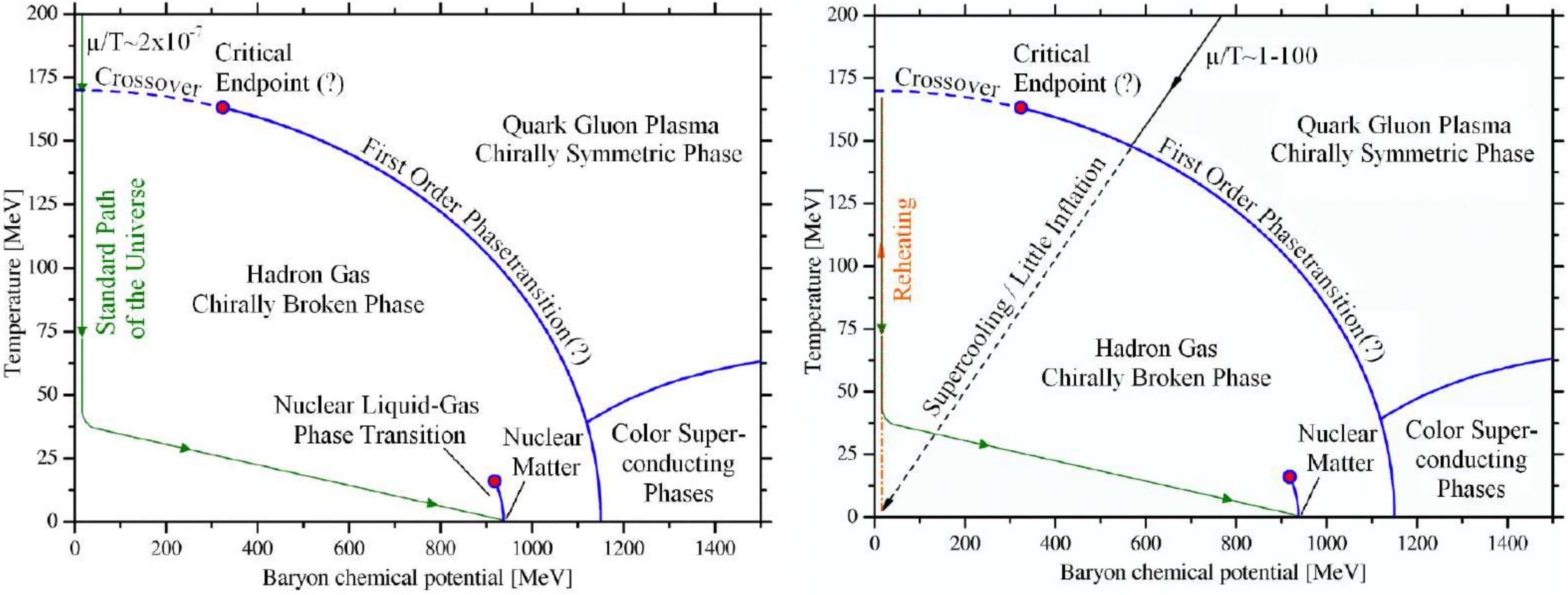




… and 2) fission (A~330 → 165) and 3) alpha decays (A>212 → A~200)

Modified by: 1) neutron evaporation ...

Task: Explain how primordial evolution leads to Lagrange parameters T=5 MeV and n_B=n_sat/10



Simon Schettler, Tillmann Boeckel, Jürgen Schaffner-Bielich, arXiv:1010.4857
Tillmann Boeckel, Jürgen Schaffner-Bielich, arXiv:1105.0832

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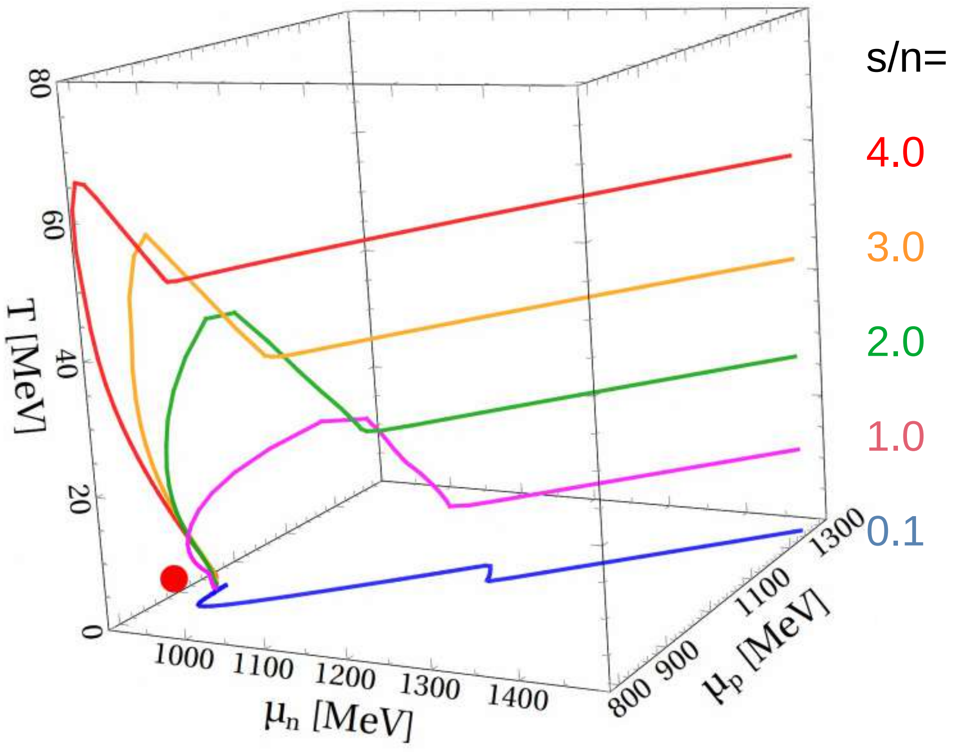
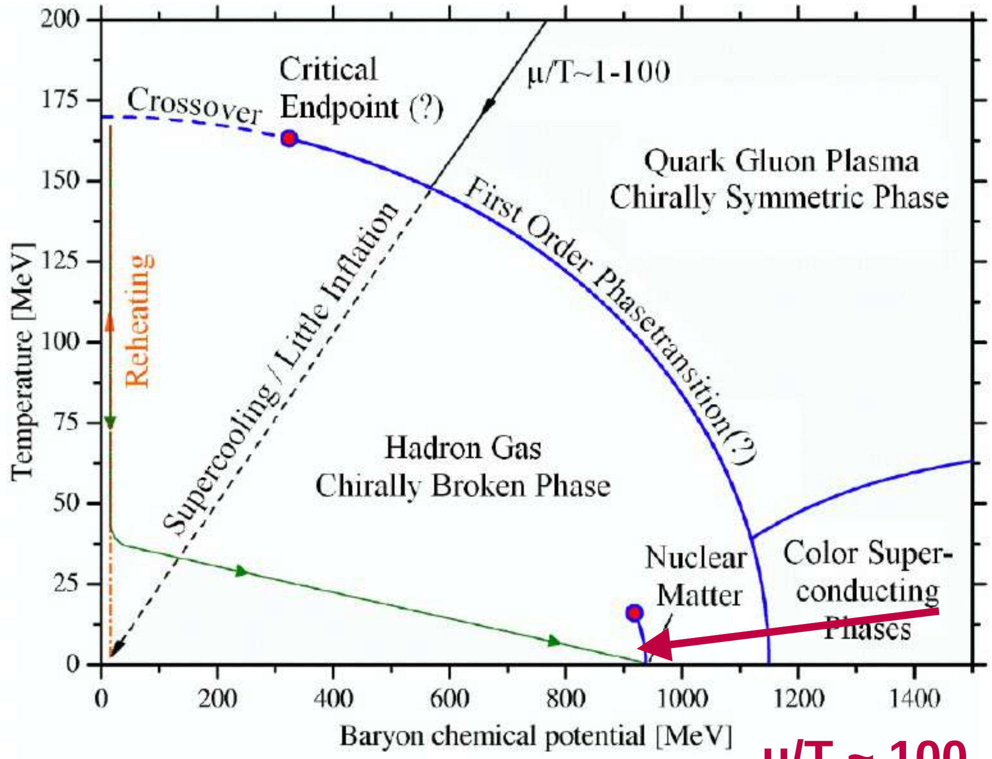


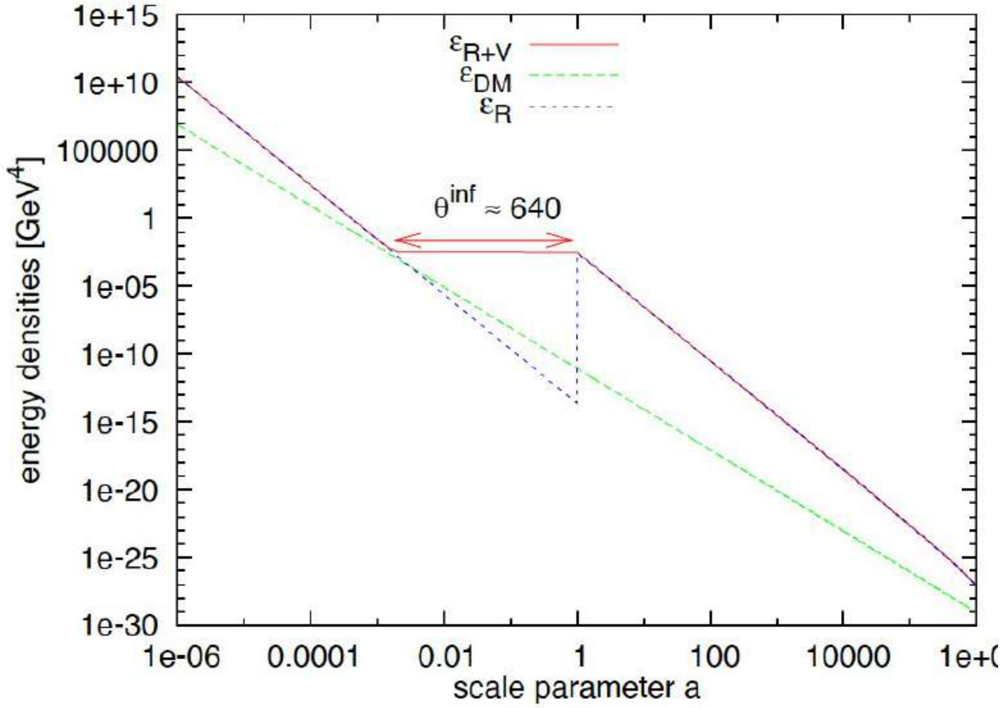


μ/T ~ 100
Affleck-Dine baryogenesis

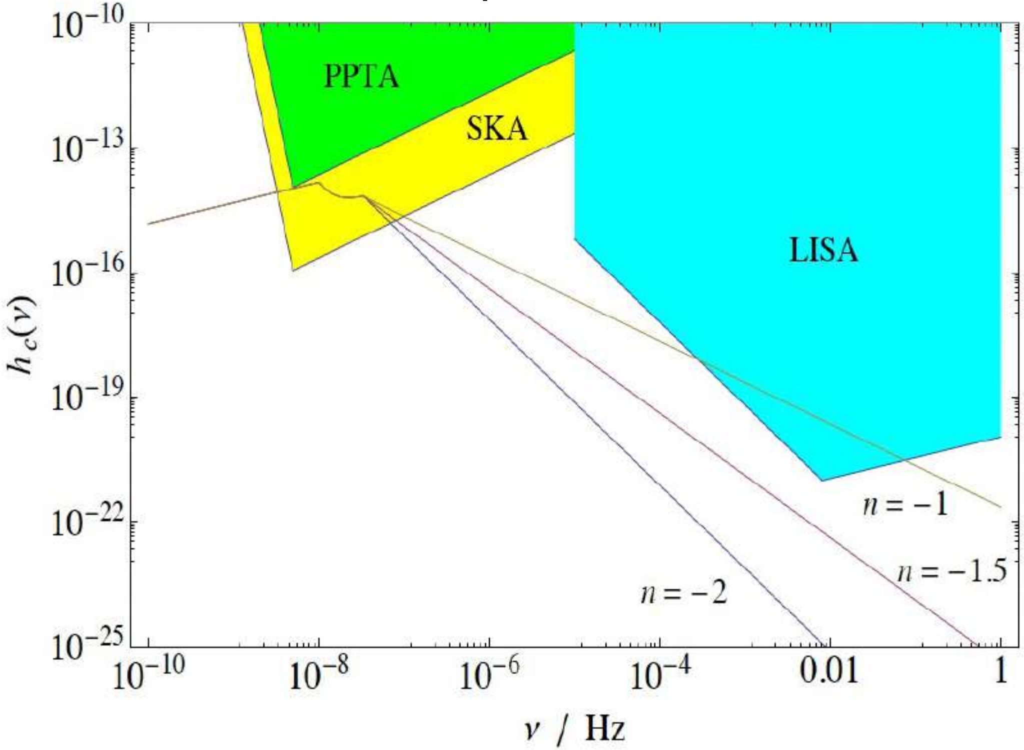
T. Boeckel, J. Schaffner-Bielich, arXiv:1105.0832;
D.B., M. Gonin, G. Hasinger, O. Ivanytskyi, G. Röpke, in preparation (2025)

Task: Explain how primordial evolution leads to Lagrange parameters T=5 MeV and n_B=n_sat/10

Supercooling, Mini-Inflation, Reheating



Gravitational wave spectrum: PTA, SKA, ...



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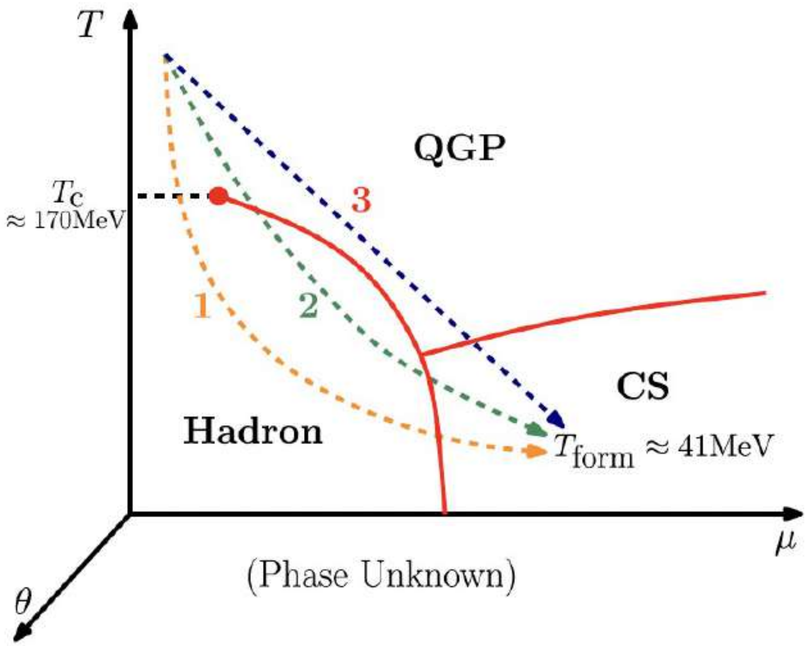
Neutrino emission → Axionic Quark nuggets



$$|B_{\mathrm{visible}}|:|B_{\mathrm{nuggets}}|:|B_{\mathrm{antinuggets}}| \simeq 1:2:3$$

Axion mass: $10^{-6}\,\mathrm{eV} \lesssim m_a \lesssim 10^{-3}\,\mathrm{eV},$

Size of the quark nugget:

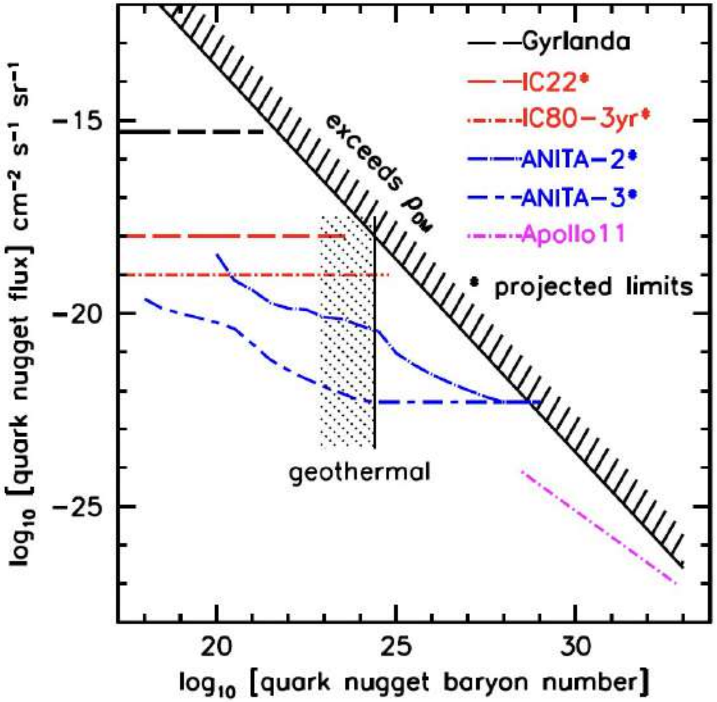
$$10^{-6}\ \mathrm{cm} \lesssim R \lesssim 10^{-3}\ \mathrm{cm}, \qquad 10^{23} \lesssim B \lesssim 10^{32},$$

Baryon-to-photon ratio now

$$\eta \equiv \frac{n_B - n_{\overline{B}}}{n_\gamma} \simeq \frac{n_B}{n_\gamma} \sim 10^{-10}.$$

Xunyu Liang, Ariel Zhitnitsky, Axion field and the quark nuggets formation at the QCD phase transition, Phys. Rev. D 94 (2016) 083502
Oswaldo Santillan, Alejandro Morano, Neutrino emission and initial evolution of axionic quark nuggets, Phys. Rev. D 104 (2021) 083530

Neutrino emission → Axionic Quark nuggets



If dark matter consists of of quark nuggets, their flux is

$$\frac{dN}{dAdt} = nv \approx \left(\frac{10^{25}}{B}\right) \text{km}^{-2}\,\text{yr}^{-1}$$

$$L = \frac{4\pi\sigma R^2(t)}{2}\dot{R}^2(t) - 4\pi\sigma R^2(t) + \frac{4\pi R^3(t)}{3}[P_{\text{in}}(\mu) - P_{\text{out}}(t)] + [\text{other terms}].$$

$$\sigma\ddot{R}(t) = -\frac{2\sigma}{R(t)} - \frac{\sigma\dot{R}^2(t)}{R(t)} + \Delta P(\mu) - 4\eta\frac{\dot{R}(t)}{R(t)}$$

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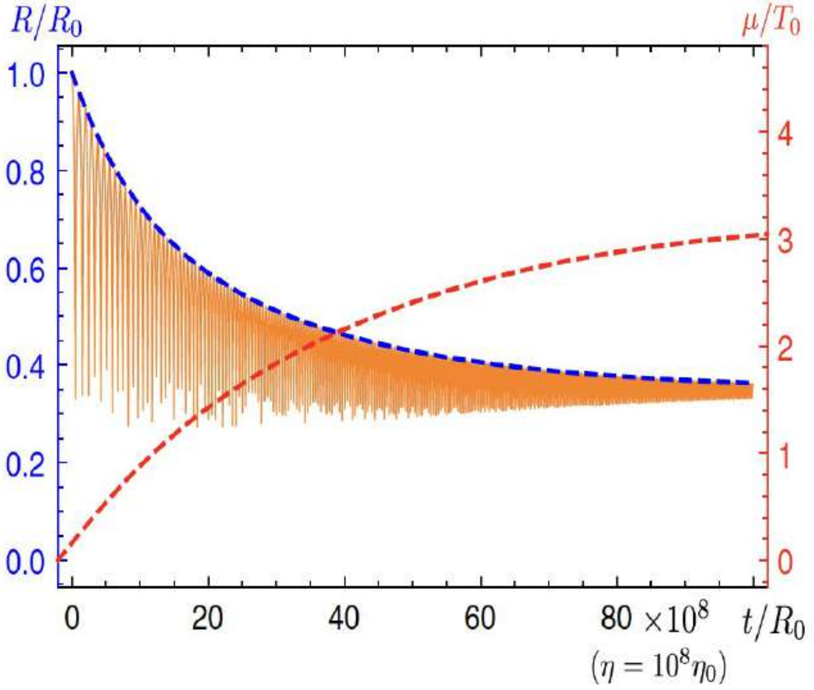

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International Conference on Quark Confinement and the Hadron Spectrum (QCHS 2026)

29.6. - 4.7.2026, Wroclaw, Poland

David Blaschke (Uni Wroclaw & HZDR/CASUS),
Nora Brambilla (TU Munich),
Pior Surowka (Wroclaw Univ. Science & Technology)

https://indico.cern.ch/event/1531304

XVIIth Conference on Quark Confinement and the Hadron Spectrum (QCHS 2026)

29 June 2026 to 4 July 2026
Wrocław University of Science and Technology Congress Centre
Europe/Warsaw timezone

Enter your search term

- Overview
- Scientific Programme
- Committees
- Venue

Inaugurated in 1994 in Como, Italy, this series of conferences has become an important forum for scientists working on strong interactions, stimulating exchanges among theorists and experimentalists as well as across related fields.

The aim of the conference is to bring together people working on strong interactions from different approaches, ranging from lattice QCD to perturbative QCD, from models of the QCD vacuum to QCD phenomenology and experiments, from effective theories to physics beyond the Standard Model.

The scope of the conference also includes the interface between QCD, nuclear physics and astrophysics, and the wider landscape of strongly coupled physics. In particular, the conference will focus on the fruitful interactions and mutual benefits between QCD and the physics of condensed matter and strongly correlated systems.

The seventeenth edition of this conference series will be held at the Grunwaldzki Campus of the Wrocław University of Science and Technology, Poland, between June 29th and July 4th, 2026.

Starts 29 Jun 2026, 08:00
Ends 4 Jul 2026, 20:00
Europe/Warsaw

Wrocław University of Science and Technology Congress Centre

ul. Janiszewskiego 8
50-372 Wrocław
Poland
Go to map

David Blaschke
Nora Brambilla
Piotr Surówka

There are no materials yet.

https://indico.cern.ch/event/1531304 **(under construction)**

Local Organizing Committee (LOC)

David Blaschke (UWr & HZDR/CASUS Görlitz, co-chair)
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Tobias Fischer (WUST)
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Gabriel Wlazlowski (Politechnika Warszawska) ...

Scientific Programme / Parallel Sessions

Vacuum Structure and Confinement	-	Session A
Light Quarks	-	Session B
Heavy Quarks	-	Session C
Deconfinement	-	Session D
QCD and New Physics	-	Session E
Nuclear and Astro-Particle Physics	-	Session F
Strongly-Coupled Theories and Dark Matter	-	Session G
Statistical Methods for Physics Analysis	-	Session H

Conference Venue:

Campus Grunwaldzki of
Wroclaw University of Science Technology

https://indico.cern.ch/event/1531304 (under construction, bookmark the website !)

Looking forward to meeting you in Wroclaw in Summer 2026

For those who cannot wait until 2026 ...

The Modern Physics of Compact Stars and Relativistic Gravity 2025

23.–26. Sept. 2025
Yerevan, Armenia

https://indico.global/event/13917