NON-TRIVIAL QCD VACUUM AGAINST BLACK HOLES OF A STELLAR MASS

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DEFINITION:

– **(super)COMPACT STAR** $\Longrightarrow \frac{1}{3}\,\varepsilon_n \;\leq\; \langle\varepsilon\rangle \;\leq\; \varepsilon_n$

$\varepsilon_n \equiv$ **the mean mass (energy) density within a nucleon (neutron).**

THE UPPER LIMIT ($\overline{M_{NS}}$) FOR THE COMPACT STAR (NS) MASS (*reliable observations*):

$M_{NS} \;\leq\; \overline{M_{NS}} \;\leq\; 2\,M_\odot$

STRICT LOWER LIMIT ($\underline{M_{CBH}}$) FOR THE MASS OF (*disputable*, *GR−motivated* ?) COMPACT BLACK HOLES (CBHs)

$M_{CBH} \;\geq\; \underline{M_{CBH}} \;=\; (4 \div 7)\,M_\odot$
(the upper value seems much more realistic).

$\Longrightarrow$ ***at least*** **: NO COMPACT STARS WITHIN THE MASS (M) BAND GAP**

$2M_\odot \;\leq\; M \;\leq\; \underline{M_{CBH}} \;=\; (4{\div}7)M_\odot$ **(OK)**

$\Longrightarrow$ ***in reality*** **:** ***NO WAY FOR***

CBH FORMATION **(??)**

TWOFOLD INSTABILITY UNDER COMPRESSION OF STAR WITH A MASS

$M \geq \overline{M_{NS}}$:

— GRAVITATIONAL COLLAPSE

— HADRONIC PHASE $\longrightarrow$ SUBHADRONIC PHASE
(HPh) (SHPh)

$\Longrightarrow$ *these are INCOMPATIBLE* :

the former pushes the star into CBH,
whereas the latter results in an enormous heating to make the collapse stopped;

THE KEY POINT IS, WHAT COMES BEFORE :

HPh $\longrightarrow$ SHPh TRANSITION OR CBH HORIZON?

THE RESULT TO BE DEFENDED:

$\Longrightarrow$ **ALMOST CERTAINLY,**
IT IS THE HPh $\longrightarrow$ SHPh TRANSITION

HPh:

$\Longrightarrow$ **QCD vacuum condensate + particle states**
(VC) **(S)**

$$(\varepsilon_{tot},\, P_{tot}) \;=\; (\varepsilon^0_{VC},\quad P^0_{VC}) \qquad + \quad (\varepsilon_S,\quad P_S)$$

$$\varepsilon^0_{VC} \;=\; -P^0_{VC} \qquad\qquad \varepsilon_S \;\geq\; 3P_S$$
$$(|\varepsilon^0_{VC}|,\quad P^0_{VC}) \quad \gg \quad (\varepsilon_S,\quad P_S)$$

almost no interaction between VC and S in the "rare" HPh (up to the within of "quiet" NSs, $M_{NS} < \overline{M_{NS}}$, where ε_S is still noticeably smaller than $\varepsilon_n \simeq |\varepsilon^0_{VC}| \simeq 5\,10^{-3}\,\mathrm{GeV}^4$ all over the star)

SHPh (***can be formed*** **ONLY** ***near the center of NS with $M_{NS} \geq \overline{M_{NS}}$***):

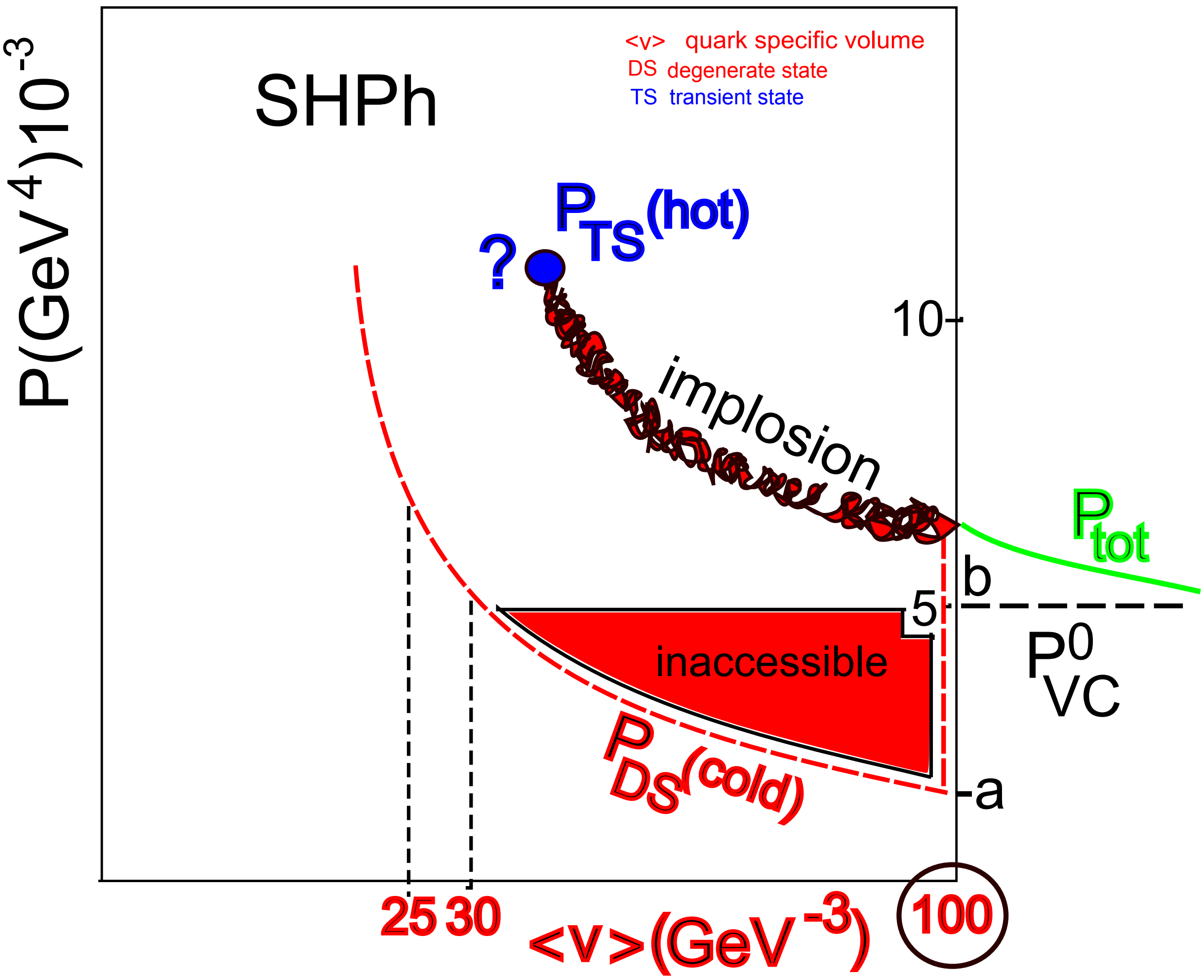
$\Longrightarrow$ **NO VACUUM CONDENSATE:** $\varepsilon_{VC} = P_{VC} = 0$

$\Longrightarrow$ $P_{tot} \;=\; P_S \;\geq\; P^0_{VC} \;=\; |\varepsilon^0_{VC}|$

$\Longrightarrow$ ***crucial softening of EoS:***
$\varepsilon_{tot} \;=\; \varepsilon_S \;\geq\; 3\,P_S \;\geq\; 3\,|\varepsilon^0_{VC}|$

$\Longrightarrow$ ***that is why HPh $\longrightarrow$ SHPh transition is nothing else than implosion, which results in enormous heating and degeneracy breaking (numerous $q\bar{q}$–pairs, thus $\mu_B/T \;\rightarrow\; 0$) near the NS center.***

ON THE HPh $\longrightarrow$ SHPh DYNAMICS



$\langle v\rangle \simeq 100\,\mathrm{GeV}^{-3} \;\rightarrow$ neutron "close packing"

$\Longrightarrow$ *unleashed color charges violate VC−generating long−range color field correlations, VC−pressure drops, implosion rate grows, and so on;*

$$dP_{tot}(a \rightarrow b)/d\langle v\rangle > 0$$

$\Longrightarrow$ *no point from the red − painted area is relevant for a real SPHh state of NS interior.*

SOME ESTIMATES (for hot QGP)

SHPh temperature, which makes the collapse stopped:

$$\sigma_{QGP}\langle T^4\rangle \;\geq\; 3|\varepsilon^0_{vac}| \qquad (1)$$

$$\sigma_{QGP} \;=\; \frac{\pi^2}{30}[2\times 8 + 2\times 3\times 2\times(2\div 3)\times\frac{7}{8} + (12\div 16)]$$

↑ quarks + gluons; ↑ photons+ leptons

$\Longrightarrow \quad T \;=\; \langle T^4\rangle^{1/4} \;\geq\; 160\,\mathrm{MeV} \;\rightarrow$ **pretty good correlation with the lattice MC simulations by Karsch et al (crossover $140 \leq T \leq 200\,\mathrm{MeV}$).**

Energy conservation low reads:

$$-AG\frac{M^2_{NS}}{R^2_{NS}}dR_{NS} \;\simeq\; 4\pi\sigma_{QGP}\langle T^4\rangle\,(1+\frac{|\varepsilon^0_{vac}| \,-\, \varepsilon_n}{\sigma_{QGP}\langle T^4\rangle})r^2dr, \qquad (2)$$

$r \ll R_{NS}$ **is the SHPh domain radius,** $\frac{6}{7} \leq A \leq \frac{3}{2}$;

$$\Longrightarrow \quad G\frac{M^2_{NS}}{R_{NS}} = \simeq \frac{4\pi}{3}\sigma_{QGP}\langle T^4\rangle r^3 + C, \qquad (3)$$

$C \simeq (0.5\div 1)\,M_\odot$ **for** $\overline{M_{NS}} \simeq (1.5\div 2.5)\,M_\odot$ **and** $R_{NS} \simeq (8\div 10)\mathrm{km}$.

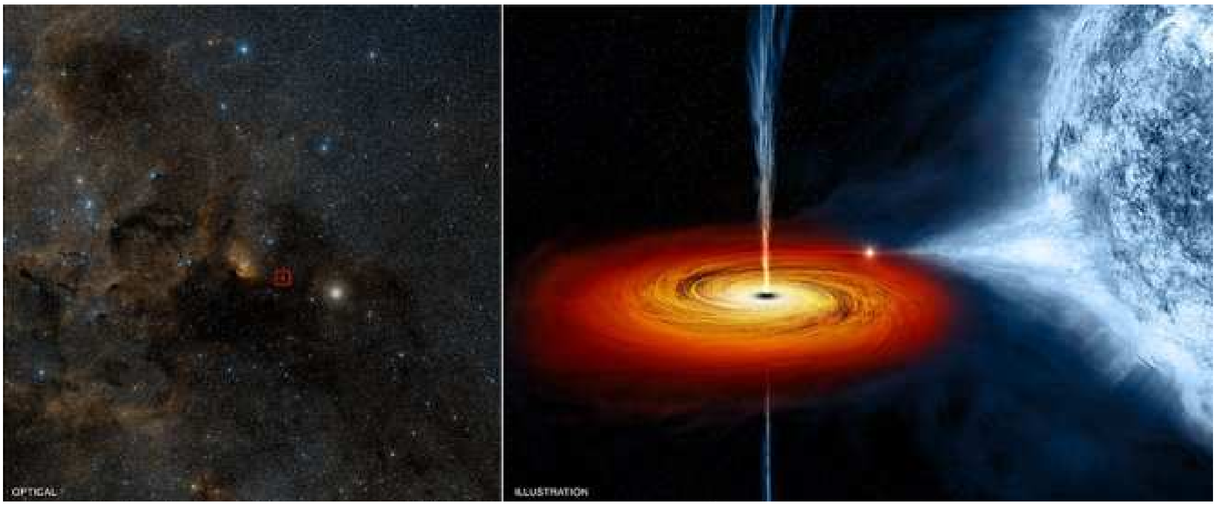
$\Longrightarrow$ a transient, hydrodynamically (*fast process* !!) "quasi-steady", heterogeneous mode is ***ONLY*** accessible at the cost of an enormous thermal (*slow process* !!) disbalance (SHPh with temperature of several hundred MeV near the NS center against HPh of some few MeV over its outer part) and
only if $r \ll R_{NS}$ (M_{NS} *only slightly exceeds* $\overline{M_{NS}}$).
$\Longrightarrow$ in this case, it seems sensible to imagine a rather "quiet" combustion (deflagration) within a slightly ultraboundary NS which does not turn into detonation in full; this is, undoubtedly, accompanied by some asrtoseismic phenomena - the quasi-periodic oscillations in the giant flares ("repeaters") as well as the eruptions of star substance (cannonballs) and/or gamma ray bursts (GRBs), both being the more powerful the more noticeable is the difference $M_{NS} - \overline{M_{NS}}$; such a "volcano activity" results in gradual loss of the star mass and is expired, as M_{NS} approaches $\overline{M_{NS}}$.
$\Longrightarrow$ at still larger initial values of M_{NS}, the Eq.(3) asks *"formally"* for $r \rightarrow R$ (these would be equal just for $M_{NS} \simeq 4M_{\odot}$), what signals, actually, that transient hydrodynamic balance is no longer attainable - instead, one can, reasonably, expect that any supermassive star is doomed for the immediate self-destruction in full as soon as it becomes compact:

***no* BH!**

$\Longrightarrow$ allowing for some "minor" factors, which make the general pattern more realistic, - star rotation and its non-sphericity, possible binary configuration as well as the energy density fluctuations results in the consolidation of the above "anti-BH" arguments.

REMARKS

• Treatment of the less compact stars asks for more reliable information on EoS. Nevertheless, sometimes one can guess certain qualitative features within the above framework. An example is rapidly spinning around ”classical BH” Cyg X-1.



Shown in this well known illustration ”jets”, forwarded normally to the accretion disc, may be interpreted as the eruption of very hot matter originated just near the star center from QGP (SHPh), which is formed there. If so, then, actually, this star is not BH - instead, it is nothing else than a kind of ”hoover”, which swamps the binary-partner’s substance, works it over and throws it out into the cosmic space, thus keeping its own mass balance for a long time. After the partner is eaten up, the Cyg X-1 is expected to cool down and gather up, lose a part of its mass and angular momentum, and, in the end, share the aforementioned twofold fate of all compact stars.

●● Since the SHPh temperature near the star center is about two order higher, than that of the supernova explosions, the relevant energy release could be up to several order higher too.

$\Longrightarrow$ some puzzling astroseismic phenomena – from the quasi-periodic oscillations of repeaters (e.g. SGR 0526-66, SGR 1900+14, SGR 1806-20) up to the "abnormally" powerful eruptions of substance and radiation from some distant ("young") objects (say, GRB 090423, GRB 080916C, GRB 080319B ("naked eye"), Sw 1644+57, etc.) – which are associated sometimes with insatiable "eating up" the stellar substance by (supposedly) nearby-situated BH are linked, actually, with the above phase instability within the compact stars themselves.