The BES way to neutron stars

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Workshop on Highly Baryonic Matter
at RHIC-BES and Future Facilities
beyond the Critical Point towards Neutron Stars
Tsukuba (April 30, 2023)


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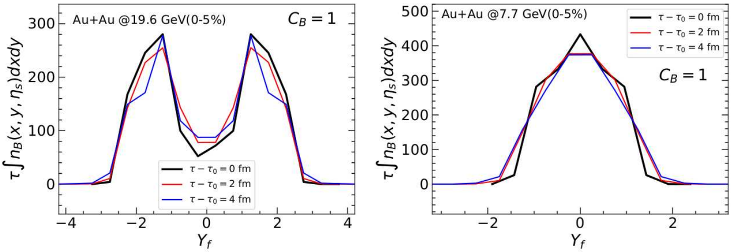
止まれ
STOP

Baryon stopping and BES

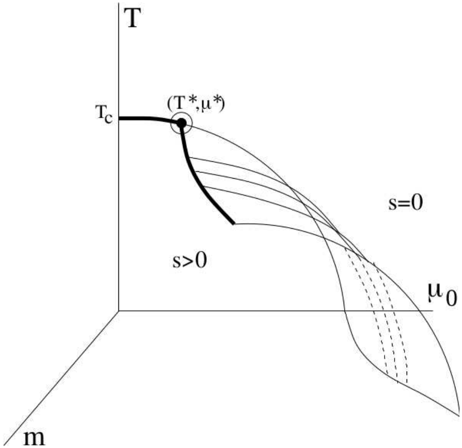
The QCD coupling is strong at low energy: gives rise to hadron physics. At high energy the QCD coupling becomes weak: parton physics dominates. Large effects on baryon stopping. Possibly significant effects on baryon fluctuations.



Figures by T. Parida

(Some details of the set up: Chatterjee's talk tomorrow)

Chiral limit of QCD misses nuclear physics



Since binding energy of nuclei $\ll$ nucleon mass or pion mass, chiral expansions do not see nuclear physics. Is the chiral limit of this phase diagram correct?

Unreal: chiral limit of QCD

Pions are massless, so nuclear force is long-ranged. Therefore there is **no liquid drop model of nucleus**.

Very likely **no deuteron**. Nucleosynthesis chain disrupted.

Proton is more massive than neutron due to QED corrections.

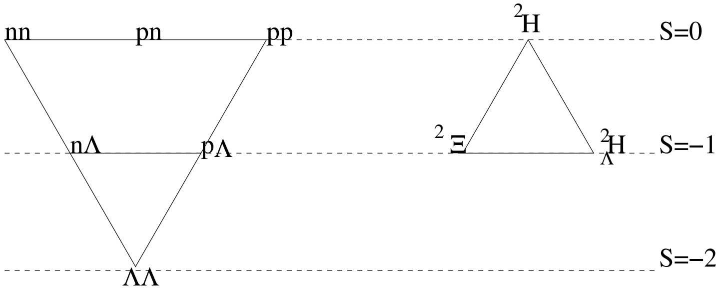
$$M_p - M_n \stackrel{?}{=} 0.58 \pm 0.16 \ \mathrm{MeV}$$

Gasser, Leutwyler, Rusetsky (arxiv:2003.13612)
Either **no β decay, otherwise** $p \to ne^+\nu_e$.

If $M_p > M_n + m_e$ then **pure neutron stars**: charge neutrality requires e^- but p weak decays to give e^+, annihilates until all protons have decayed, leaving only neutrons.

Real: hyper-nuclear physics

Start with an SU(3) triplet of baryons: $\overline{\mathbf{3}} = (\text{p,n}, \Lambda)$, like the Sakata model (1956). Dibaryons irreps of SU(3): $\overline{\mathbf{3}} \times \overline{\mathbf{3}} = \overline{\mathbf{6}} + \mathbf{3}$.



$^2\Xi$ stands for Xenosium (from the Greek $\xi\epsilon\nu o\zeta$ for stranger).
Likely decay mode: $^2\Xi \to (p\pi^-)(pe\overline{\nu}_e)$.
Is the neutral $^2\Xi(n\Lambda)$ bound or free? Implications for particle-nuclear physics.