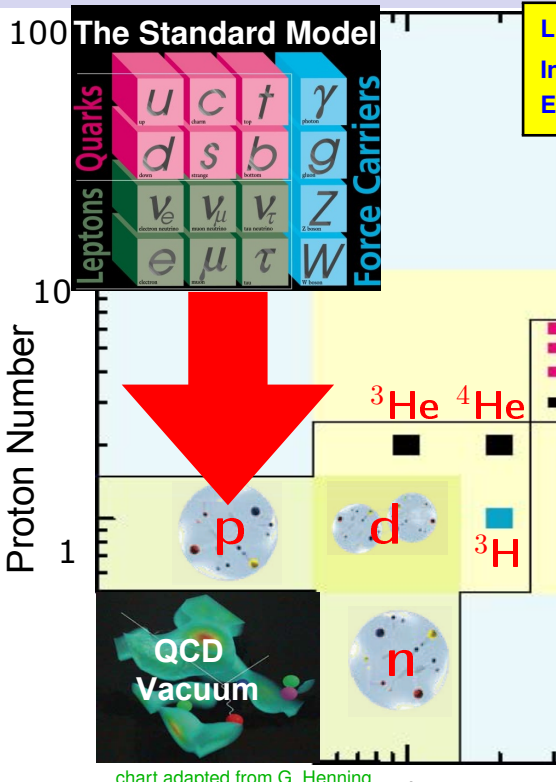


How Important is QCD For The Nuclear Chart?

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Emergence & Reductionism in Nuclear Physics: “Order from Chaos”



LRP: Support Theory!

Investments in theory crucial to fully realise scientific potential.
Enable exploring conceptual (“brushstroke”) ideas.

“simple” QCD \Rightarrow rich low-E structure \Rightarrow patterns

\Rightarrow Quantitatively differentiate between:

Universality \Leftrightarrow unique QCD/Chiral Symmetries & Dynamics

“Trivial” \Leftrightarrow “Interesting” observables

How important are anomalously large NN scatt. lengths?:

$a(^1S_0) = -23.7 \text{ fm}$, $a(^3S_1) = +5.4 \text{ fm} \gg \text{typ. QCD scales}$

Unitarity Limit $|a| \rightarrow \infty$ is State of Heightened Symmetry:

Amplitude saturated – Wigner’s $SU(4)$ spin-isospin symmetry

Scale invariance – dynamically broken in $A \geq 3$ by Efimov effect.

\Rightarrow LO: Nuclear Physics correlated to just one scale: $B(^3\text{H})$.

Is there a “Goldilocks Point of NP”: $\frac{1}{a} \ll k_{\text{typ}} \ll m_\pi$?

\Rightarrow Quantify if expansion about Unitarity converges (also to data)!

Few-Nucleon Consistent With Unitarity

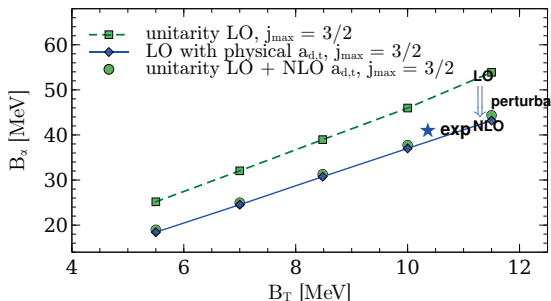
$A = 3$: Parameter-free expansion about Unitarity:

$$[B_{3\text{H-}^3\text{He}}]^{\text{NLO}} = [0.92 \pm 0.18] \text{ MeV} \Leftrightarrow 0.764 \text{ MeV}_{\text{exp}}$$

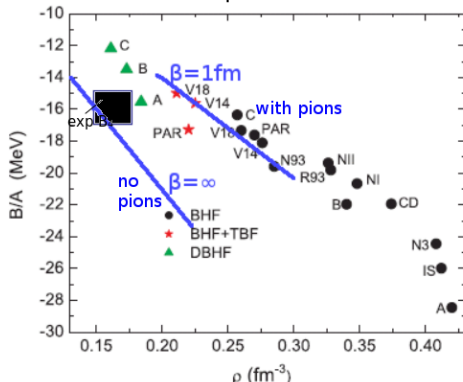
$A = 4$: Efimov Physics: 2 bound states, 1 barely bound.

	Fermion Unitarity LO \rightarrow NLO	exp $^4\text{He}/^3\text{H}$
ground: B_4/B_3	4.6 \rightarrow 3.8 ± 0.2	3.66
excitation: B_4^*/B_3	$\sim 1.1 \rightarrow \sim 0.98 \pm 0.05$	0.96

Explain Tjon line: correlation of ^3H - ^4He binding



Nuclear Matter: Explain near-linear Coester band



	ρ_0	B/A	E_{sym}	slope E_{sym}	K_{∞}
Kievsky/...	0.15	-16	35	70	251
exp	0.16	-16	≈ 30	[40...60]	210

How Far Is Too Far?

Radiates into χ EFT: Re-evaluate rôle of 3N interactions.

PARADIGM SHIFT: De-emphasise πN & NN, emphasise 3N scale & universality.

Insight into concepts \implies Quantitatively test Emergence of ORDER/SIMPLICITY from complexity of NP.

Atomic/Molecular systems: World of "nuclear-landscape-like" states for He, Rb etc. (Feshbach resonances)?

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