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Implication of Quarkyonic duality to the hyperon puzzle

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Duality between quarks and baryons is one of the most fundamental properties of QCD.
We have recently shown in Ref. [1] that the duality is closely tied to Quarkyonic nature of matter at high baryon density. We have formulated a dual model for cold, dense QCD, which allows a thermodynamic description both in terms of baryons or quarks, i.e., one can simultaneously consider the system in terms of quarks and baryons. The confinement of quarks inside baryons sets the transformation between quark and baryonic descriptions. At low density, the baryonic description is more natural, and at high density, the quark description becomes more natural, but at any density one might use one or the other. The nontrivial feature of this theory is that when we persist with the baryonic picture in the region where the quark description is more natural, the shell structure, which is the notable feature of Quarkyonic matter, appears in the pure baryonic distribution owing to the Pauli exclusions among quarks. This Quarkyonic shell structure is dual to a description in terms of quarks with a filled Fermi sea of quarks with a finite Fermi surface.

In this talk, we discuss the implication of this Quarkyonic duality to the hyperon puzzle [2]. We extend the model to three flavors to consider the combined effect between the duality and the strangeness. We discuss that the Quarkyonic shell structure arising from the duality retains even in the presence of strangeness. As a result, the threshold density for the hyperons are shifted to even higher density compared to the conventional treatment, and the hyperonic softening of the equation of state becomes milder. This will provide a systematic way toward the resolution of the hyperon puzzle from the fundamental aspect of QCD.

References:
[1] Y. Fujimoto, T. Kojo, L. McLerran, To appear in Phys. Rev. Lett., arXiv:2306.04304 [nucl-th].
[2] Y. Fujimoto, T. Kojo, L. McLerran, In preparation.

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