High-density kaonic-proton matter (*KPM*) composed of $\Lambda^* \equiv K^-p$ multiplets and its astrophysical connections

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We propose and examine a new high-density composite of $\Lambda^* \equiv K^-p = (s\bar{u}) \otimes (uud)$, which may be called kaonic proton matter (KPM), or simply Λ^*-*Matter*[1)], where baryonic bound systems originating from the strong attraction of the $(\bar{K}N)^{I=0}$ interaction shrinks substantially,[2,3)] providing a ground-state neutral baryonic system with a huge energy gap (see details in Ref. 1). Recent experimental data[4–6)] support this view.

The mass of an ensemble of $(K^-p)_m$, where m, the number of the K^-p pair, is larger than $m \approx 10$, is predicted to drop below its corresponding neutron ensemble, $(n)_m$, since the attractive interaction is further increased by the Heitler-London type molecular covalency[7)], as well as by chiral symmetry restoration of the QCD vacuum.[8–11)] Since the seed clusters (K^-p, K^-pp and K^-K^-pp) are short-lived, the formation of such a stabilized relic ensemble, $(K^-p)_m$, may be conceived during the Big-Bang quark-gluon-plasma (QGP) period in the early universe before the hadronization and *quark-anti-quark* annihilation proceed.

At the final stage of baryogenesis a substantial amount of primordial $(\bar{u}, \bar{d})$s are transferred and captured into KPM, where the anti-quarks find places to survive forever. The expected KPM state may be *cold, dense and neutral* $\bar{q}q$*-hybrid (quark gluon bound (QGB)) states,* $[s(\bar{u} \otimes u)ud]_m$, to which the relic of the disappearing anti-quarks plays an essential role as hidden components. The KPM may also be produced during the formation and decay of neutron stars.

The formation of KPM from the primordial Big Bang proceeds, as $u, \bar{u}, d, \bar{d}, s, \bar{s}$ quarks are produced in QGP at high temperatures and densities. With decreasing temperature it changes to the pre-hadronization stage, where K^-p, K^-pp and K^-K^-pp with large binding energies are formed. Then, stable $(\Lambda^*)_{10}$ composites are formed, which eventually grow the increasingly larger, but become cold matter with eventual formation of QGB states. Three quark sectors in the early universe during the disappearance of anti-quark matter become i) the disappearing *ANTI-QUARK* sector ii) quark-anti-quark *HYBRID* sector, where *relic and stable* precursors of $K^-p = s\bar{u} - uud$ are formed, and iii) the remaining ordinary *QUARK* sector.

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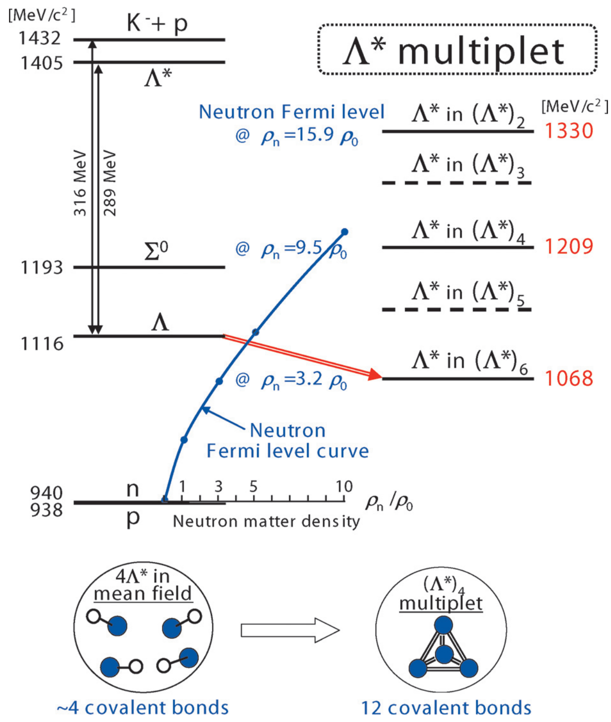

Fig. 1. Predicted energy levels of $\Lambda^* = K^-p$ in Λ^* multiplets calculated by a variational method. The corresponding nuclear densities and neutron Fermi levels are also shown, indicating that the Λ^* in $(\Lambda^*)_6$ cannot decay to a neutron in neutron matter at $\rho = 3.2 \times \rho_0$.

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