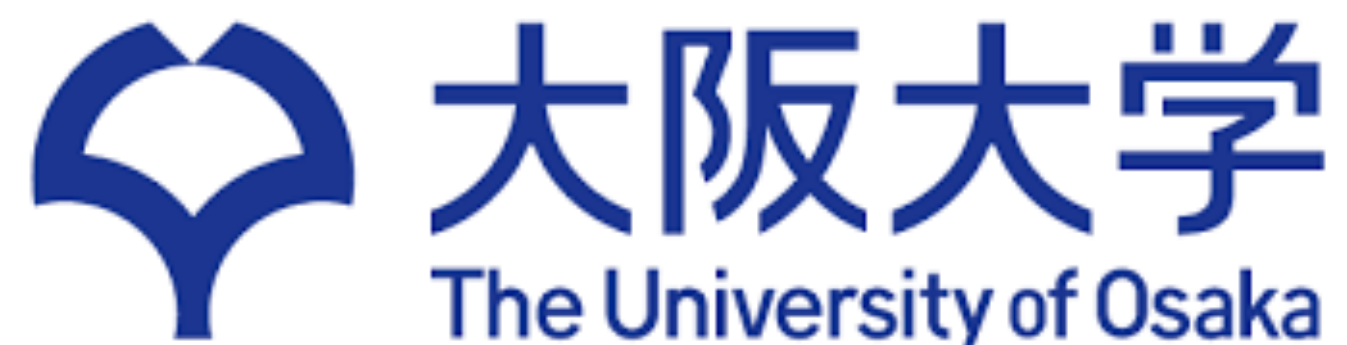


Chiral symmetry restoration and hyperon suppression in neutron stars

Bikai Gao

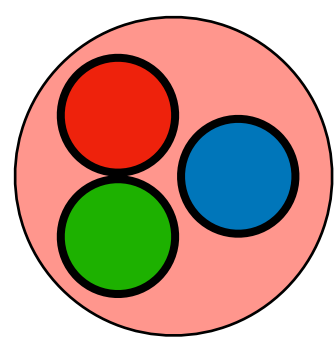
Research Center for Nuclear Physics (RCNP), Osaka University

B. Gao, *Phys.Rev.D* 113 (2026) 8, 083012

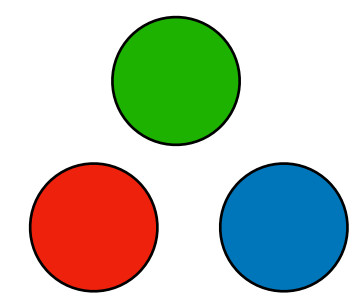


Origin of nucleon mass?

Nucleon \longrightarrow Three quarks



$\sim 1000 \text{ MeV}$



$\sim 10 \text{ MeV}$

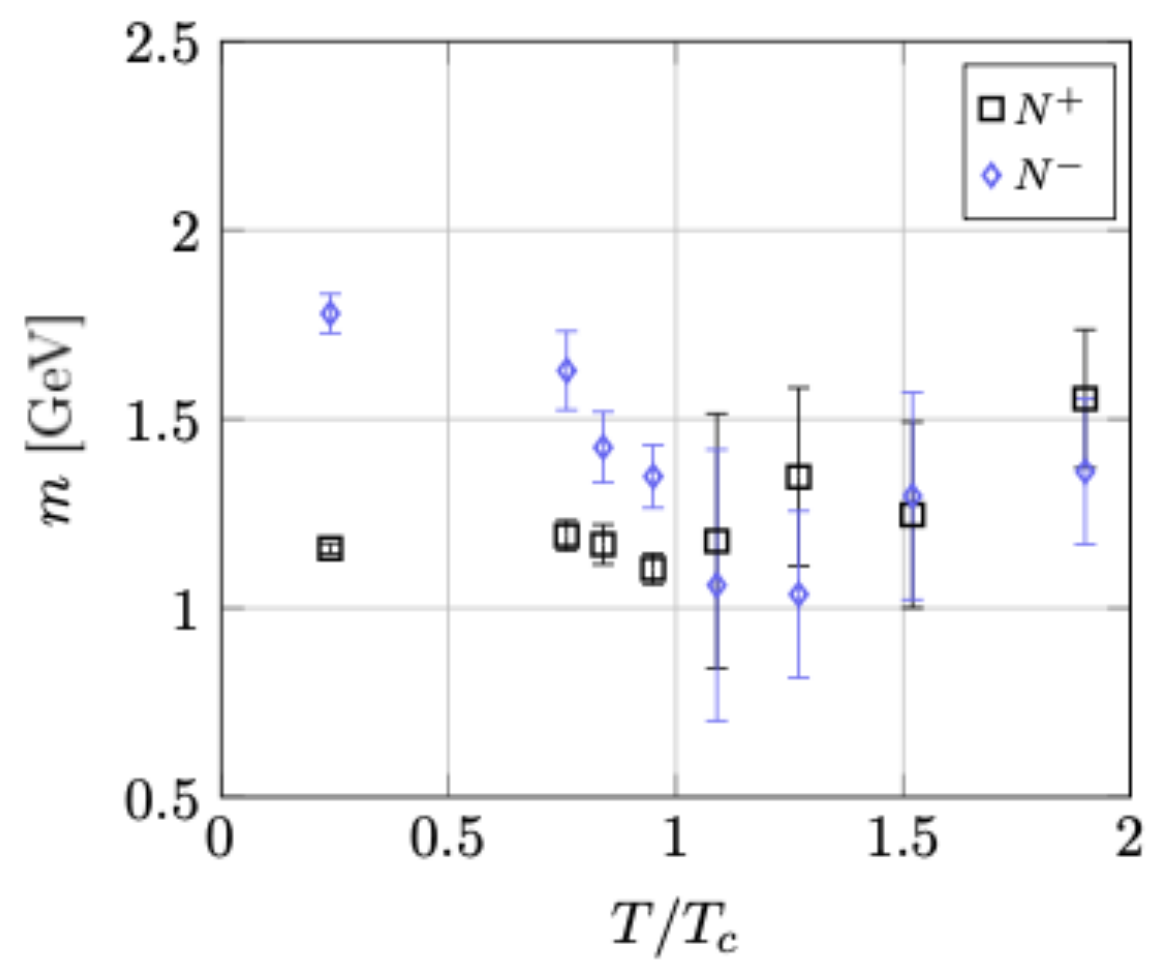
Where is the actual origin of nucleon mass?

- Spontaneous breaking of chiral symmetry $\sigma \sim \langle \bar{q}q \rangle$

In effective models, e.g. linear-sigma model, $M_N \propto \sigma$

$M_N \rightarrow 0 ?$

- On the other hand, **lattice QCD at finite T** (e.g. Aarts+'15,'18):



Other contribution?
chiral invariant mass m_0

m_0 : from gluon condensation?

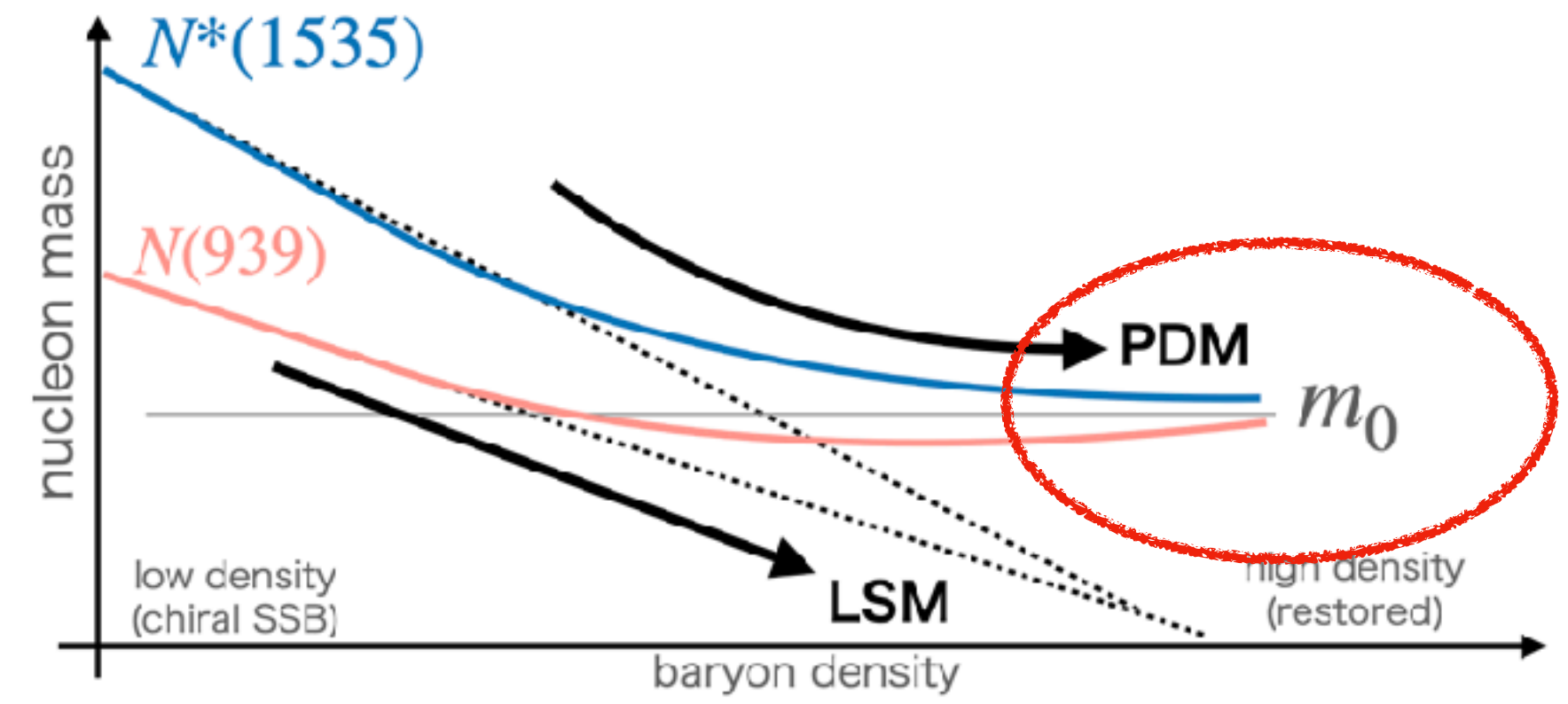
Hadronic chiral effective model based on parity doublet structure

C. DeTar and T. Kunihiro(1989);
D. Jido, M. Oka, and A. Hosaka(2001)

SU(2) Parity Doublet Model(PDM)

$$M_{N_{\pm}} = \sqrt{m_0^2 + g_+^2 \sigma^2} \mp g_- \sigma \xrightarrow{\sigma \rightarrow 0} m_0$$

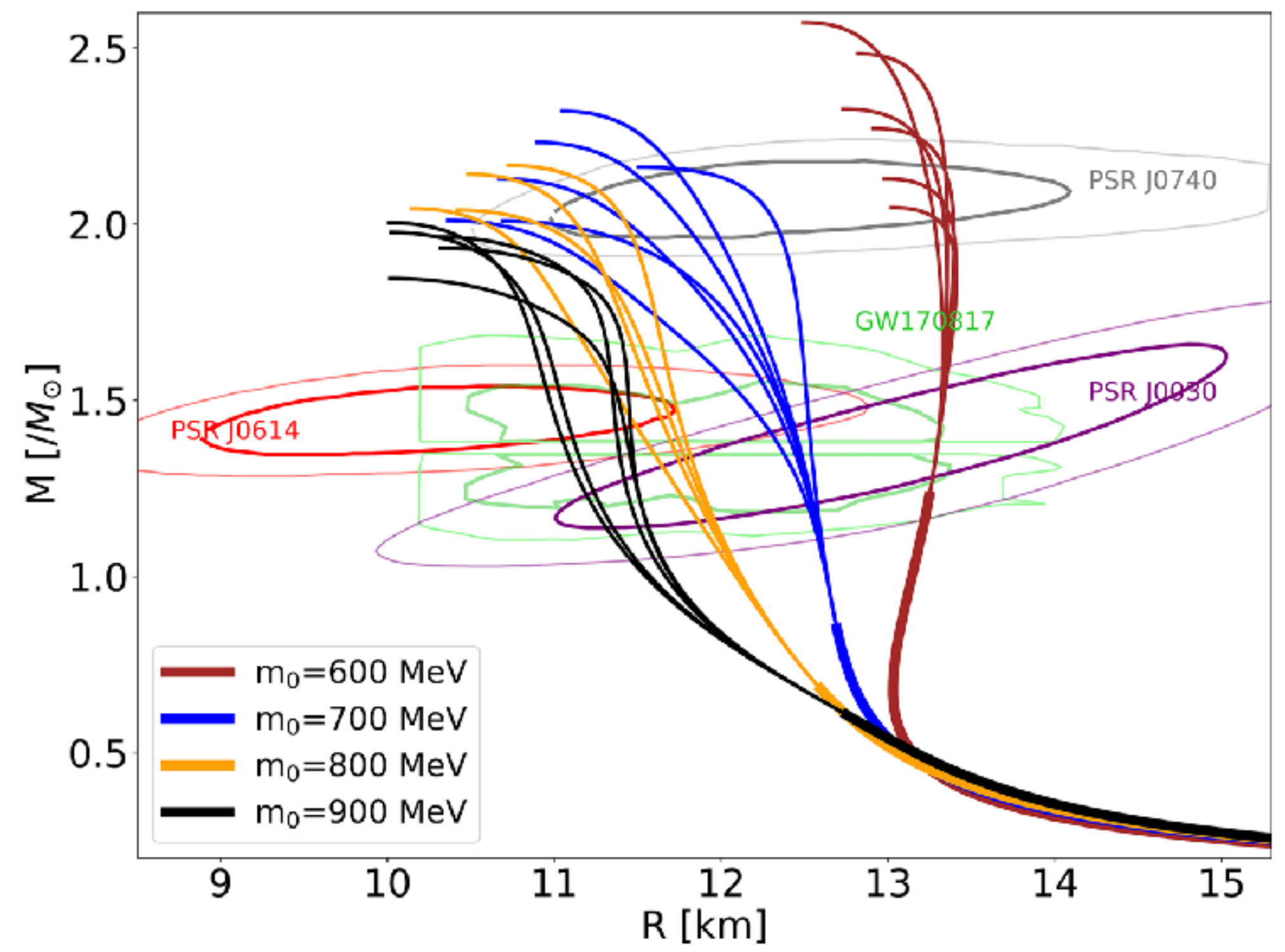
N_+ : Ground state nucleon; N_- : Excited state $N^*(1535)$



$$M_N = M_{SB} + m_0$$

Hyperon puzzle

B. Gao, Y. Kong, Y.L. Ma. (2025)

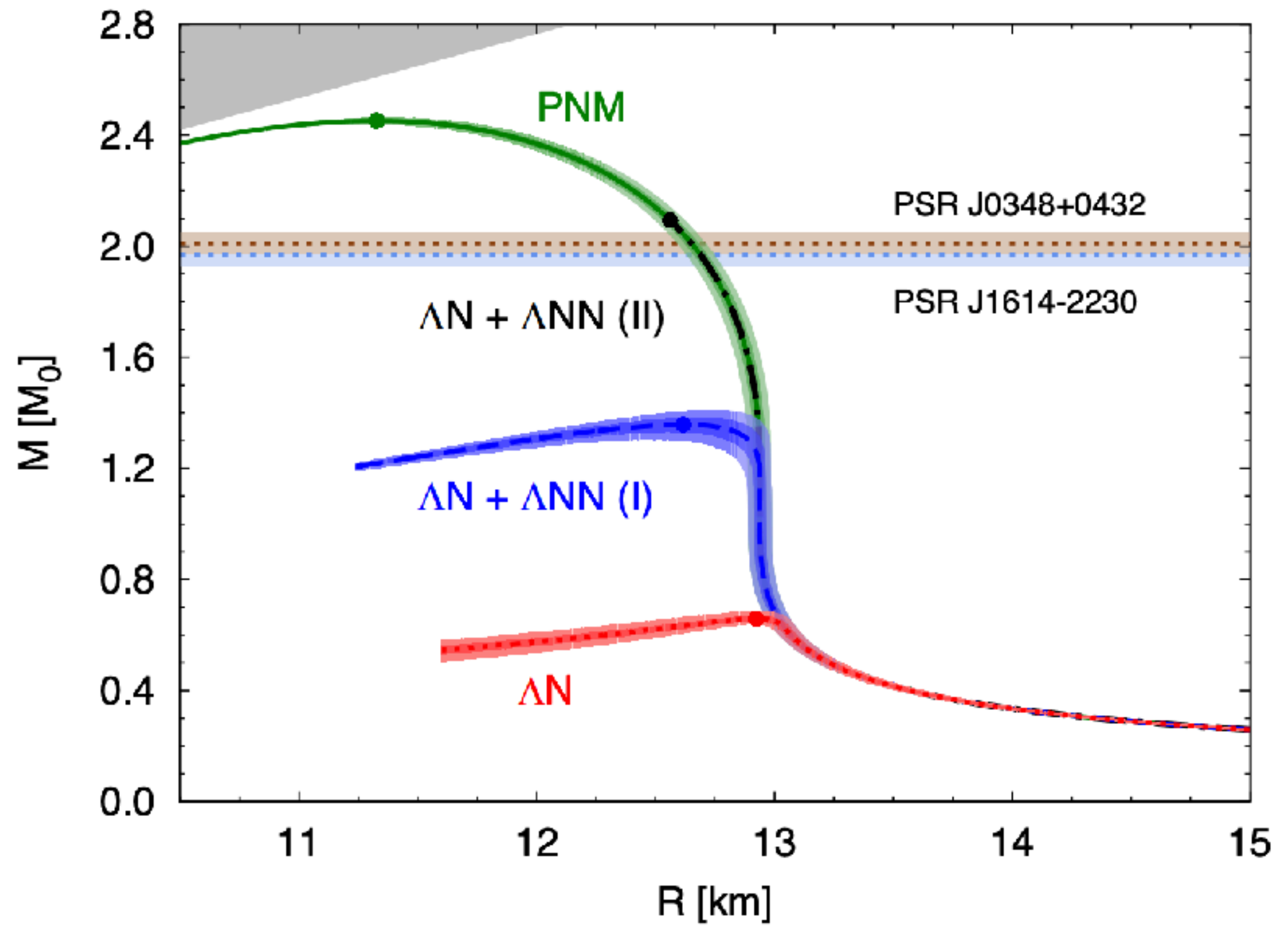


GW + PSR J0030 + PSR J0740

$$580 \leq m_0 \leq 860 \text{ MeV}$$

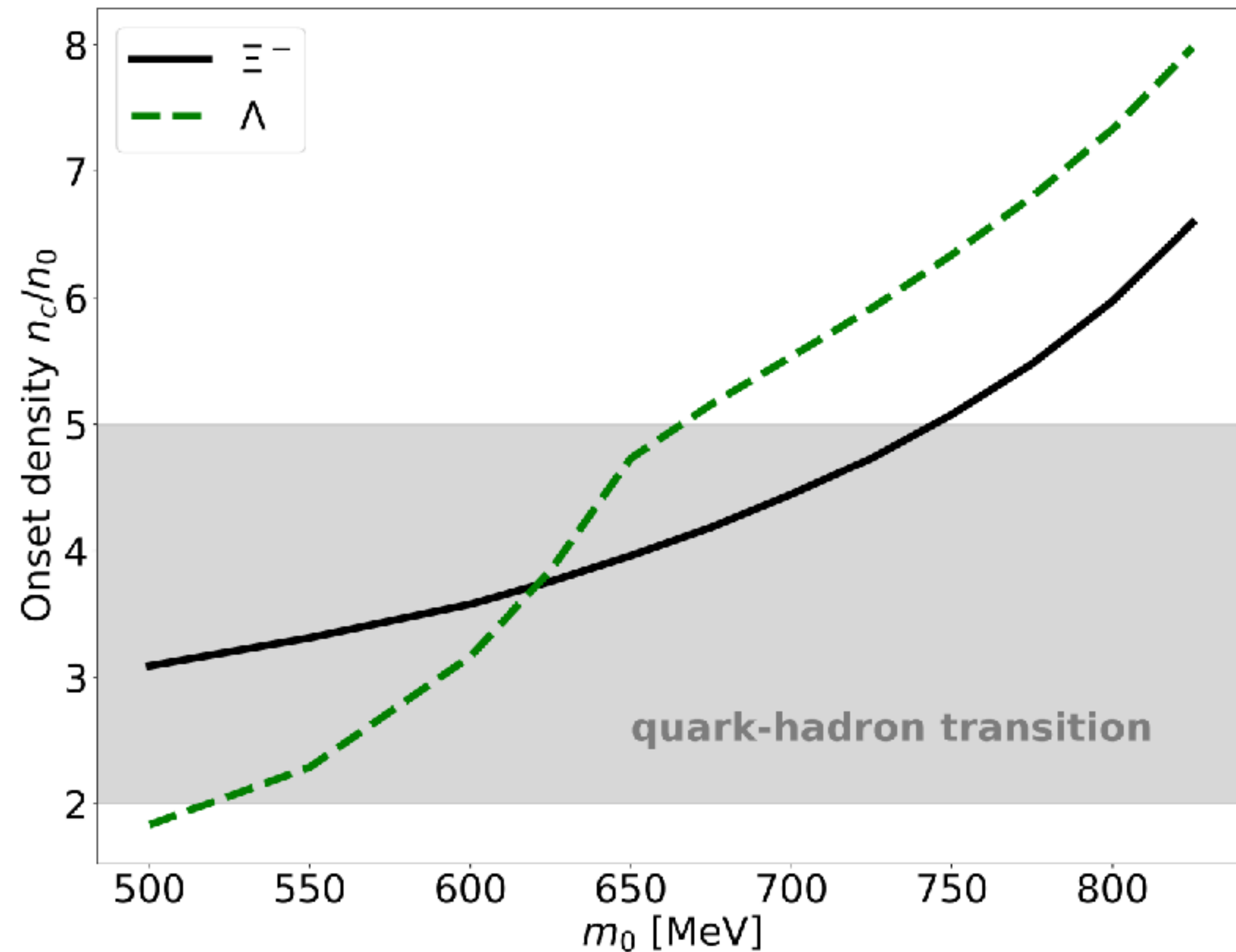
More than half of the nucleon mass originates from the source beyond the chiral condensate!

Hyperon puzzle



Motivation: **Effects of m_0 for hyperons**

Onset of hyperon



Main result:

For $m_0 = 700$ MeV,
**Appear above the density range associated with
quark-hadron phase transition**

For large chiral invariant mass

Hyperons may not appear in the NS core!
(Possible solution to hyperon puzzle)

Thanks for your attention!