Neutron Star Mergers Chirp About Vacuum Energy

[arXiv:1802.04813 [astro-ph.HE]]

Gabriele Rigo (Syracuse)

Csaba Csáki (Cornell), Cem Eröncel (Syracuse),
Jay Hubisz (Syracuse), John Terning (Davis)

Mass: From the Higgs to Cosmology

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Conclusion

It is possible to learn about fundamental physics from the observation of gravitational waves.

The Cosmological Constant Problem

Today the cosmological constant is very small:

$$\Lambda \sim (10^{-3}\,\mathsf{eV})^4 \ll \mathsf{TeV}^4, M_{\mathsf{Pl}}^4.$$

There are still a lot of questions:

- Should we interpret it as vacuum energy of the underlying QFT?
- Why so small? Why not zero?
- Is it always small? Is there an adjustment mechanism?

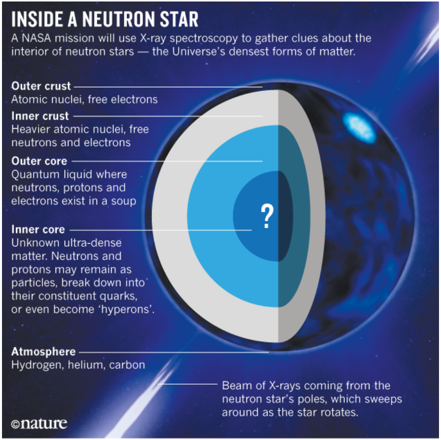
Testing the CC Picture

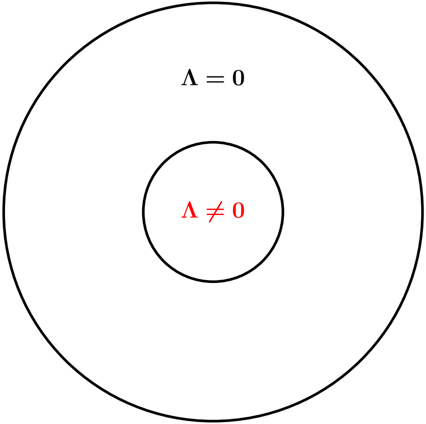
How to test phases of the SM different from the usual one?

NEUTRON STARS

- In the core there might be an unconventional QCD phase at low temperature T and large chemical potential μ
- The VE is an $\mathcal{O}(1)$ fraction of the total energy
- The internal structure is described by an equation of state

Dissecting Neutron Stars





E. Gibney, "Neutron Stars Set to Open Their Heavy Hearts", *Nature* **546**, 18 (2017).

Effects of Vacuum Energy in the Core

Let's assume that the core is in a different phase of QCD.

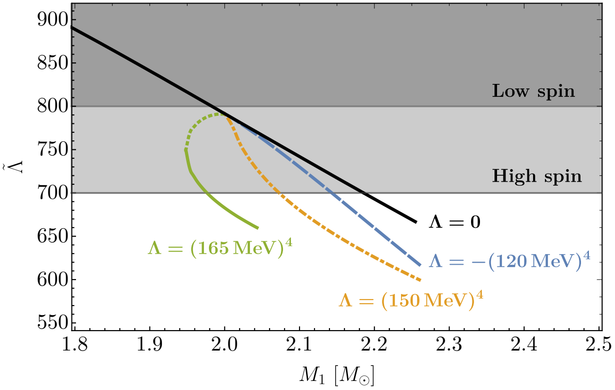
By definition we introduce a vacuum energy contribution as

$$p = K_7 \rho^{\gamma_7} - \Lambda,$$
$$\epsilon = (1 + a_7)\rho + \frac{K_7}{\gamma_7 - 1}\rho^{\gamma_7} + \Lambda.$$

Notice that:

- VE is a term which is independent of density
- We assume the phase transition to be first order

Money Plot



- $\tilde{\Lambda}$ describes how the stars deform
- It is one of the main physical observables of LIGO/Virgo
- VE can significantly alter the allowed mass range

Thank you!