Finding strangelets in cosmic rays from HESS J1731-347, a possible strange quark star

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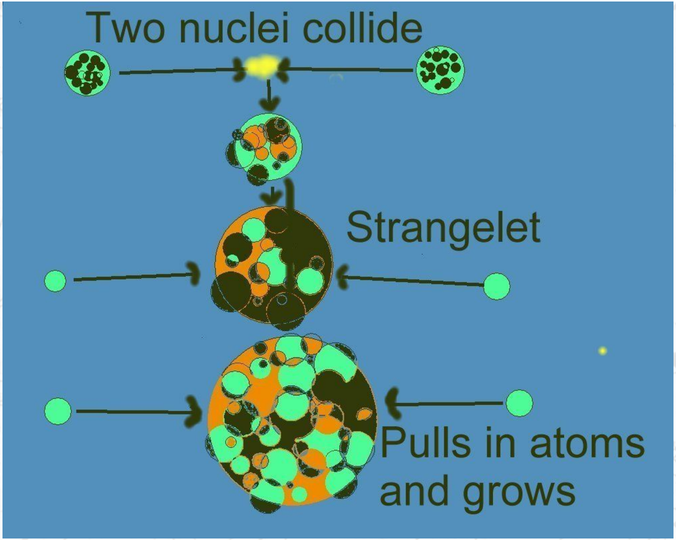


Strangelets are composed of about equal numbers of up, down, and strange quarks; their mass number A is the total of all quarks divided by three; and Z is the charge number, or net electric charge.

Strangelet is highly stable!

- Original Strangelet Stability Arguments:
  - *Cosmic separation of phases, Edward Witten, Phys. Rev. D **30**, 272 (1984).*
  - *Strange matter, Edward Farhi and R. L. Jaffe, Phys. Rev. D **30**, 2379 (1984).*

- Low-A, Negatively Charged Strangelets as a Danger:
  - *Collapsed Nuclei, A. R. Bodmer, Phys. Rev. D **4**, 1601 (1971).*
  - *Strangelet propagation and cosmic ray flux, Jes Madsen, Phys. Rev. D **71**, 014026 (2005).*
  - *Universal Charge-Radius Relation for Subatomic and Astrophysical Compact Objects, Jes Madsen, Phys. Rev. Lett. **100**, 151102 (2008).*
  - *Separation of strangeness from antistrangeness in the phase transition from quark to hadron matter: Possible formation of strange quark matter in heavy-ion collisions, Carsten Greiner, Peter Koch, and Horst Stöcker, Phys. Rev. Lett. **58**, 1825 (1987).*

Experimental Constraints

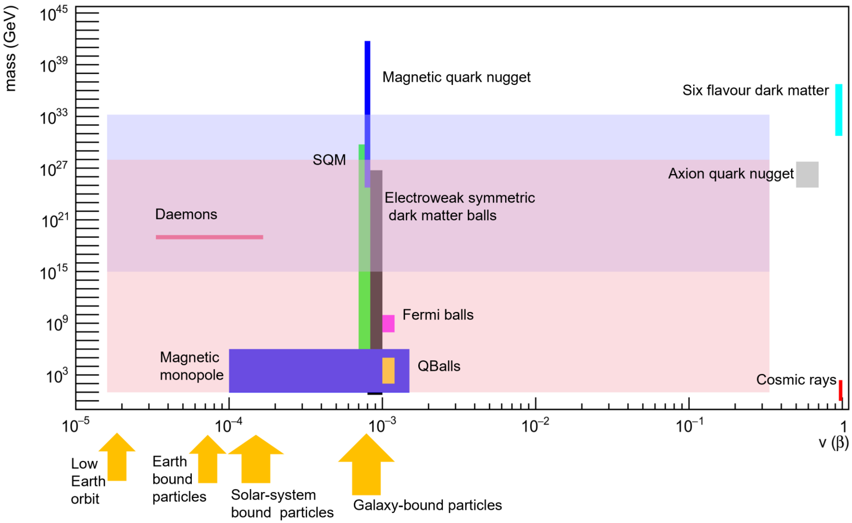
- If stable and negatively charged strangelets existed, they would be observable in cosmic rays, but none have been discovered.

Strangelets, Nuclearites, Q-balls–A Brief Overview, Jes Madsen, arXiv: astro-ph/0612740.

*Review of the safety of LHC collisions, John Ellis et al, J. Phys. G: Nucl. Part. Phys. **35**, 115004 (2008).*

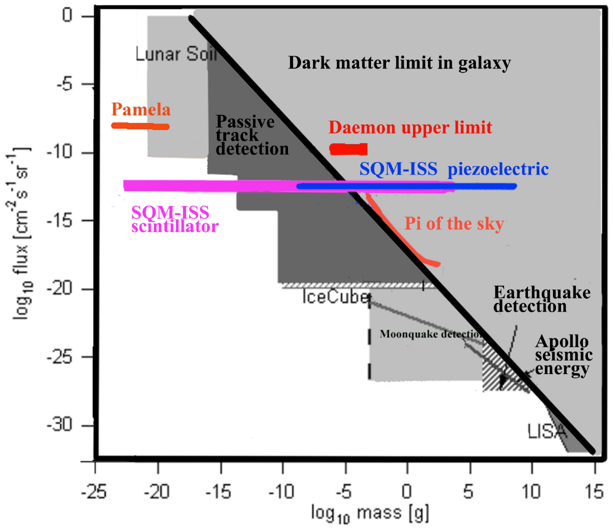
A critical look at risk assessments for global catastrophes, Adrian Kent, arXiv: hep-ph/0009204.

Strange Quark Matter (SQM)



Plot of velocity and mass range for hypothetical slow-moving, heavy particles.

Strange Quark Matter (SQM)



Current upper bounds on SQM search as a function of presumed mass.

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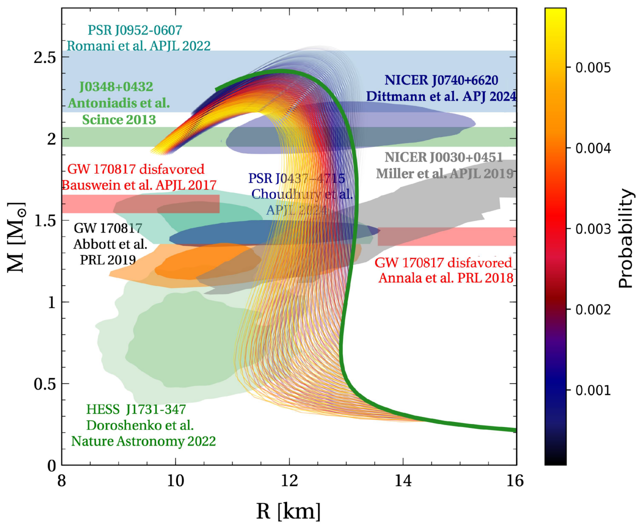

Mass: $\sim 0.77 - 0.88 M_\odot$ and Radius: ~ 10.4 km.

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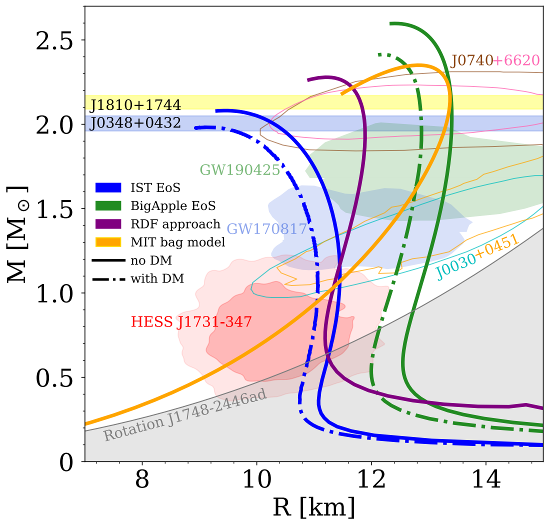

Mass: $\sim 0.77^{+0.20}_{-0.17} M_\odot$ and Radius: $\sim 10.4^{+0.86}_{-0.78}$ km.

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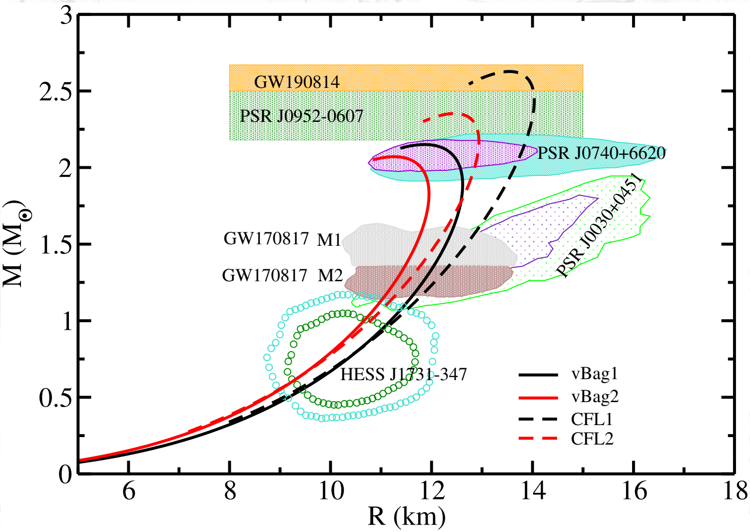

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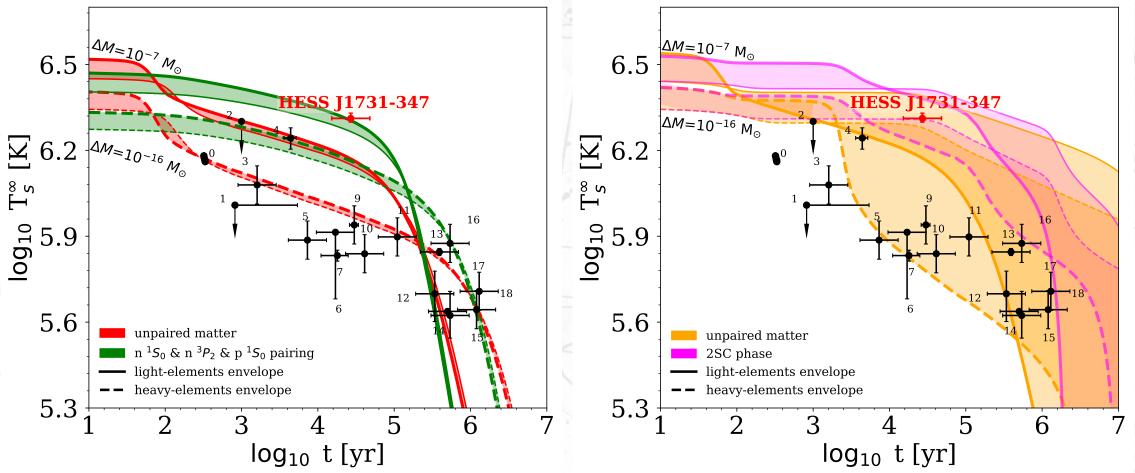

The left and right panels, respectively, display the cooling curves for NSs and HSs.

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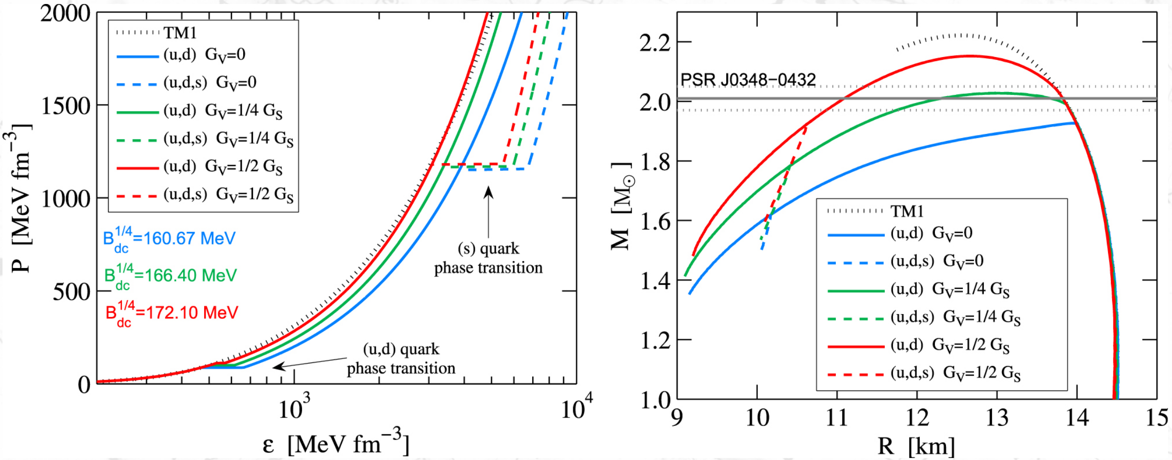

Energy density $\epsilon = 200 - 600$ MeV$/$fm^{-3} and pressure $P = 60 - 80$ MeV$/$fm^{-3}.

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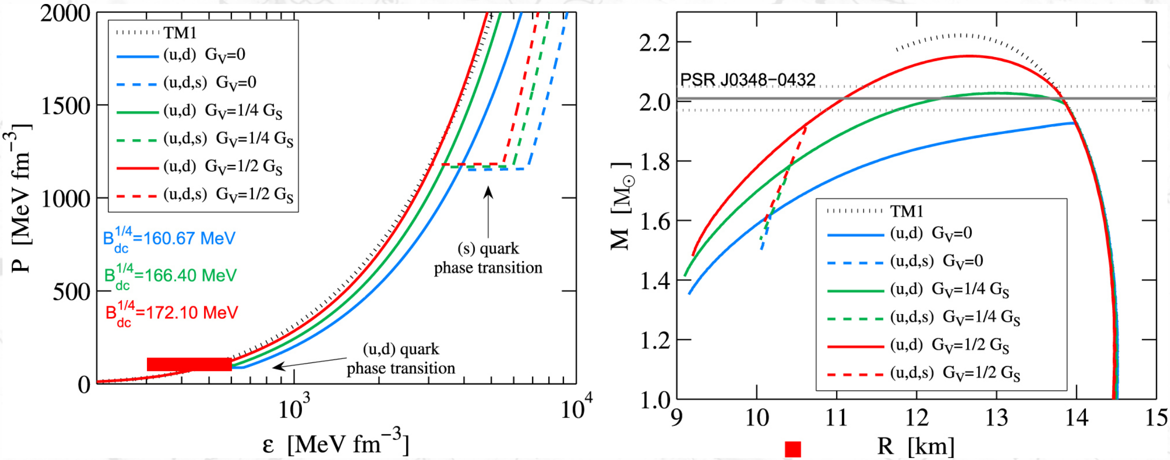

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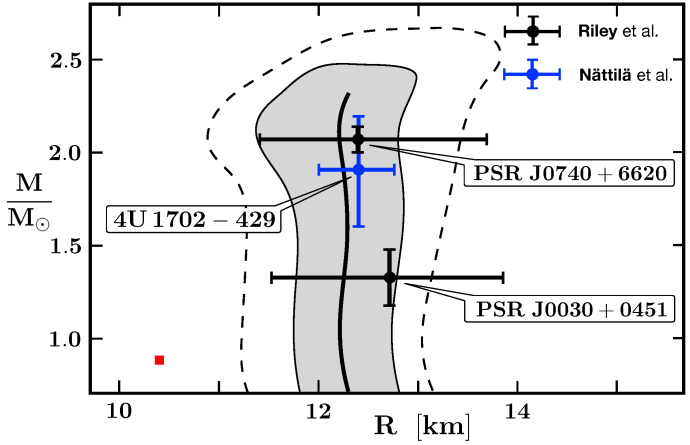

Numerically solving the Tolman-Oppenheimer-Volkov (TOV) equations yields posterior credible bands for the mass-radius relationship of neutron stars at the 68% (gray band) and 95% (dashed line) levels, as compared to NICER data analysis.

Strangelet production in HESS J1731-347