# The Physics of Neutron Stars

Reed Clasey Essick
KICP

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Compton Lectures
University of Chicago

NOTE!
next week's lecture will be in
**KPTC 120**

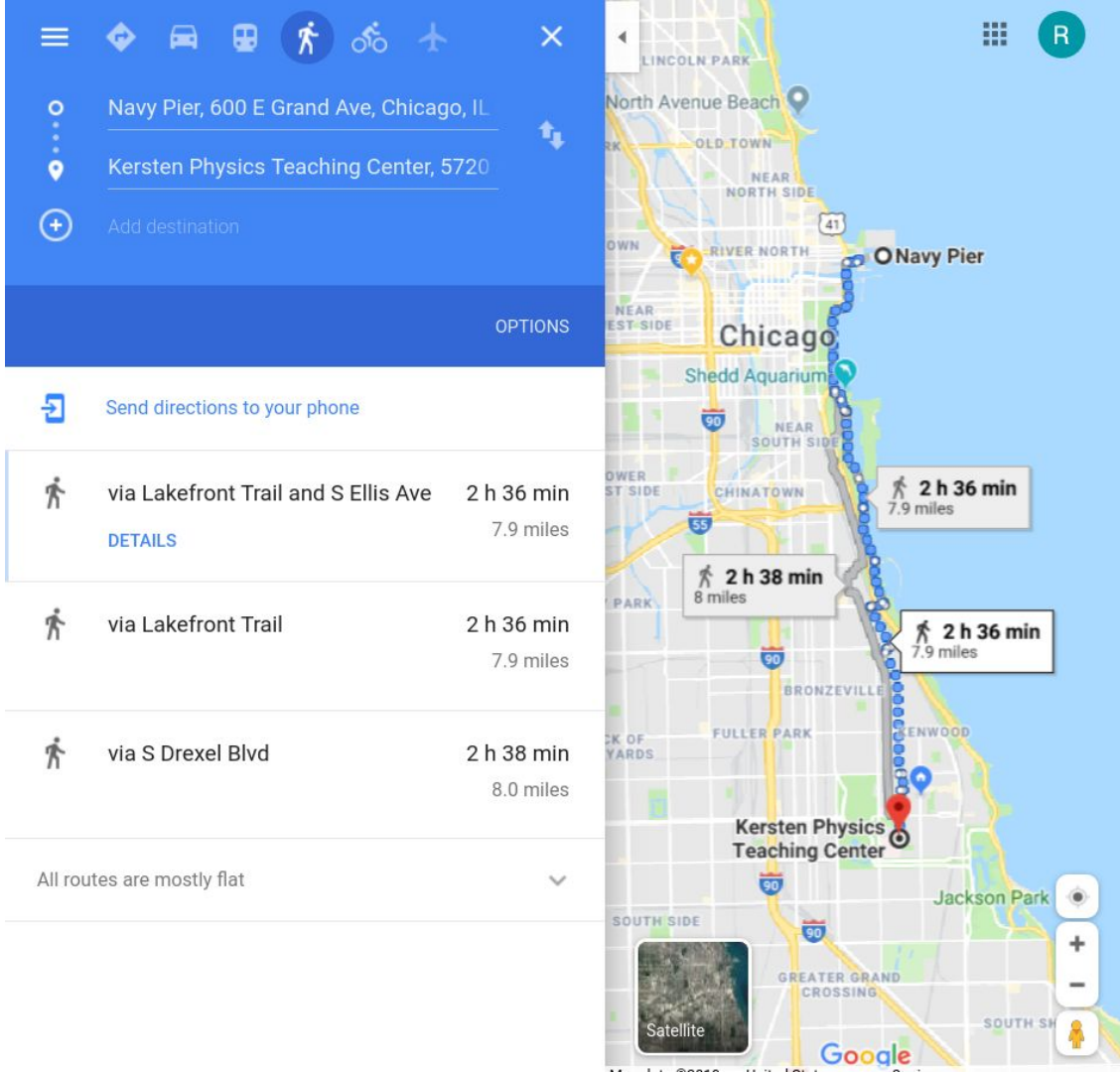
https://github.com/reedessick/compton-lectures-2019

# Review

Neutron stars go by many names

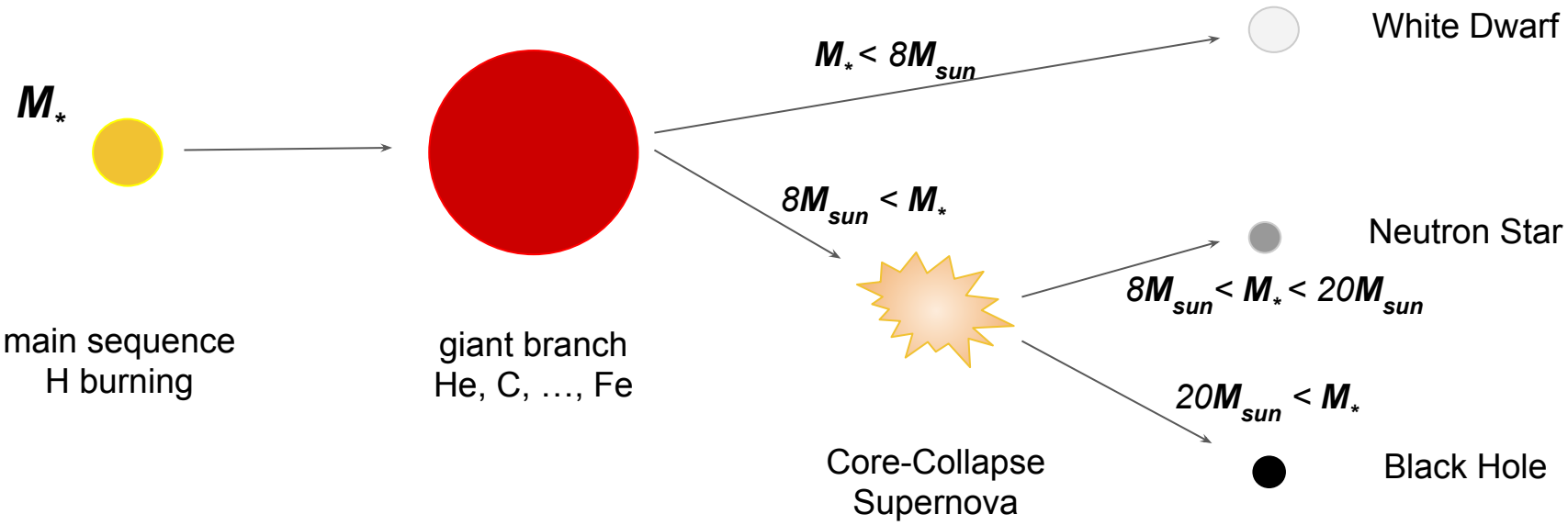
- Pulsar
- Magnetar
- Low-mass X-ray binary
- High-mass X-ray binary

**The mass of the sun in a ball**
**16 miles in diameter**



# Review

**Neutron Stars** and **Black Holes** are the end states of massive stars



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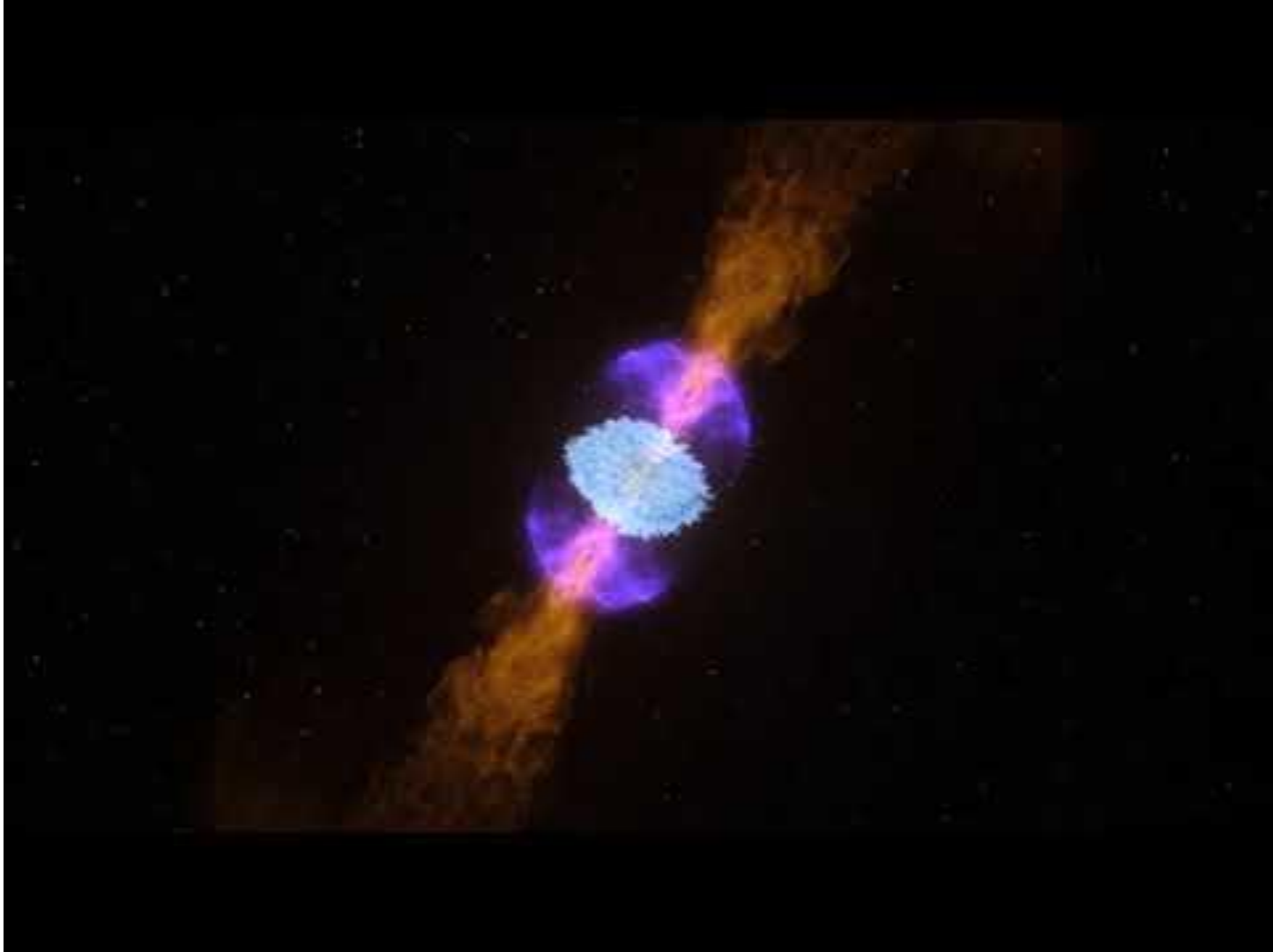

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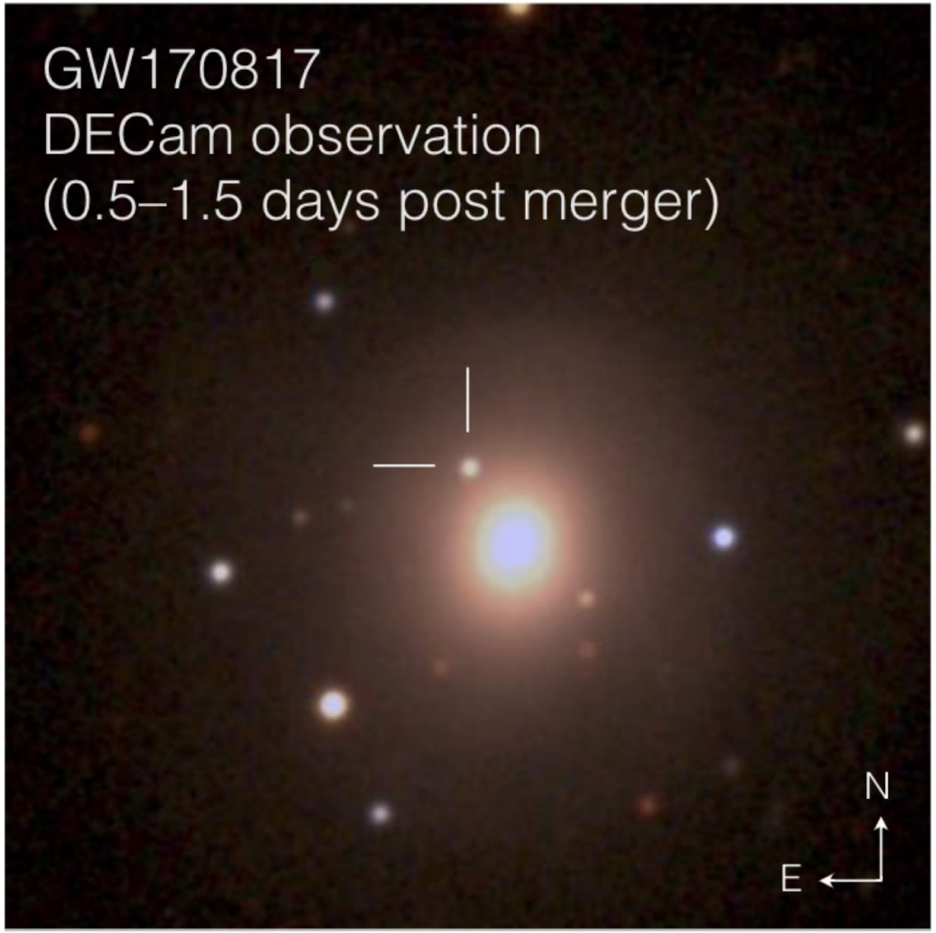
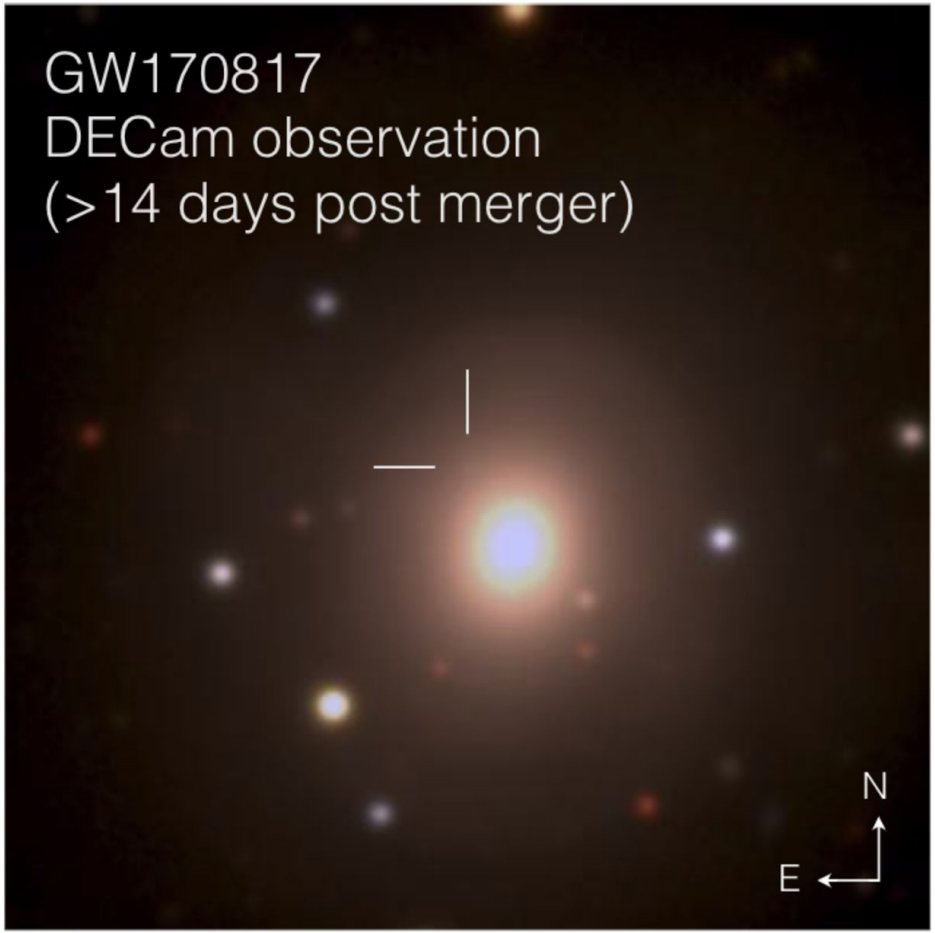
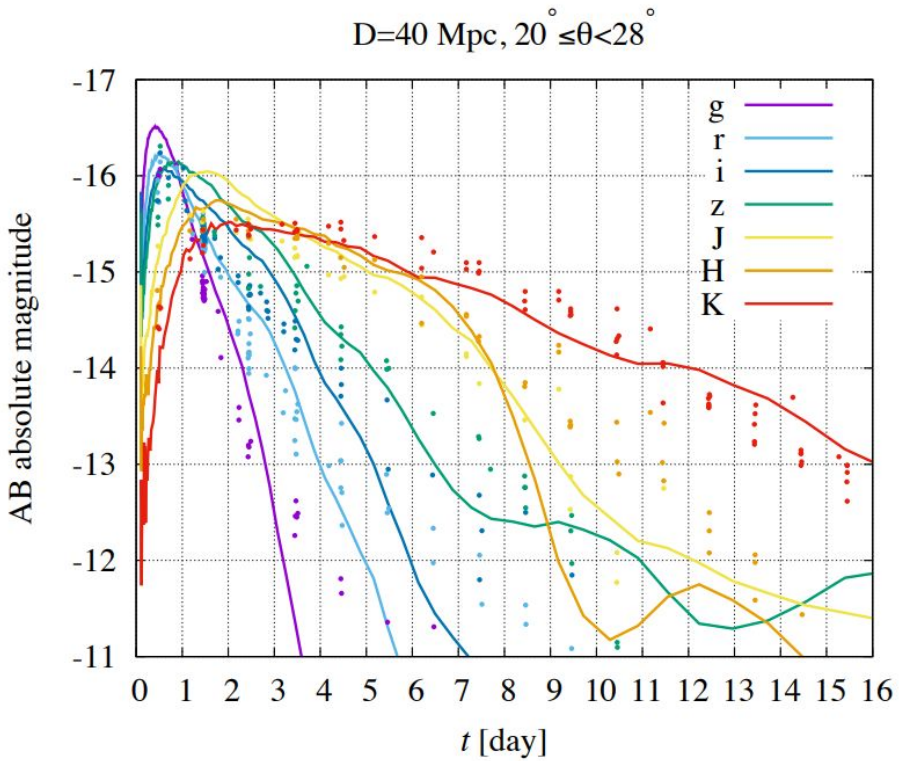
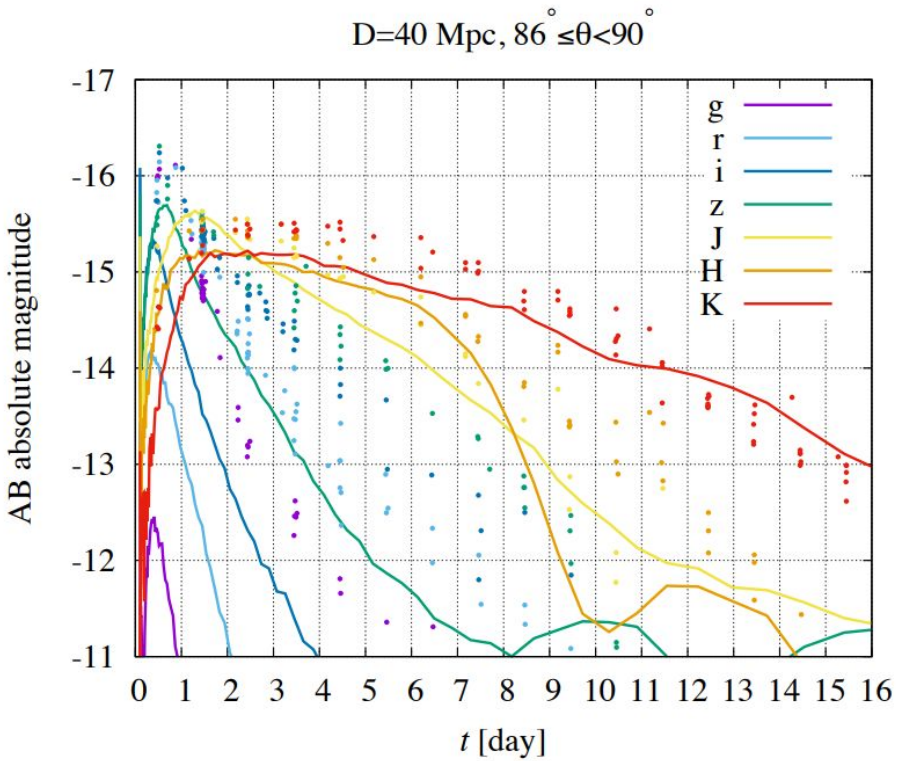

GW170817
DECam observation
(0.5–1.5 days post merger)
N
E


GW170817
DECam observation
(>14 days post merger)
N
E

# Review


D=40 Mpc, 20°≤θ<28°
AB absolute magnitude
t [day]
g
r
i
z
J
H
K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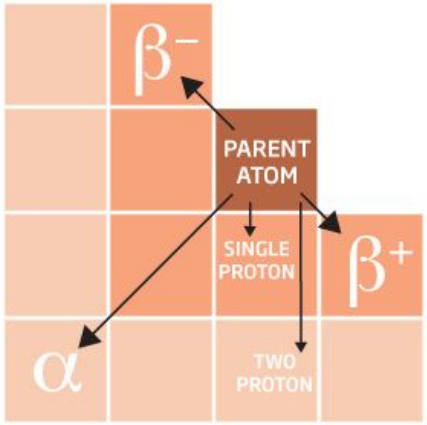




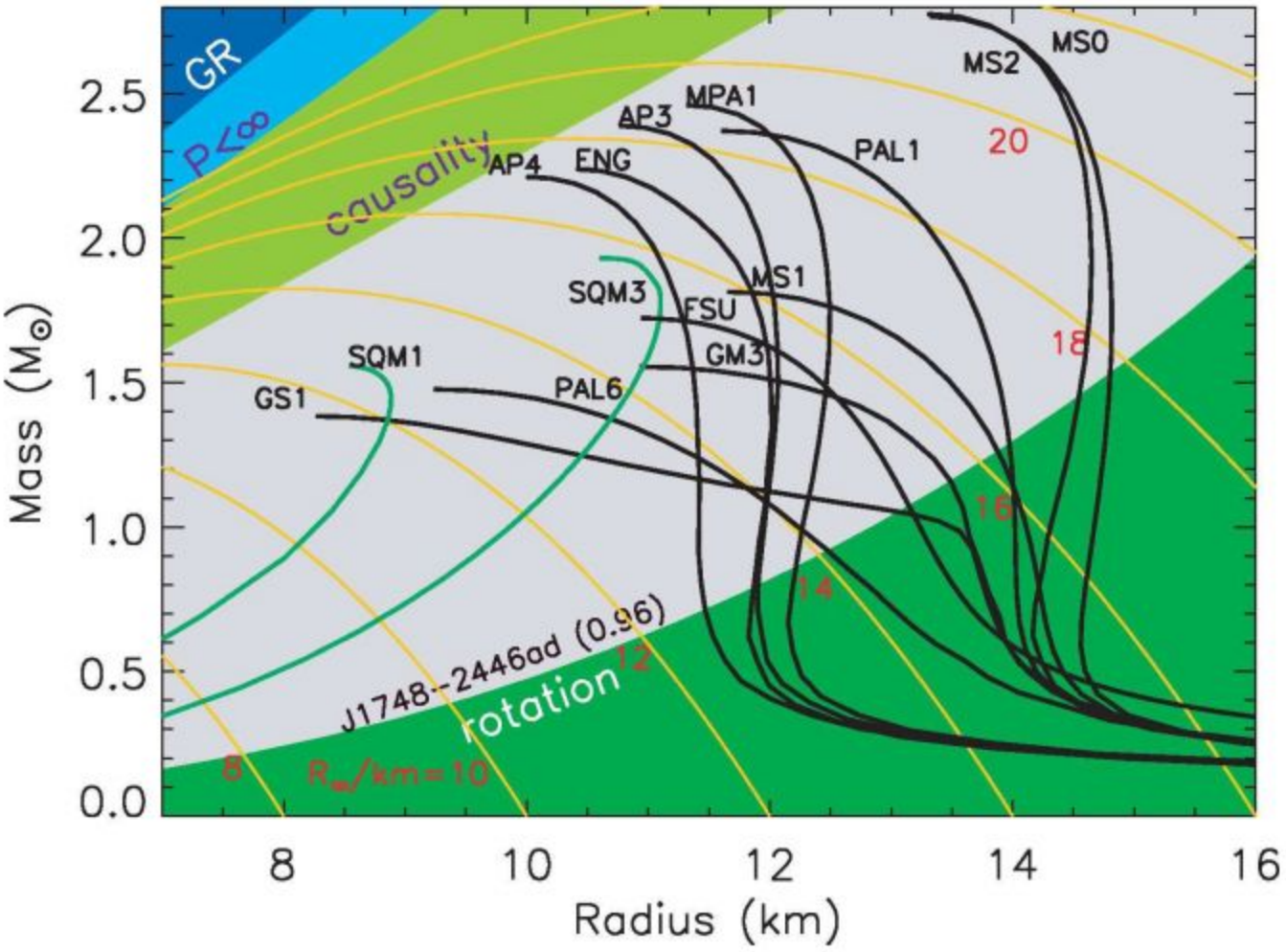


CCSN?
Kilonova?

main-sequence fusion

Iron-56

# What are Neutron Stars?



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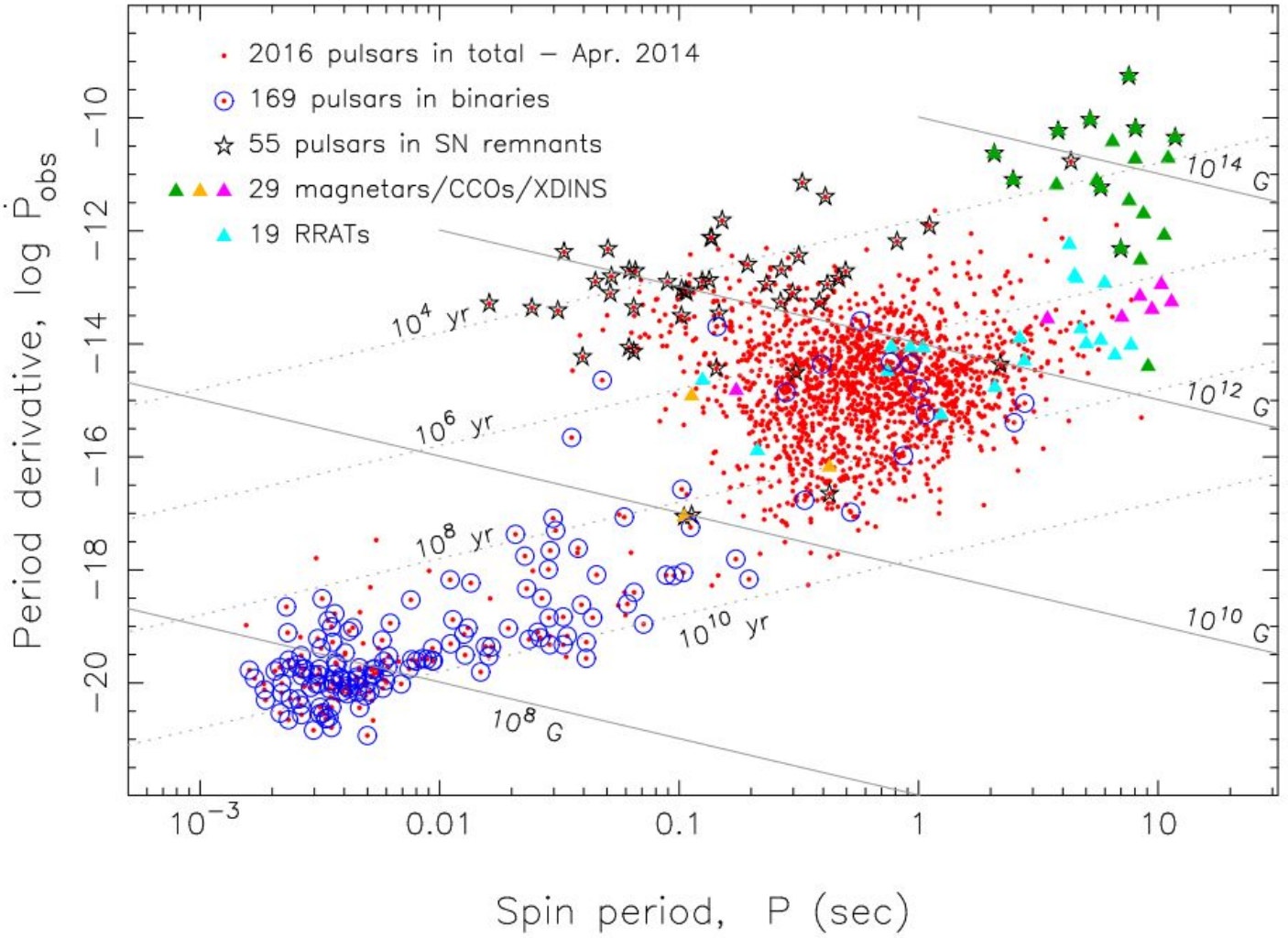

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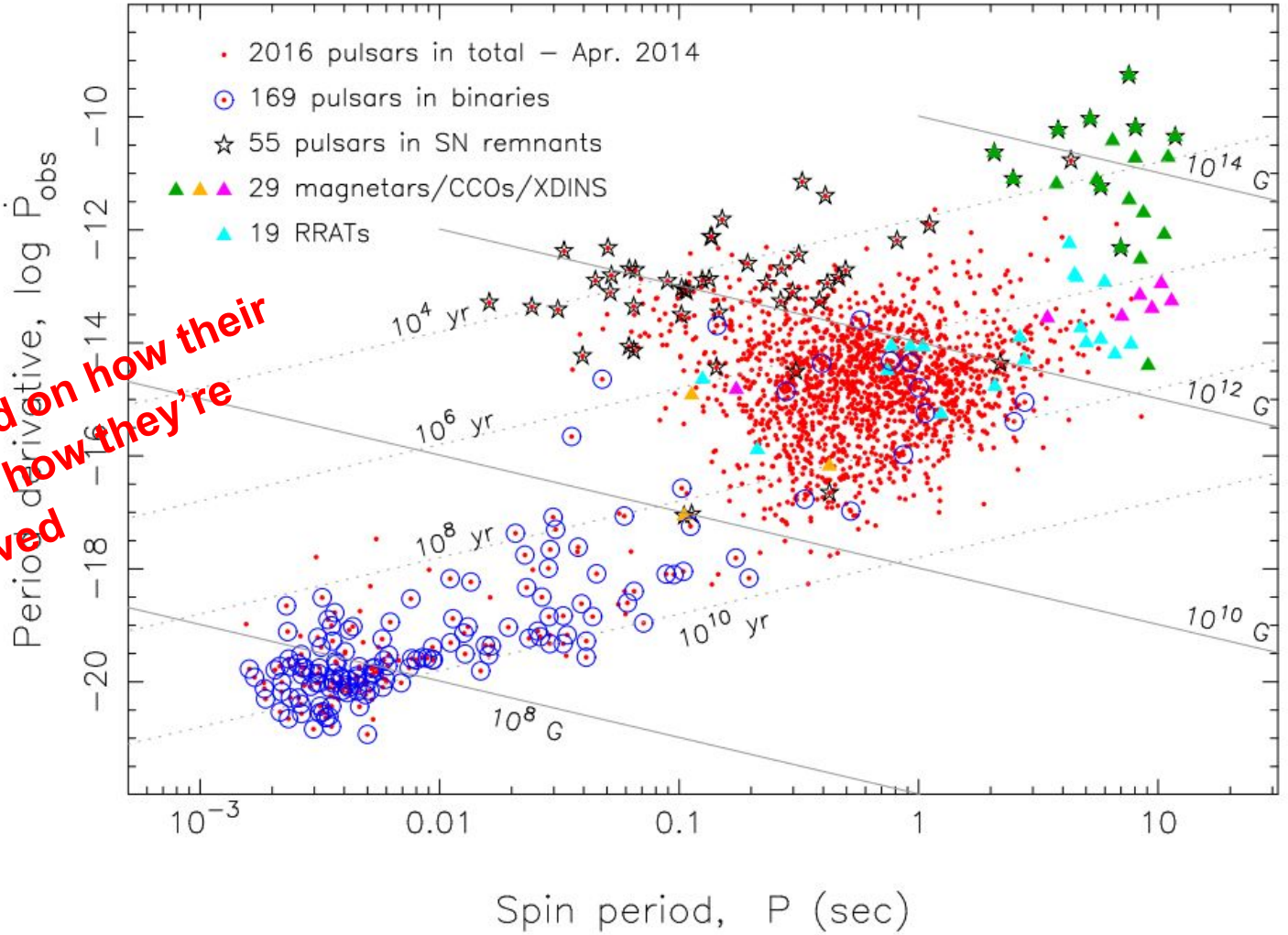


**different names based on how their environment and how they're observed**

# What are Neutron Stars?

- How do stars support themselves against gravity?
- What is an Equation of State?

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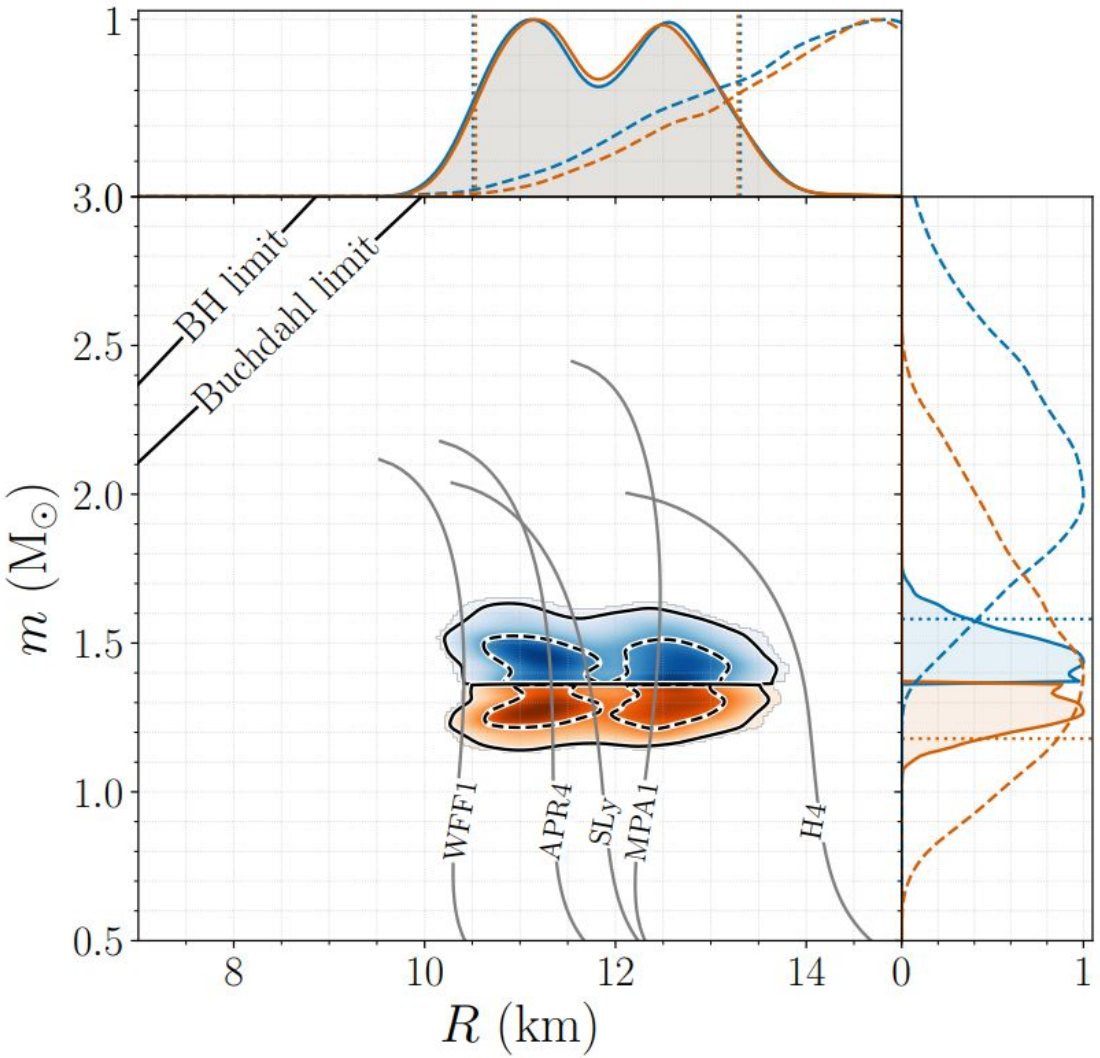
# What do NS do in CBCs?

- Linear tidal deformability
- Dynamical tides, nonlinear tides
- Tidal disruption

# EOS Inference with GWs



# EOS Inference with GWs

- Self-consistently incorporate information from arbitrary tabulated EOS models
- Automatically incorporate causality constraints and thermodynamic stability
- Allow for large amounts of model freedom
- Incorporate transparent priors

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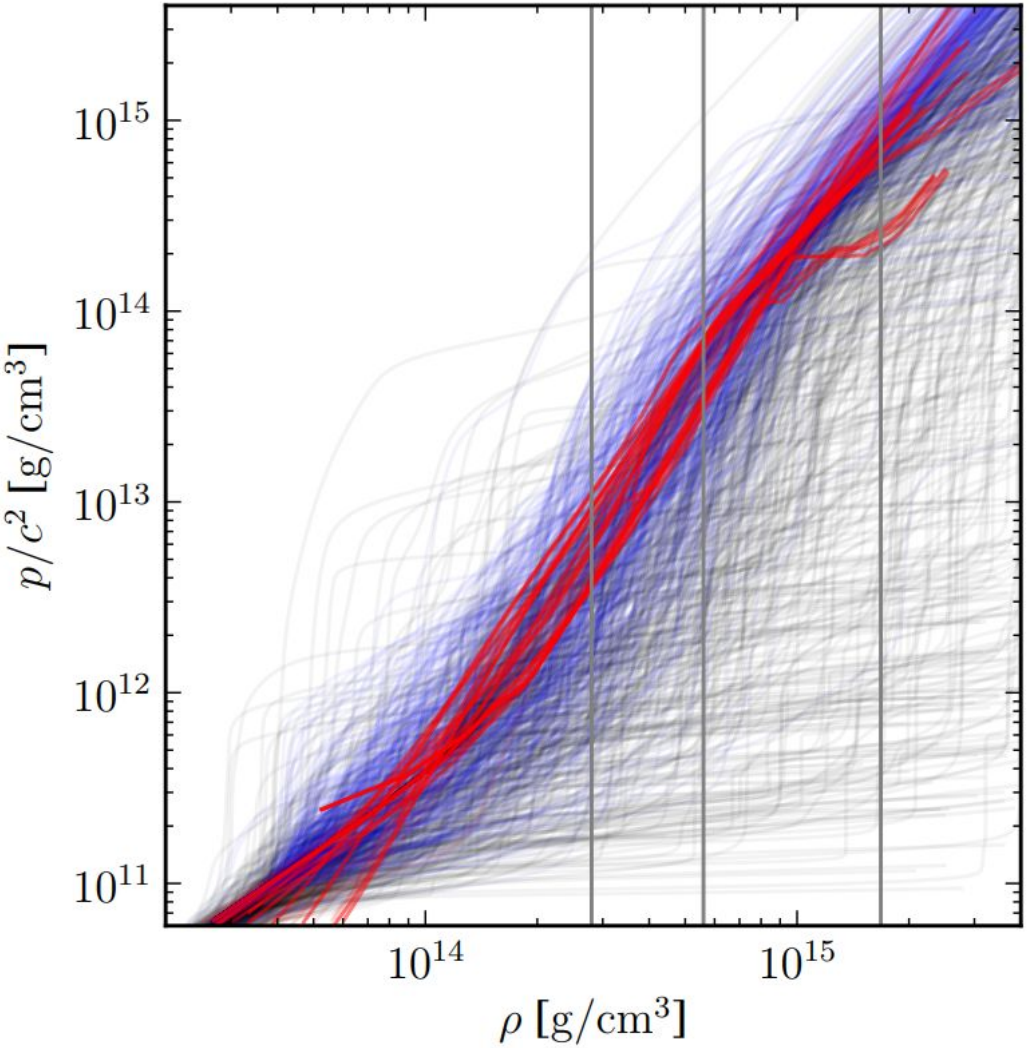

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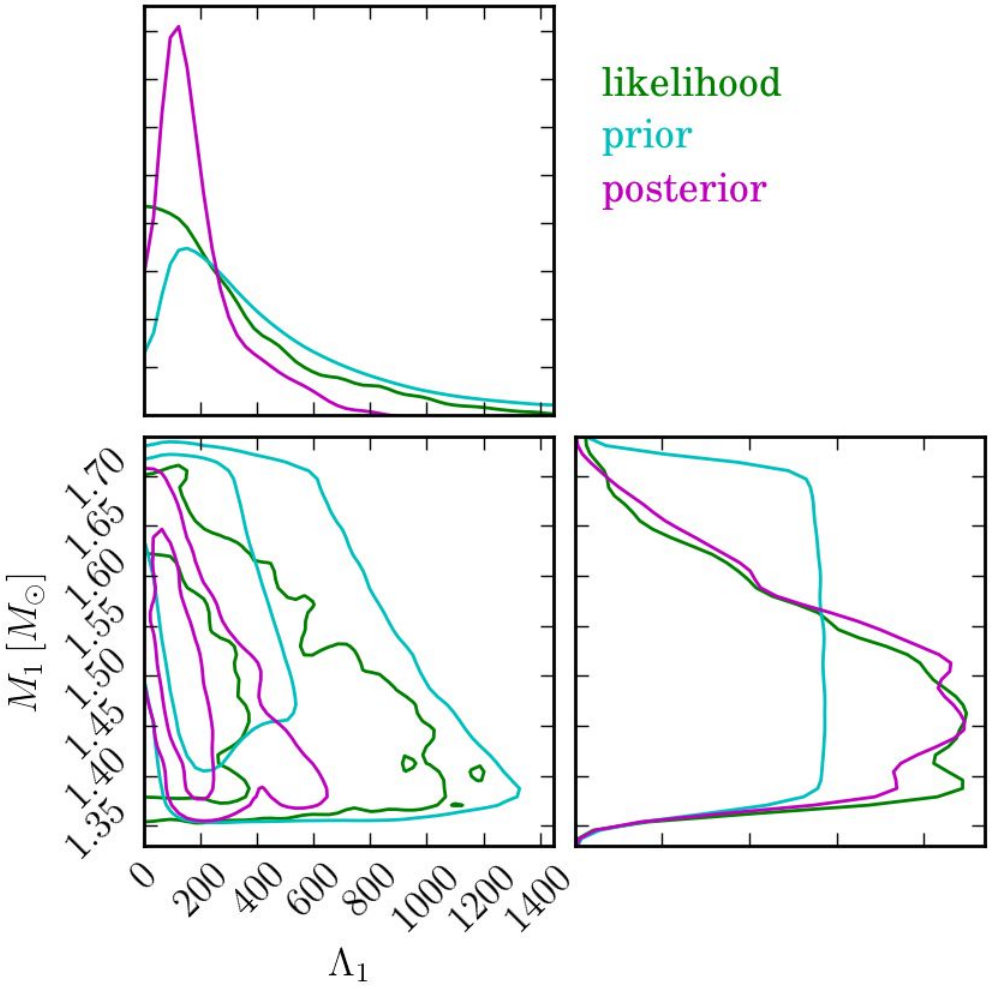

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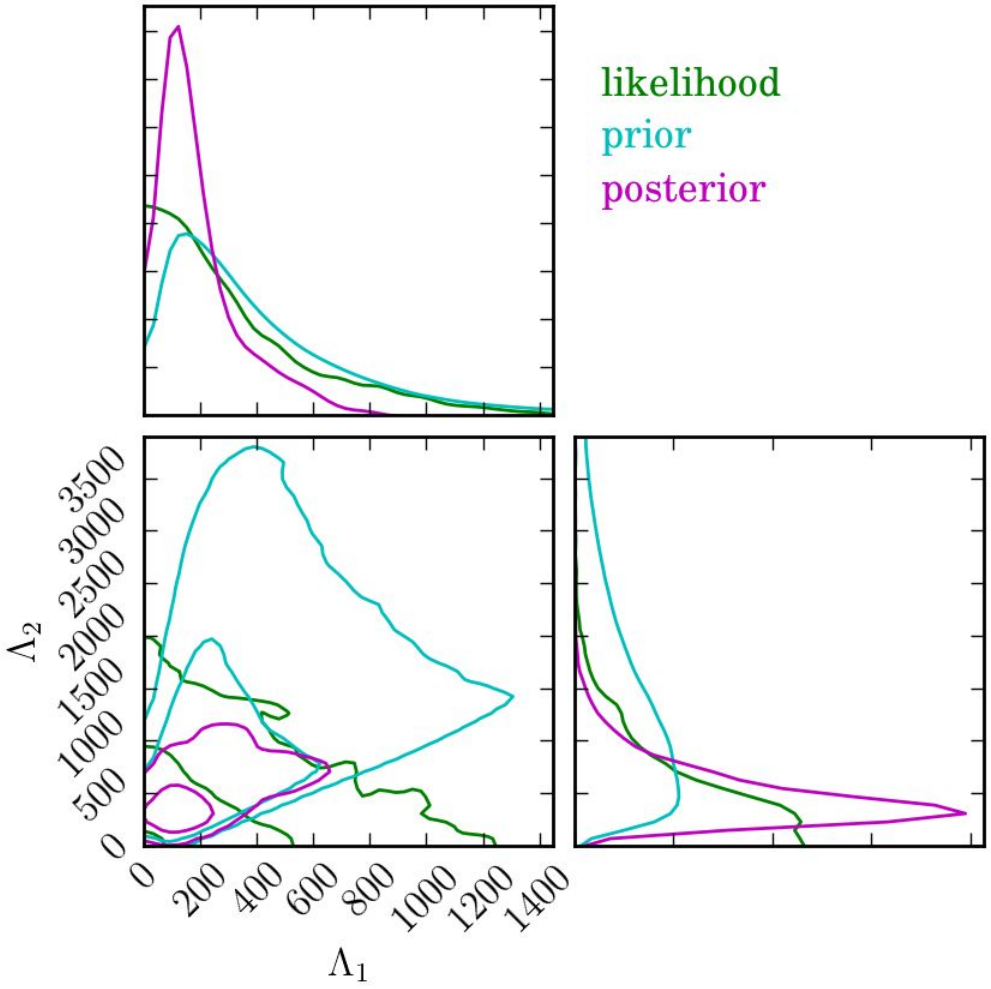

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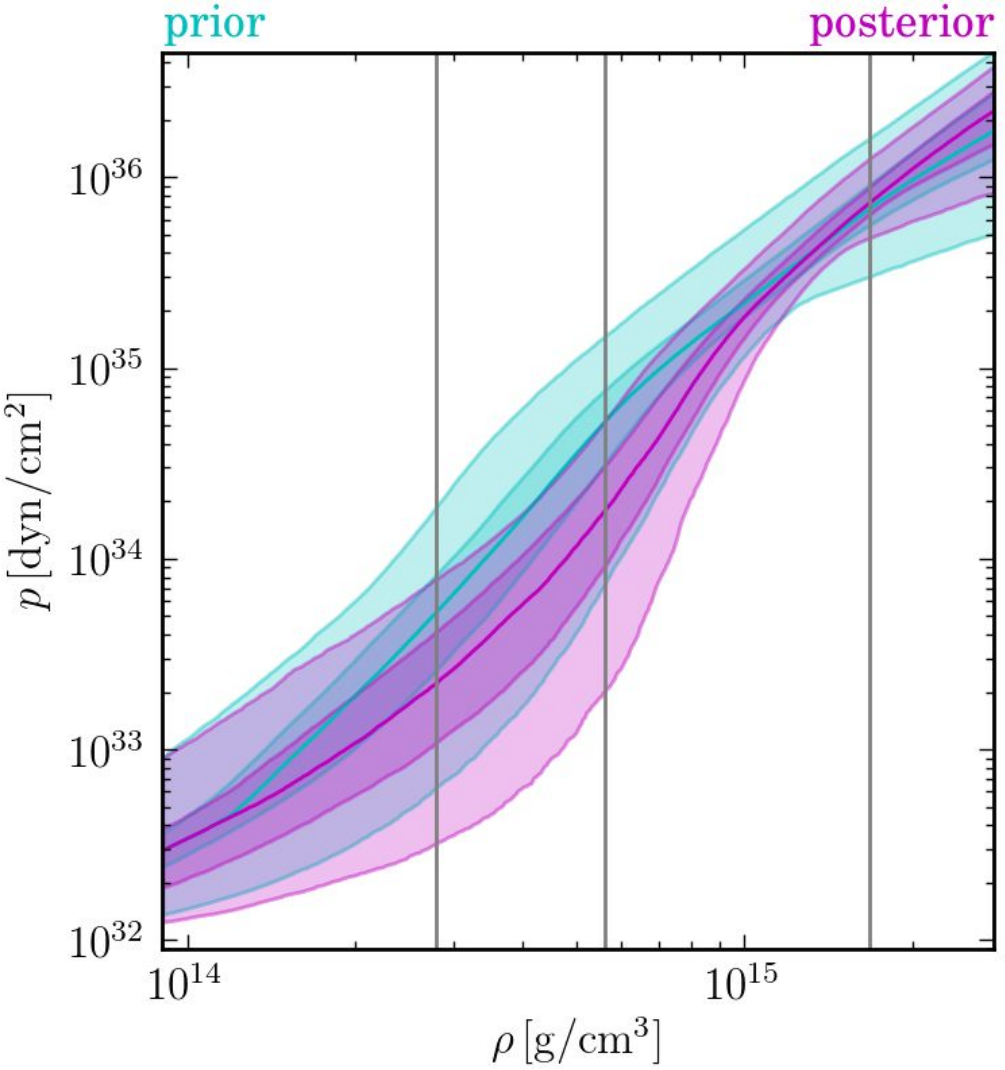

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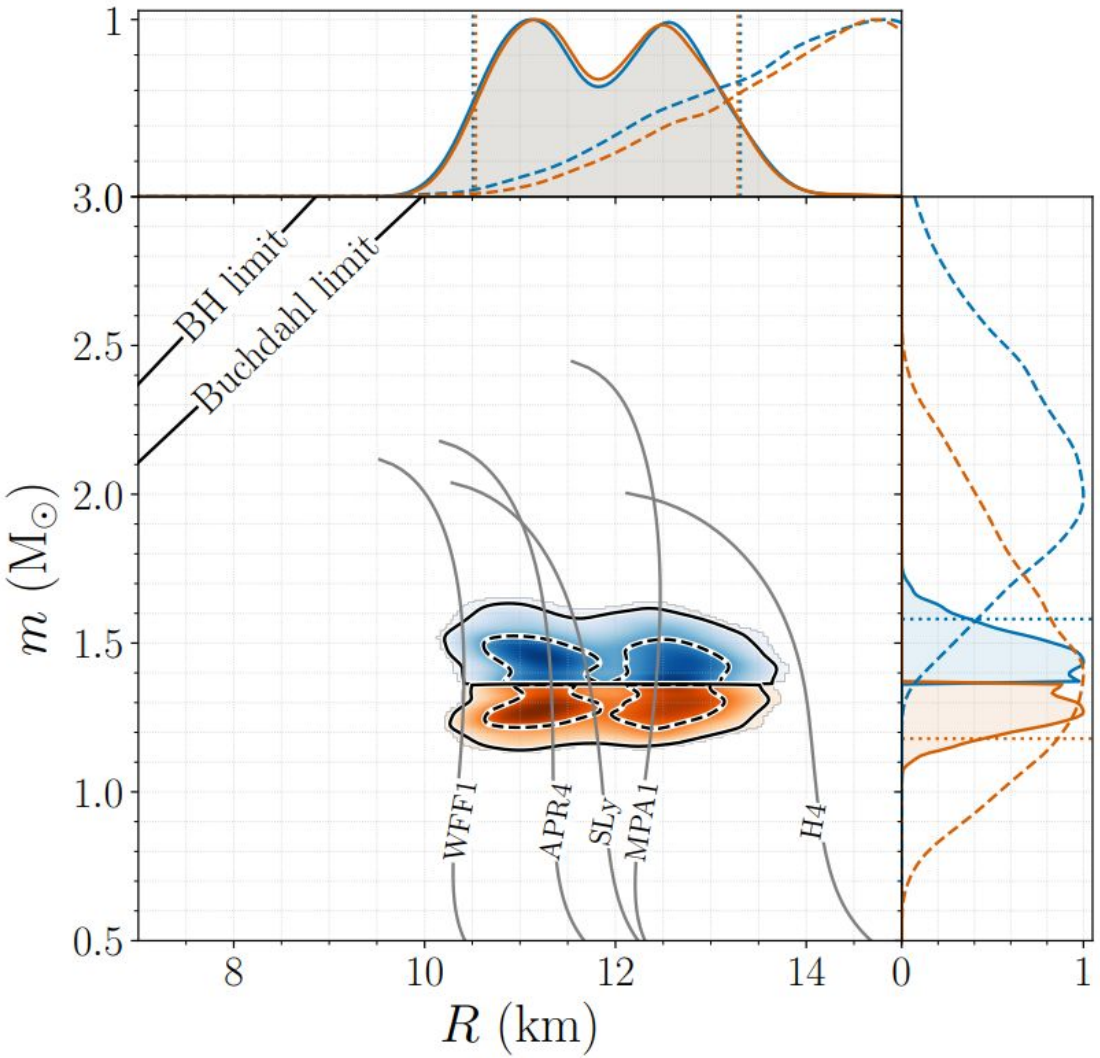

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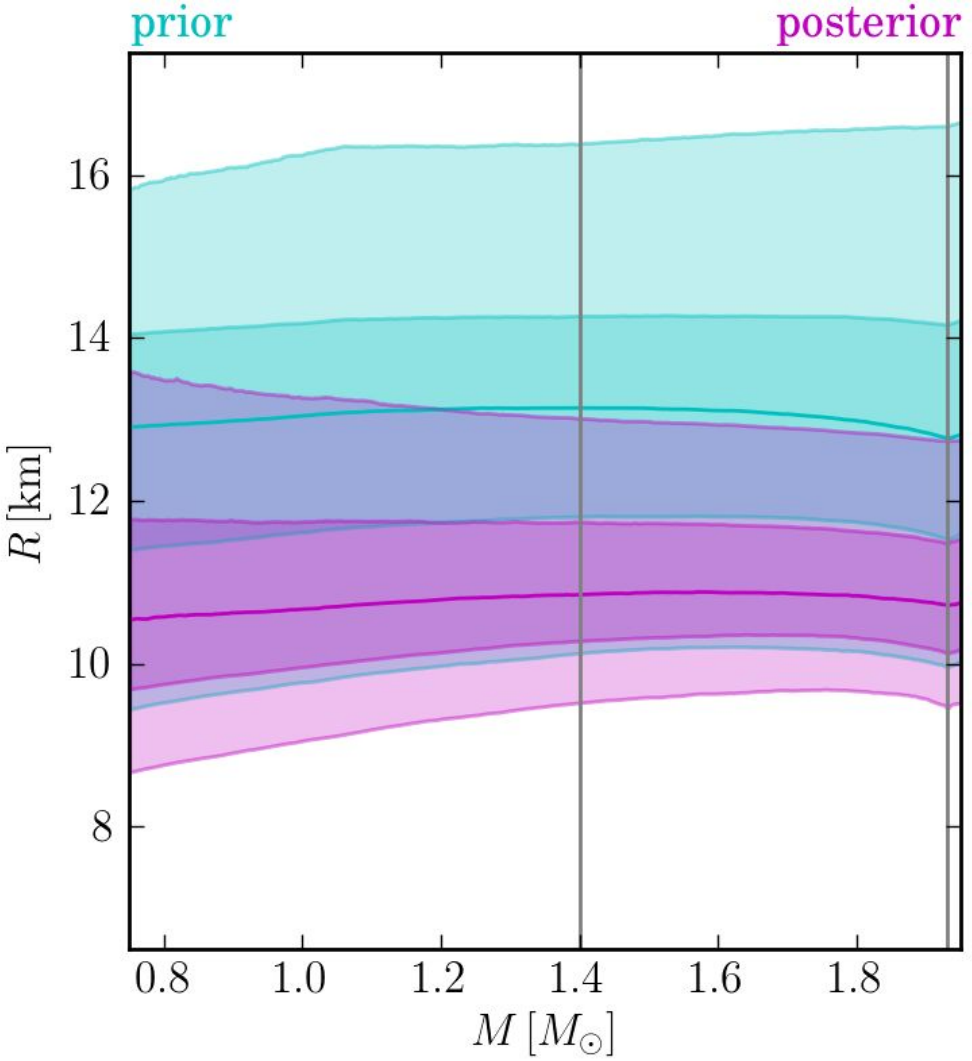

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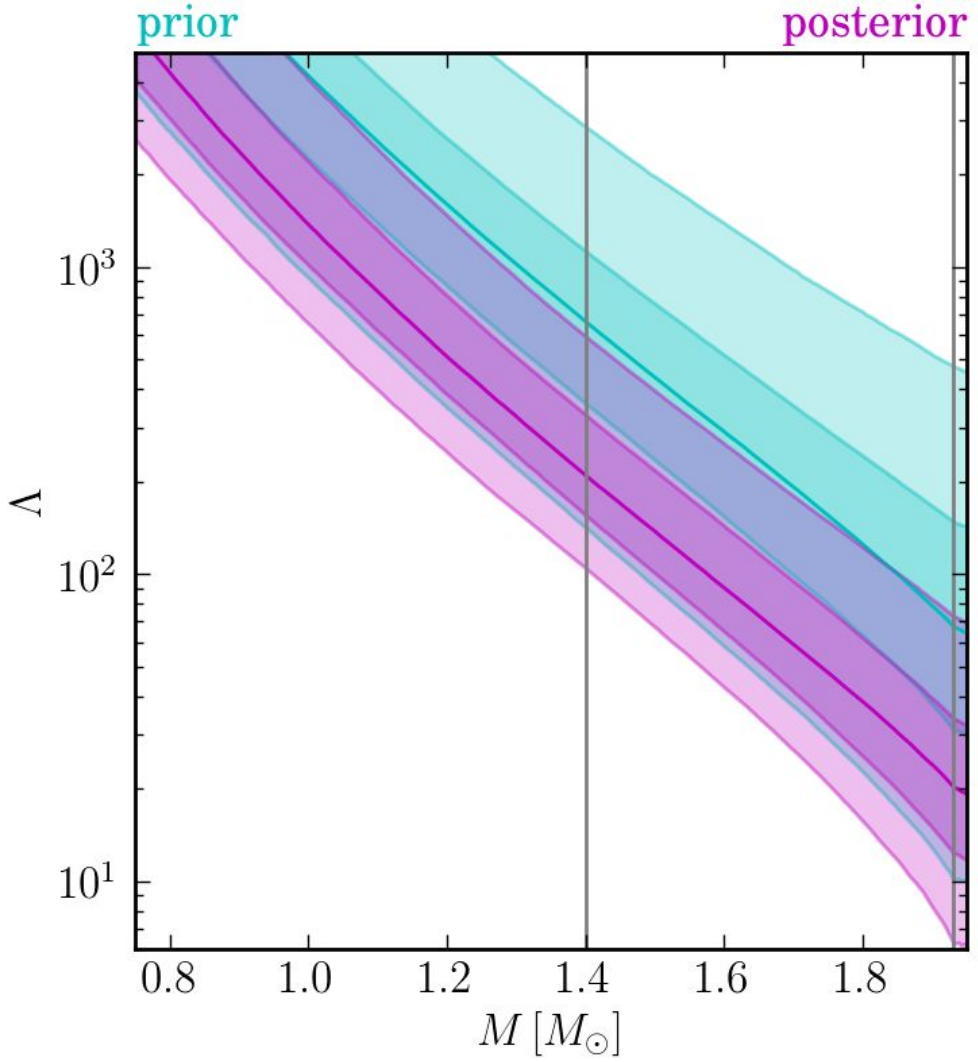

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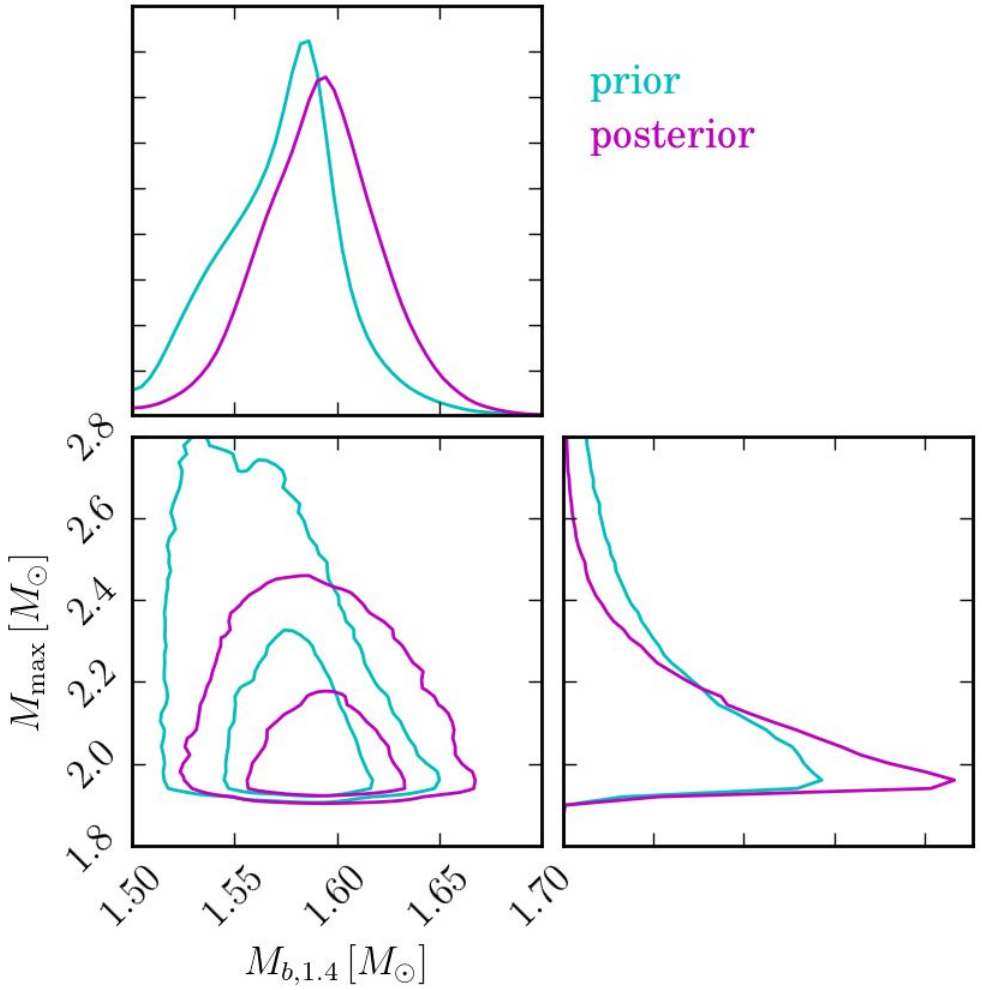

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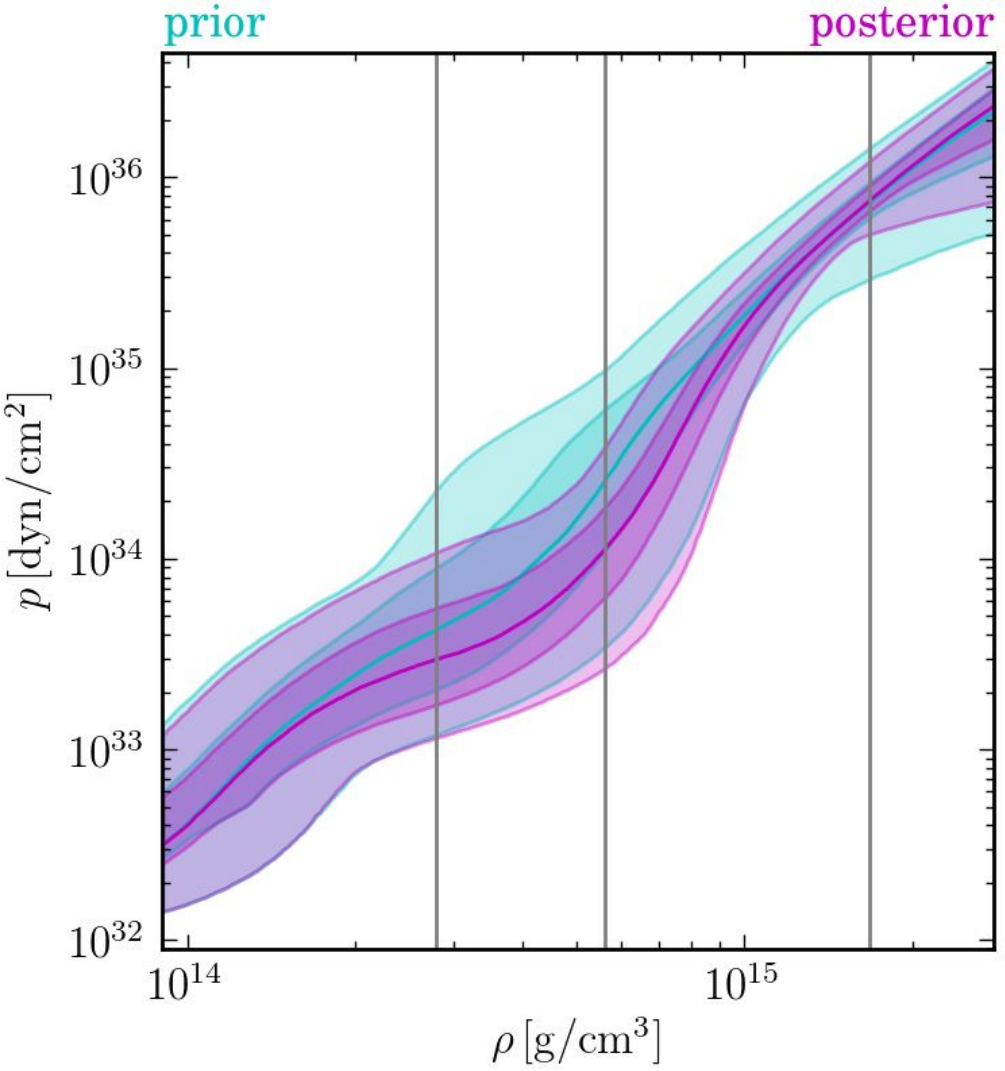

# Next time

Testing General Relativity with Gravitational Waves

- What types of tests have been performed?
- What have we learned about gravity from these tests?
- How can we use GR's accuracy to improve our detectors?

NOTE!
Next week's lecture will be in
**KPTC 120**

# Suggested Reading

- P. Landy and R. Essick. *Non-parametric inference of the neutron star equation of state from gravitational wave observations*. arXiv:1811.12529 (2019).
- R. Essick, P. Landry, and D. Holz. *Nonparametric inference of neutron star composition, equation of state, and maximum mass with GW170817*. arXiv:1910.09740 (2019).
- *How Big are Neutron Stars?* https://www.ligo.org/science/Publication-GW170817EoS/index.php

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