NEUTRON STARS – A SPACE ODDITY

Astro McGill

Astronomy on Tap

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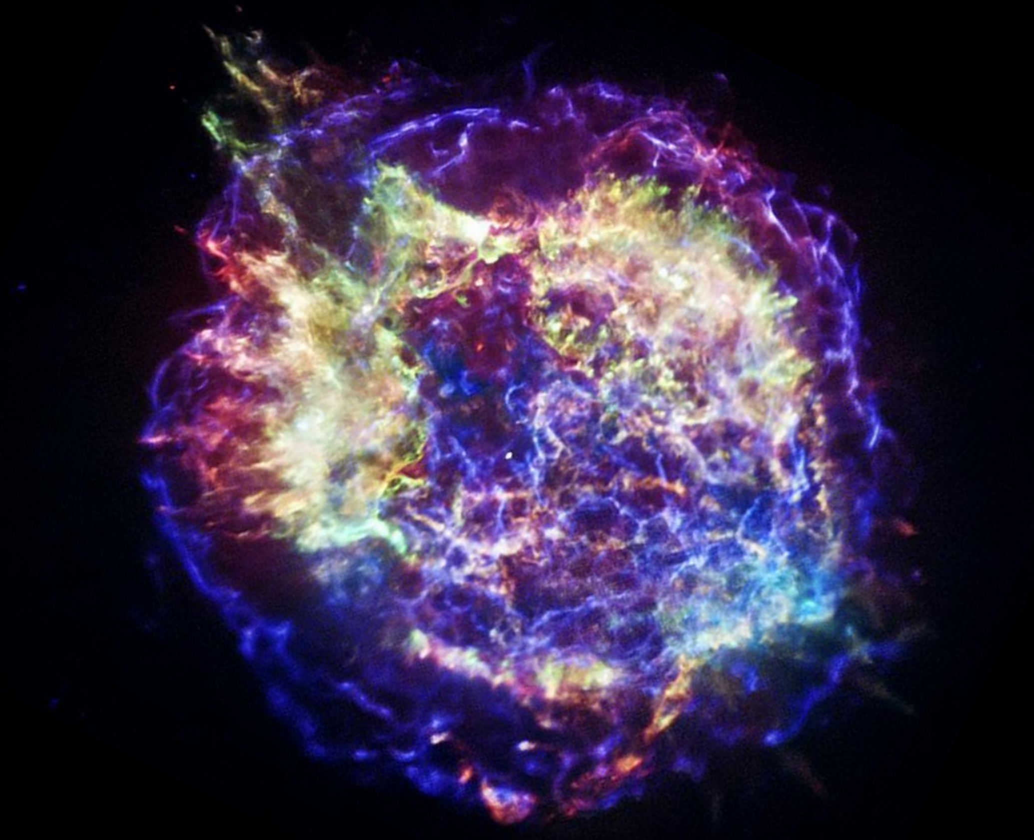
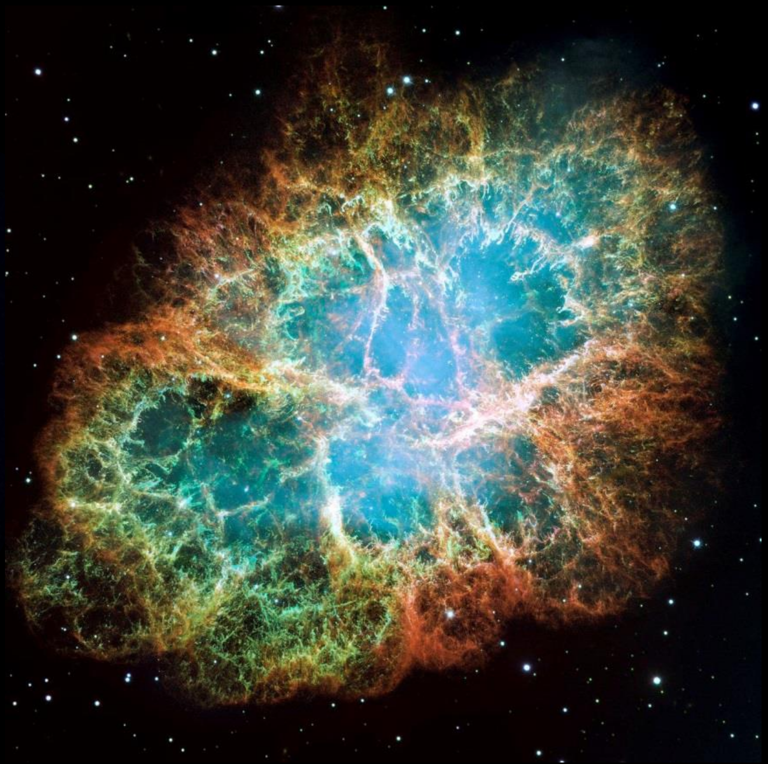
Neutron stars are born in supernovae: the explosions of massive stars.



Cassiopeia A, supernova ~1670



Crab Nebula, supernova 1054

Neutron star masses are comparable to the Sun's with a radius of $\sim$12km.

Neutron stars mainly contain neutrons and are the densest object we know.

density: $\sim\mathbf{10^{14}}\ g\ cm^{-3}$

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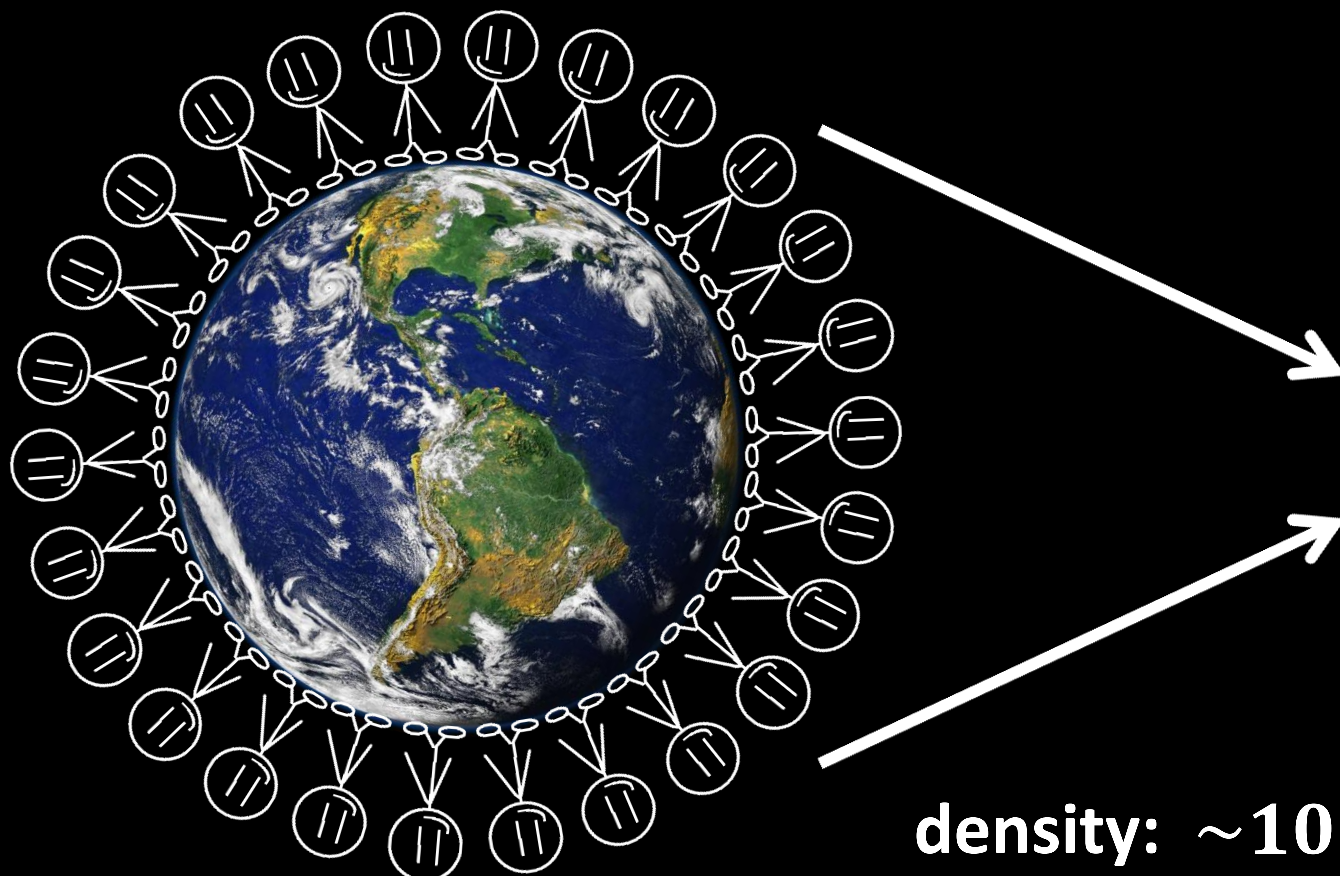

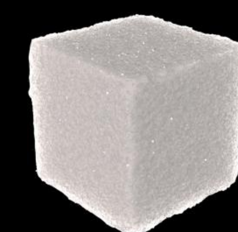

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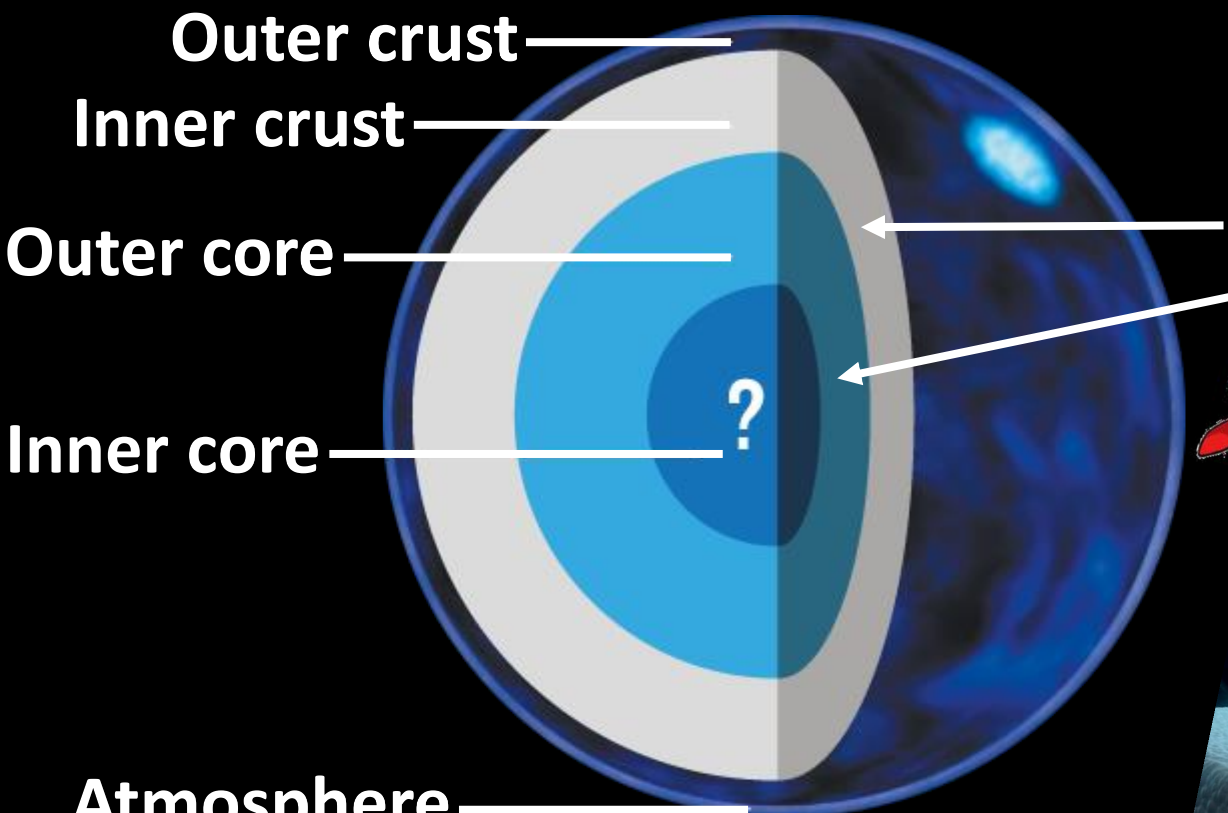
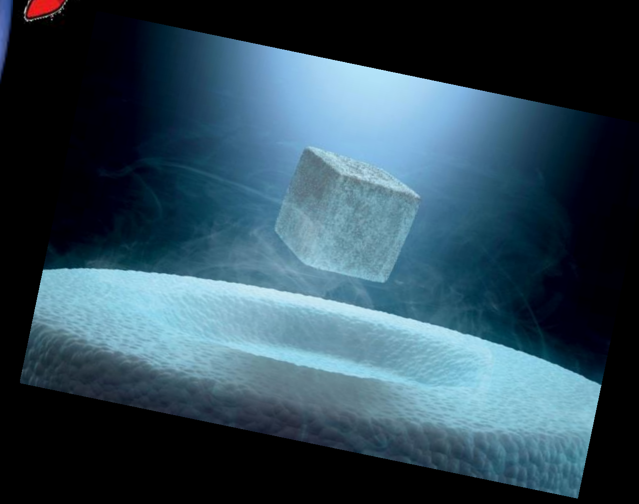
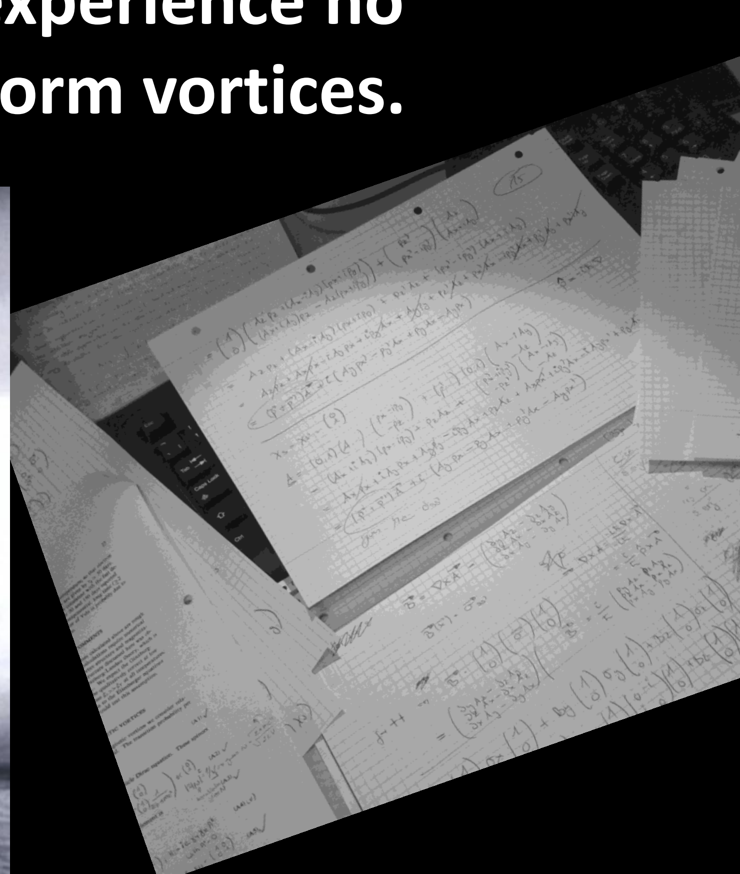
Neutron stars have a layered structure.





Their interiors are exotic superfluids.

Superfluids experience no friction and form vortices.



We use mathematics to understand how these superfluids affect the star.

How do we know that our theoretical models are correct?

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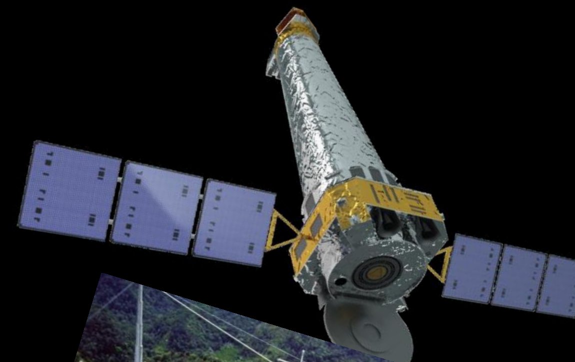
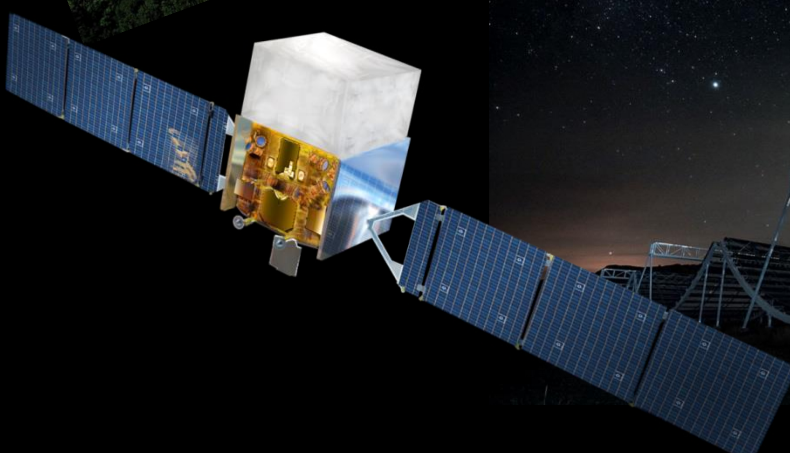


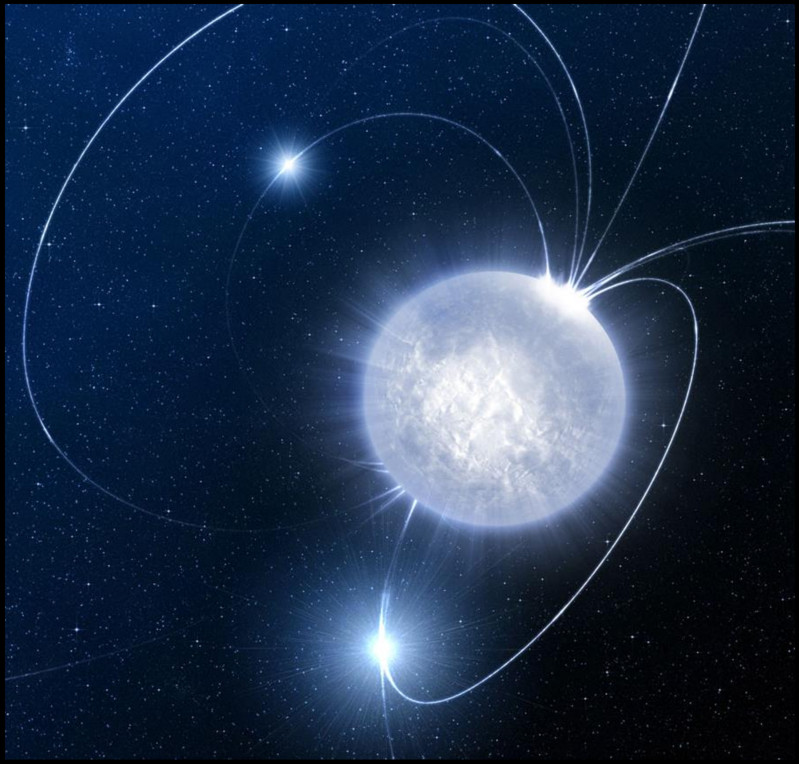


Observations!!!

Neutron stars have the strongest magnetic fields in the Universe.

$\sim 10^{12}$ Gauss

$= 2,000,000,000,000 \times$ Earth's magnetic field



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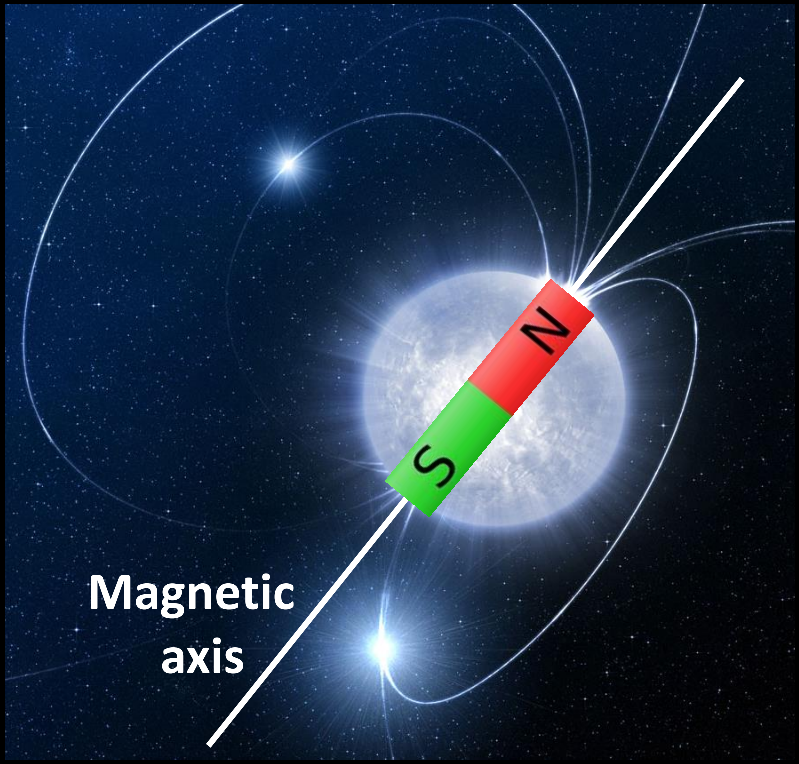

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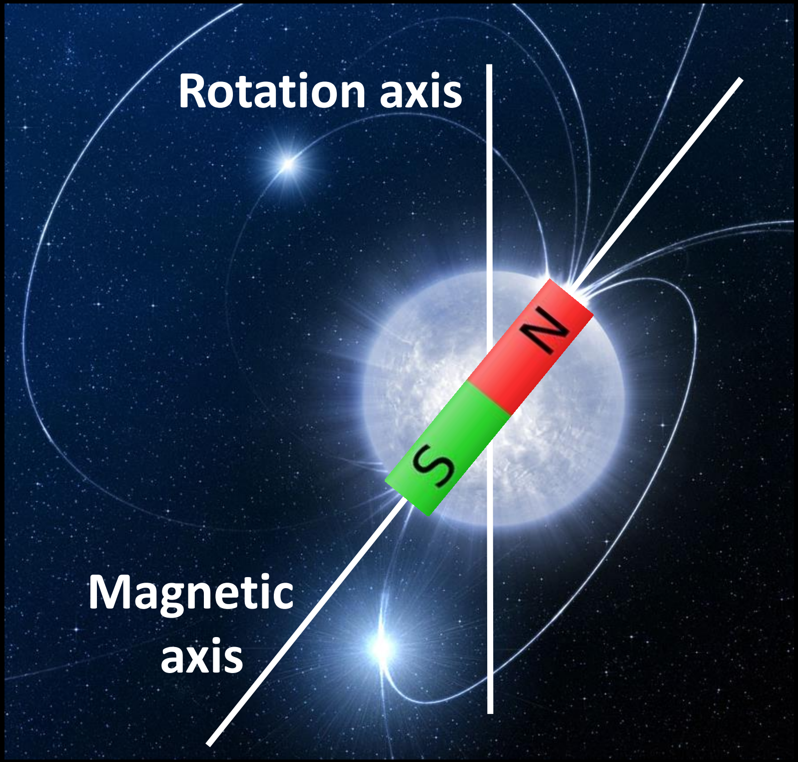
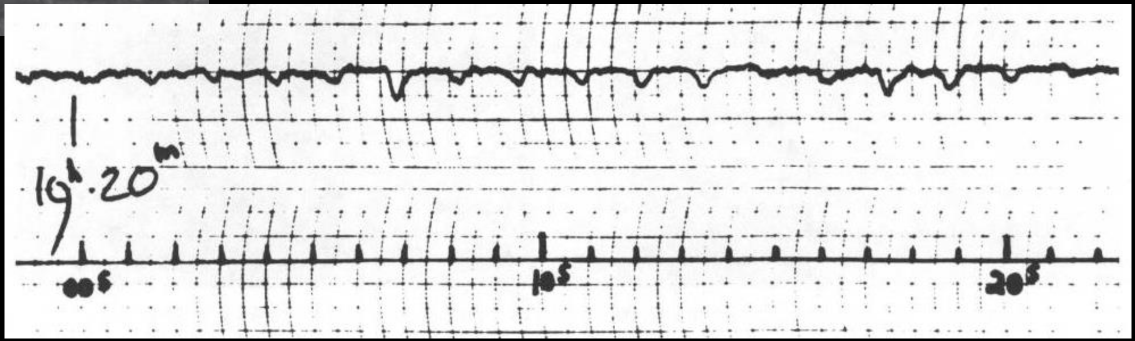


As the magnetic field rotates it emits a beam of radiation, like a light house.

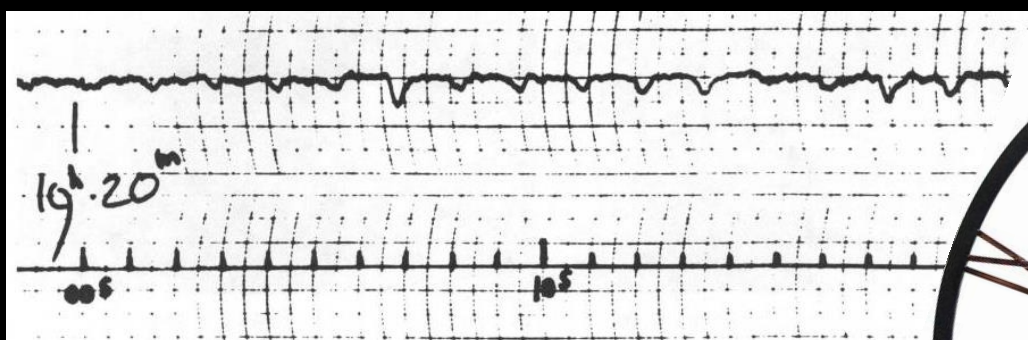
Neutron stars were first observed as pulsars in 1967 by Jocelyn Bell Burnell.

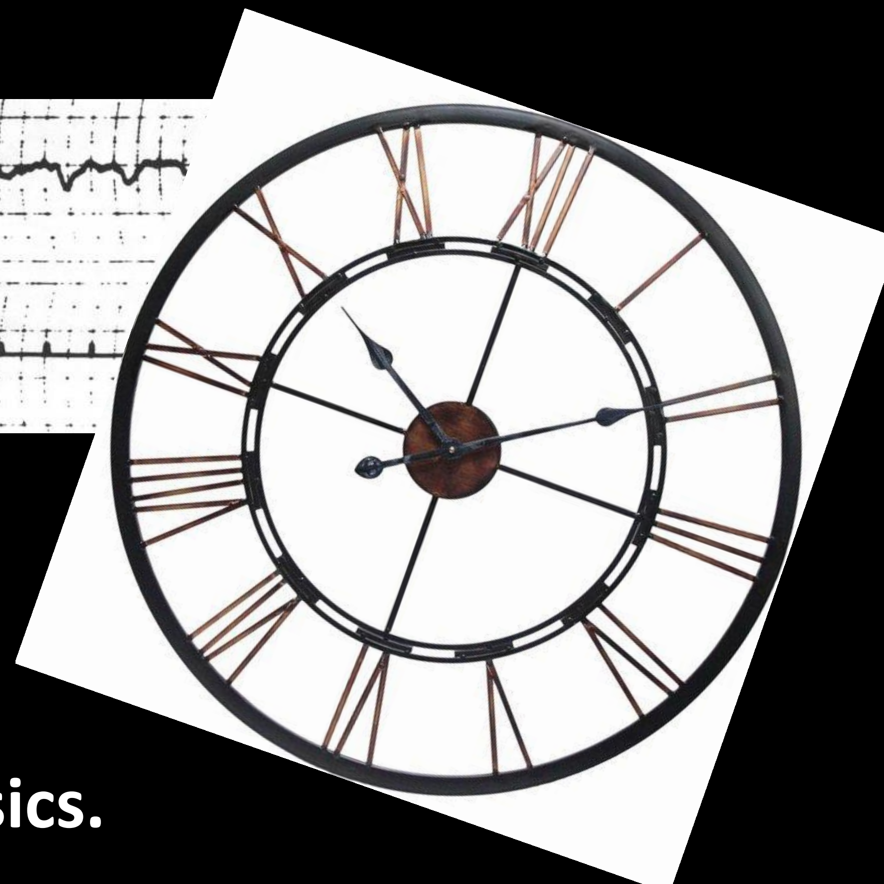
LGM-1 (‘Little green man’)

$\sim$2500 neutron stars have been observed as radio pulsars.



Pulsars are very stable rotators.
They are like clocks.



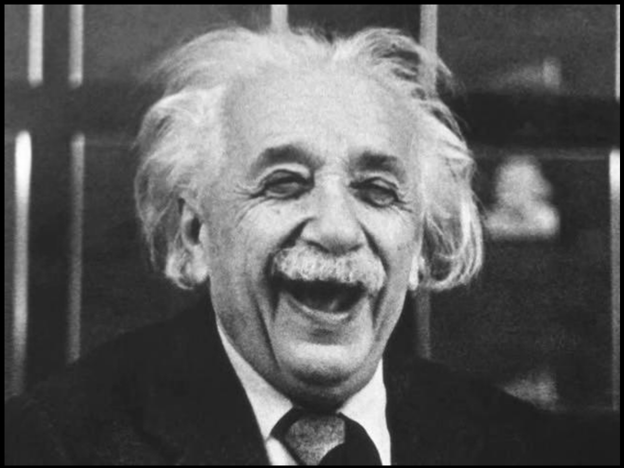


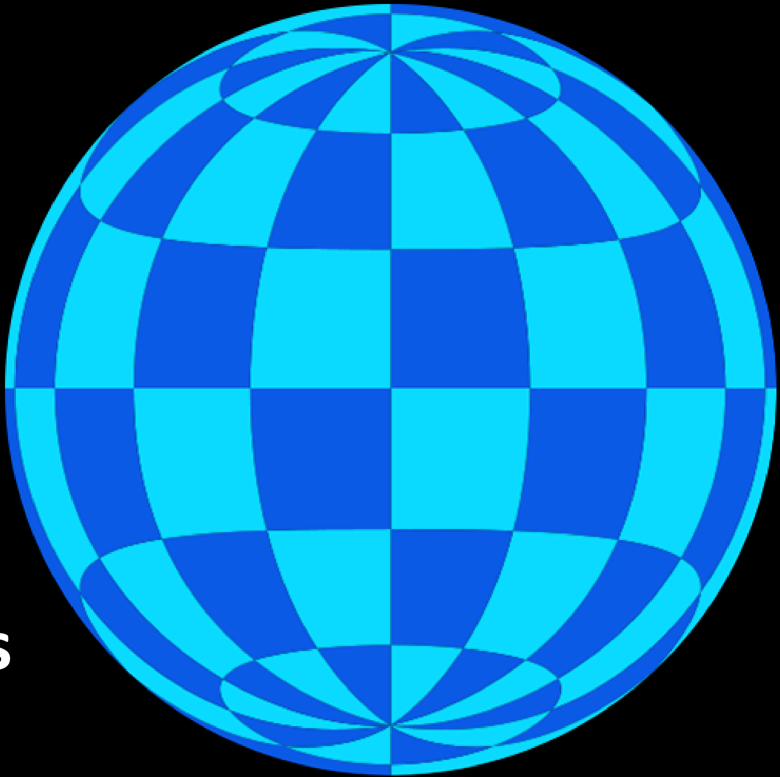
**Deviations from
the model could be
related to the interior physics.**

Due to their compactness, neutron stars have very strong gravity.

$$\sim 2 \times 10^{12}\ m\ s^{-2}$$

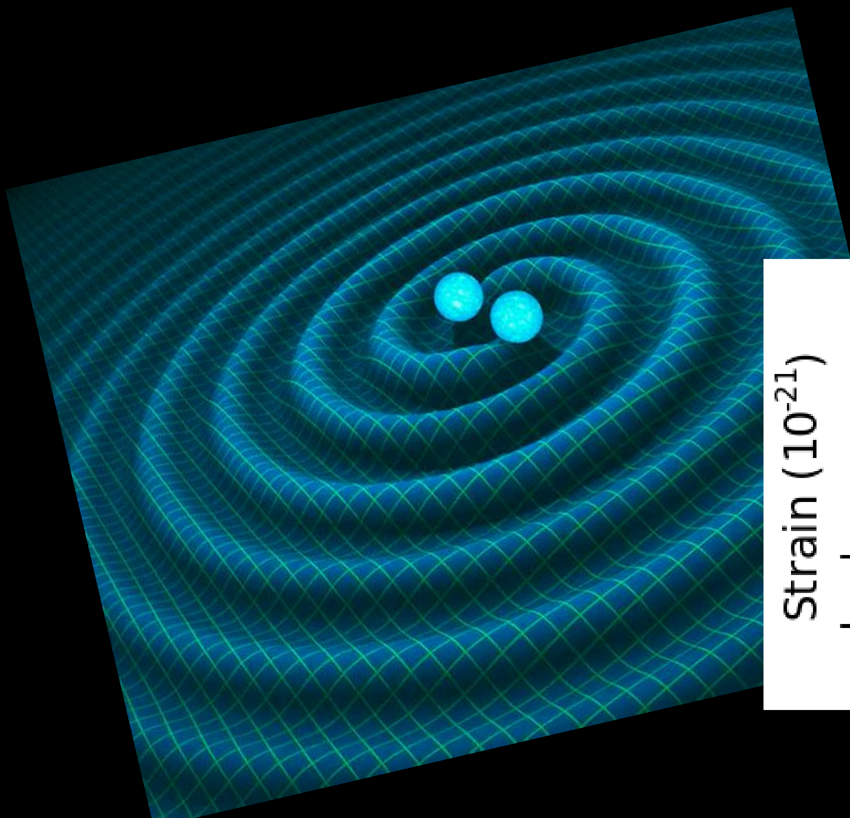
$= 200,000,000,000\ \times$ Earth's gravitational field

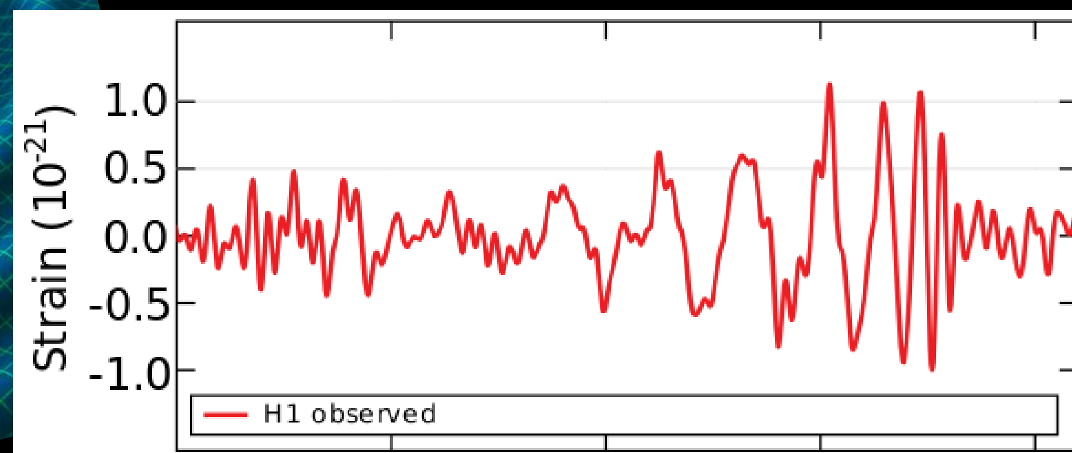




General relativity describes neutron stars, their interactions with light, space and time.

Neutron stars are very promising gravitational waves sources.





Because of complex physics (hair), the GW signals from neutron stars are difficult to predict.

Neutron stars combine many extremes of physics, making them perfect cosmic laboratories.