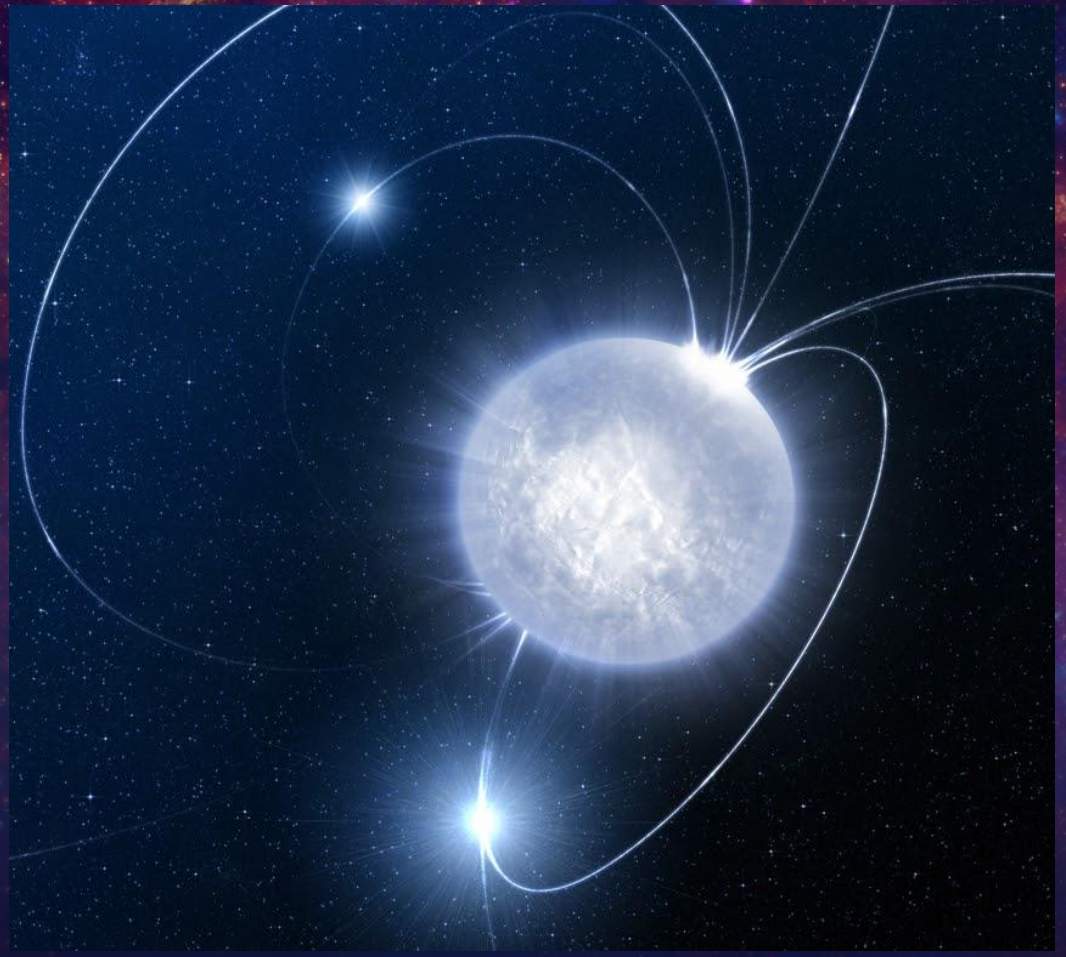
Neutron Stars - The Strongest Magnets in the Universe



Dr. Vanessa Graber

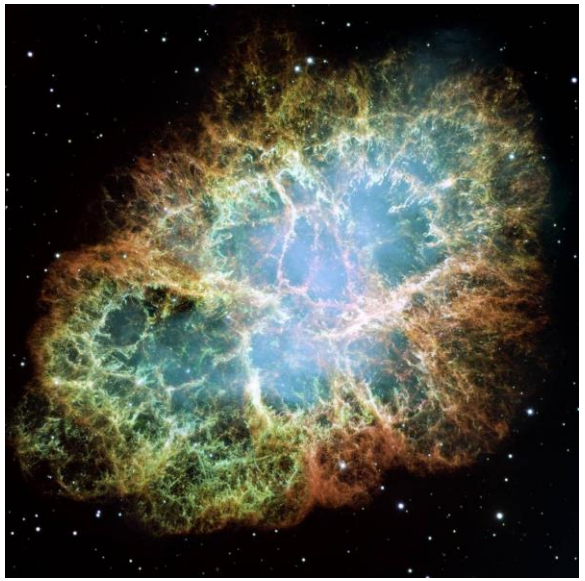
Institute of Space Sciences (ICE-CSIC), Barcelona

NASA'S UNIVERSE OF LEARNING

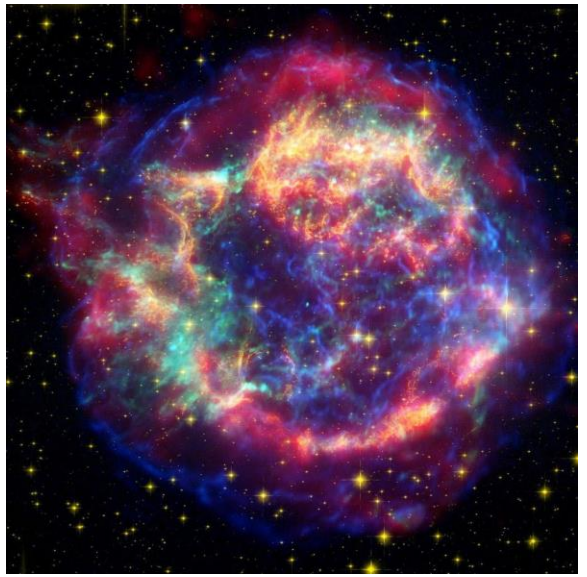
Neutron Star Formation

- At the end of their lives, very **massive stars** explode in so-called **supernovae**, leaving behind gigantic remnants.

Crab Nebula, 1054



Credit: NASA, ESA, J. Hester, A. Loll (ASU)



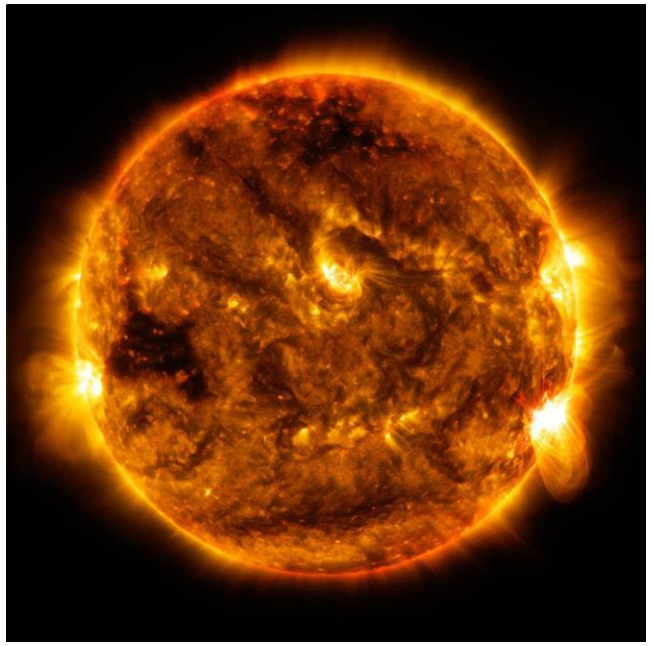
Cassiopeia A, ~1670

Credit: NASA, JPL-Caltech, STScI, CXC, SAO

Neutron Star Sizes and Masses

- Neutron stars have **sizes** that are comparable to a **city**.

Credit:
Google,
ESO, L. Calçada



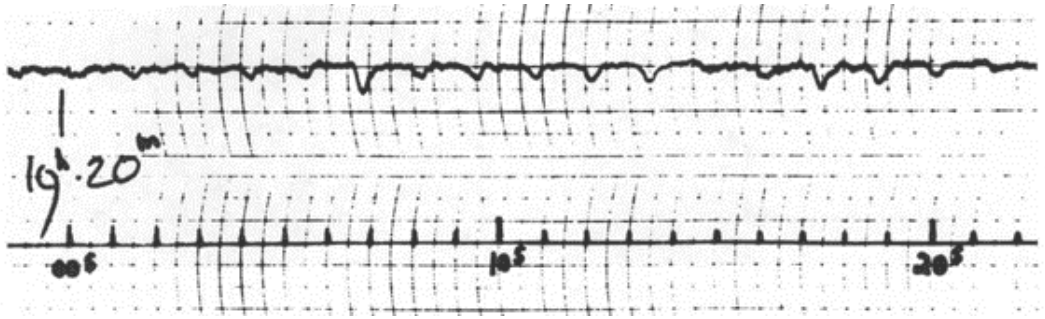
Credit:
NASA, SDO

- Their **masses** are comparable to that of the **Sun**.

Neutron Star Discovery

- They were first observed by Jocelyn Bell Burnell in **1967**.

Credit: J. Bell Burnell



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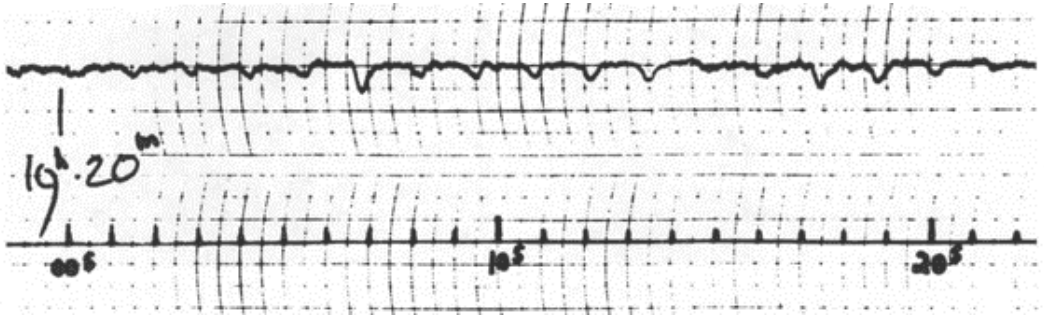

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Neutron Star Rotation

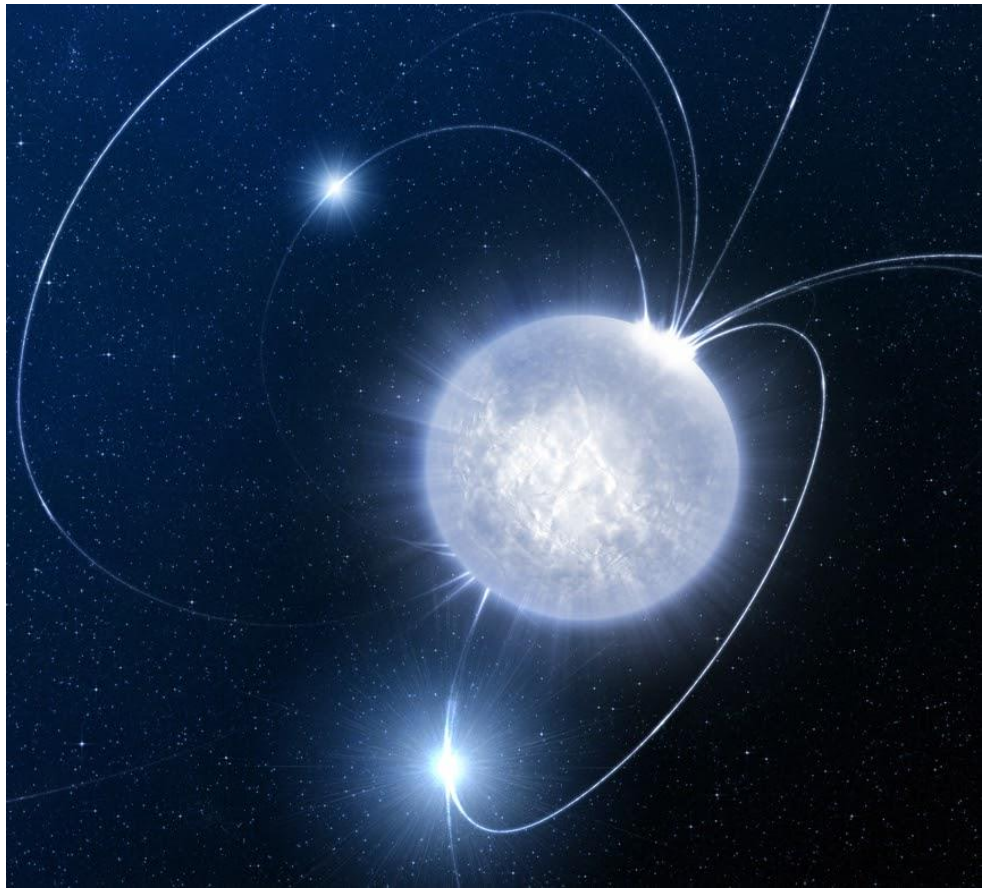
- These regular signals arise due to **fast rotation** and extremely strong magnetic fields.

- Neutron stars **spin** up to **~700 times** per second.

Neutron Star Magnetic Fields

- Neutron stars are the **strongest magnets** in the Universe.

- Their fields are a **trillion times stronger** than the Earth's magnetic field.

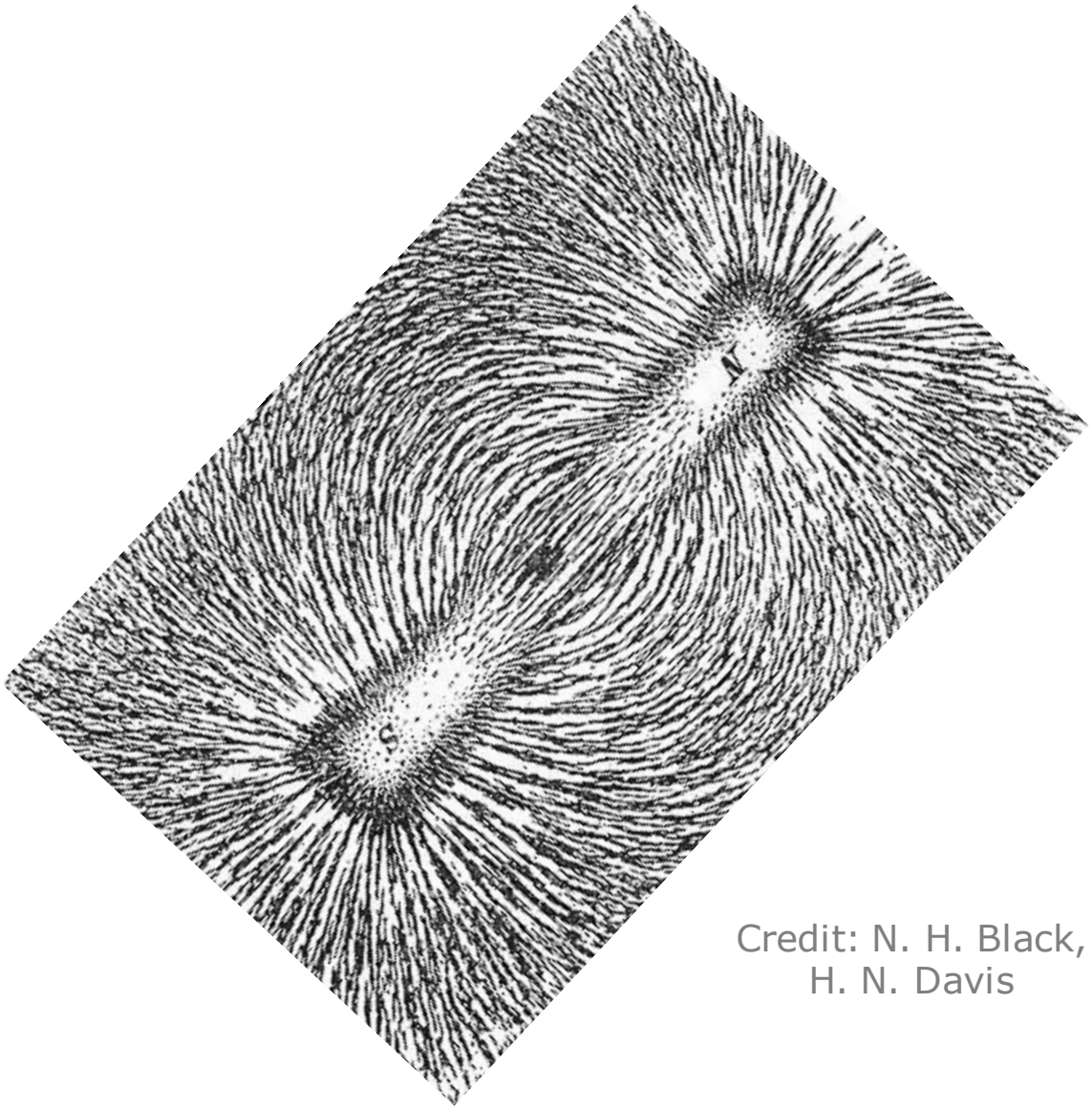


Credit: ESO, L. Calçada

Neutron Star Magnetic Fields

- The magnetic field on large scales is dominated by its **dipolar nature**.

- The field lines resemble those of **magnets** with a **north** and **south pole**.

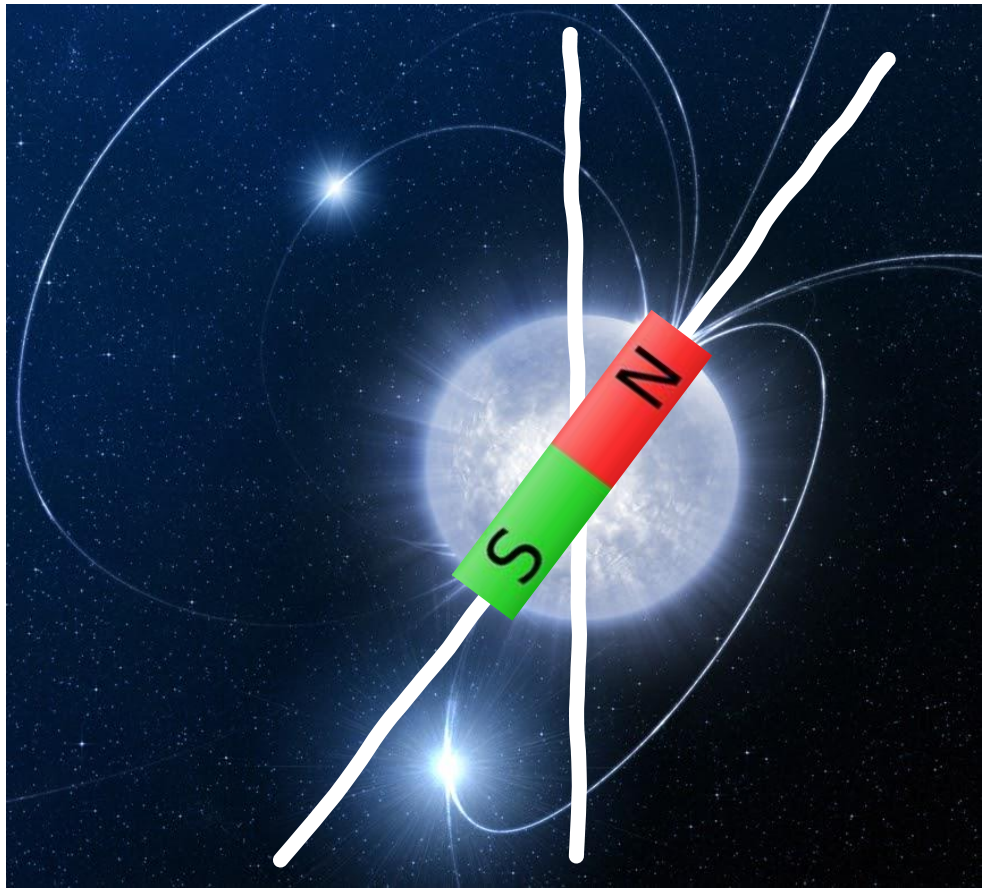


Credit: N. H. Black, H. N. Davis

Neutron Star Magnetic Fields

- **Particles** are accelerated along the open field lines and **emit radiation**.

- The rotation and magnetic field **axes** do not coincide but **form an angle.**

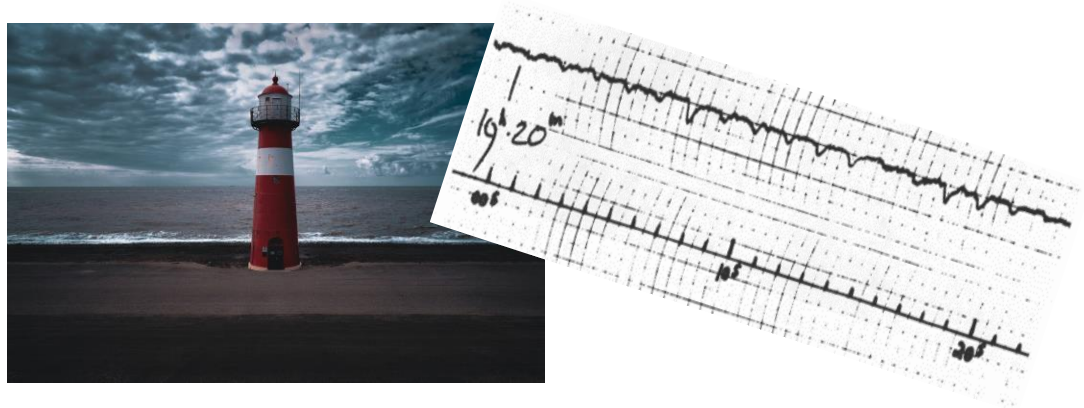


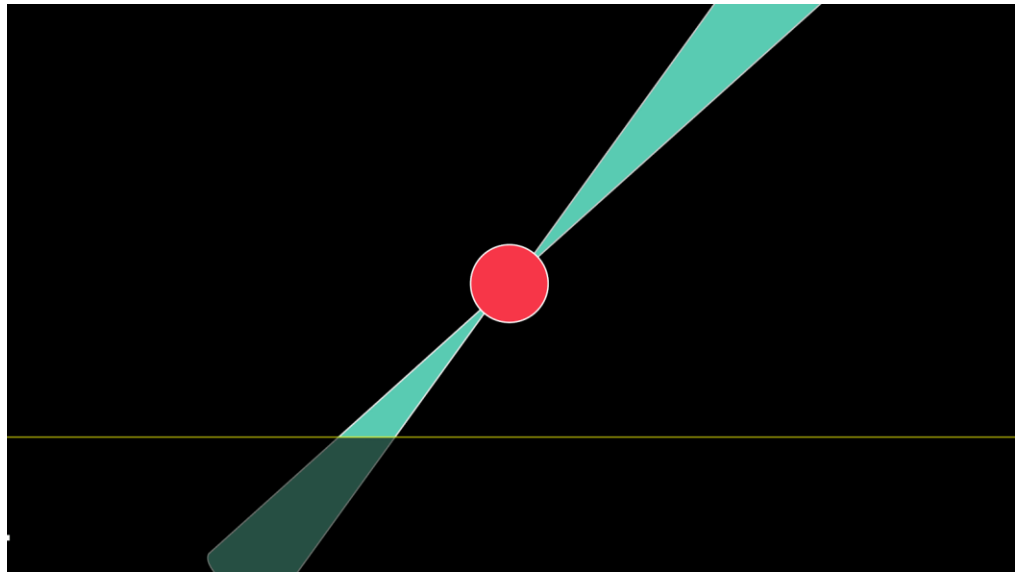
Credit: ESO, L. Calçada

Neutron Star Magnetic Fields

- Neutron stars emit radio waves similar to the way a **lighthouse** emits its light.

- This causes **regular radio emission** of many neutron stars, so-called **pulsars.**





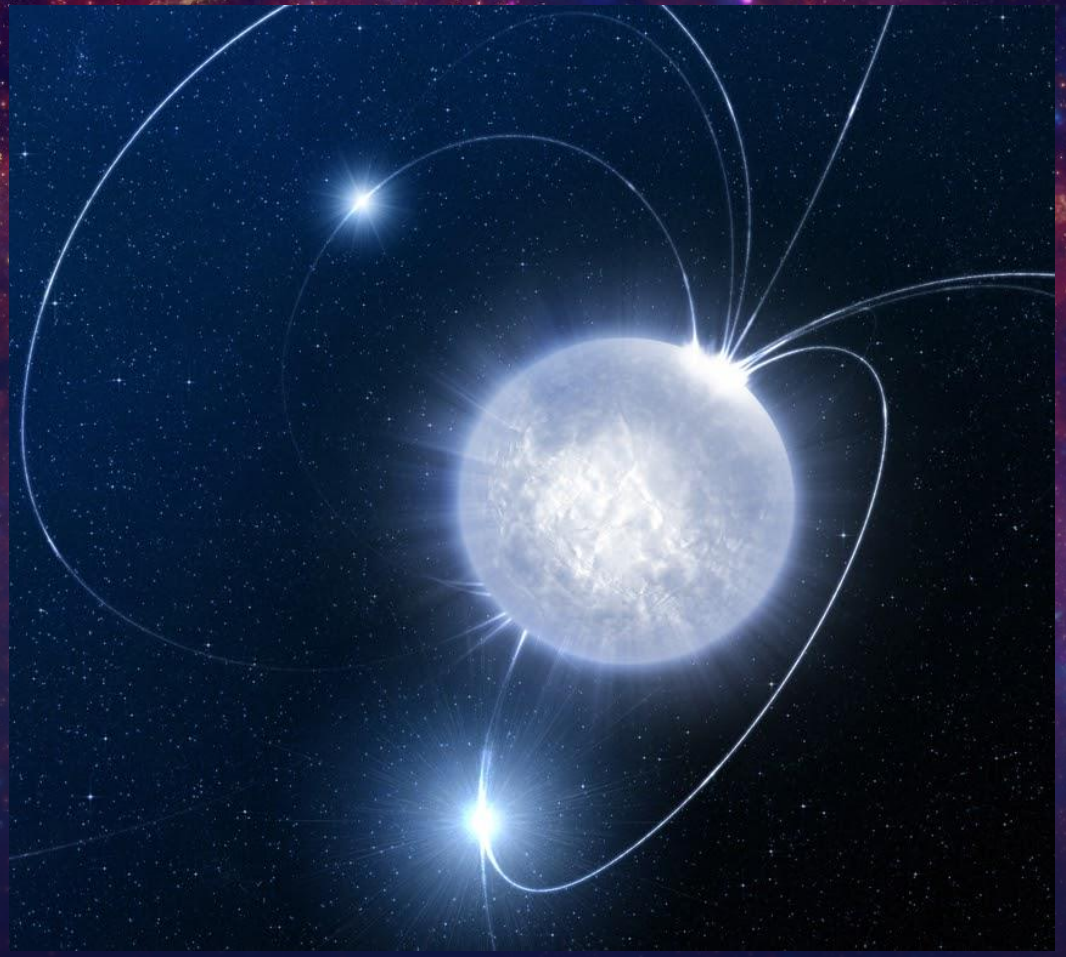
Credit: J. Christiansen

Pulses as Diagnostic Tools

- By studying **pulse shapes**, we can e.g. learn more about the emission cone's structure and the magnetic field itself.

- The **difference in arrival time** between two pulses teaches us about **internal mechanisms** that affect the neutron star rotation.

Credit: Factory Records



Neutron stars are the strongest magnets in the Universe and the perfect laboratory to study matter under extreme conditions.