Continuous gravitational waves from known pulsars

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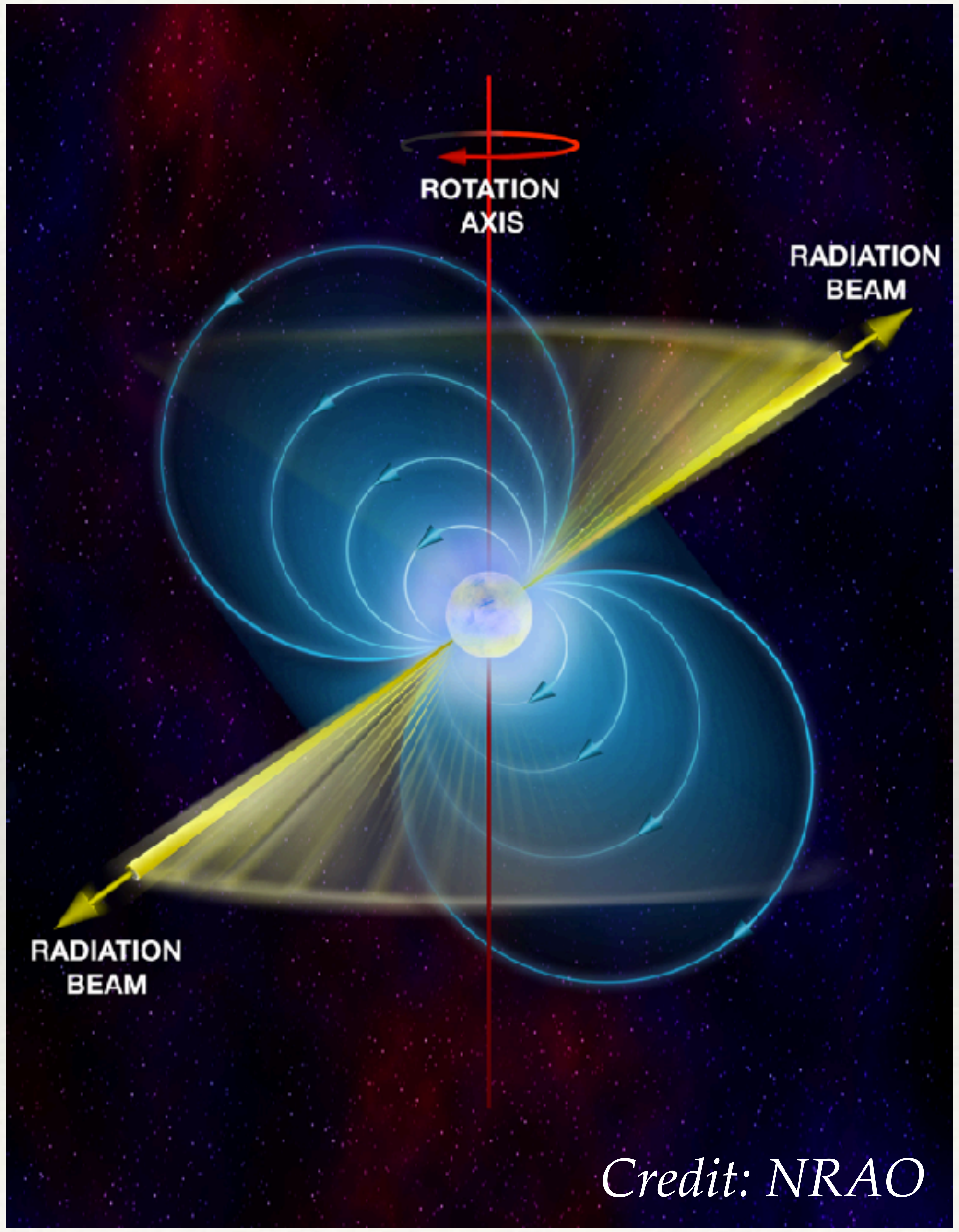
When the M meets the P

Photo credit: Hubble, ESA/NASA

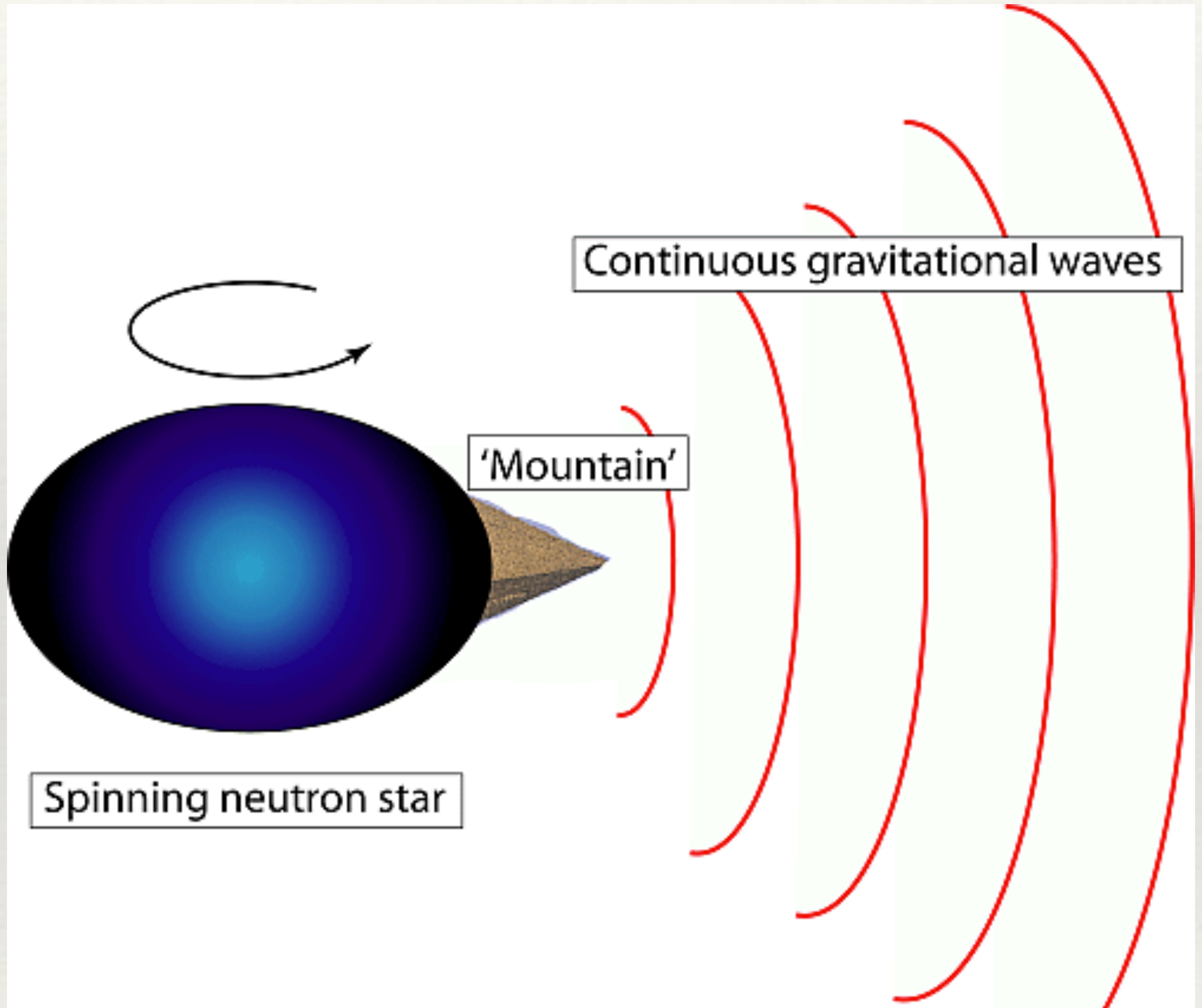
What are pulsars?

- Dead stars formed after supernova
- Super dense: mass of our sun, radius of ~10 km
- Rotate very fast: ~100 times/second!
- Lighthouse effect: we see a beam of light at regular intervals from the poles



How do pulsars emit gravitational waves?

- In general, gravitational waves are emitted when a mass distribution changes over time, e.g. deviations from axial spherical symmetry while rotating
- Pulsars could have ‘bump’ or ‘mountain’
- Rotational energy —> gravitational-wave energy
- But, mountain is so small, < O(mm), that very little energy is lost —> very slow change in frequency
- Continuous gravitational waves!
    - Quasi-monochromatic, quasi-infinite



Credit: Astrobites

How do we detect gravitational waves from known pulsars?

- We use laser interferometry to measure the tidal effect of gravitational waves
- Astronomers measure the most important parameters that affect the tidal forces: the source’s location, the rotational frequency, the rate of change of the frequency, etc.
- With this information, we analyze the data for a particular sky location by correcting for all changes in gravitational-wave frequency due to the Doppler effect and the loss of rotational energy over time
- These corrections create a pure sinusoid at a fixed frequency, so we perform a single Fourier Transform and look for a peak

Crab pulsar; credit: Hubble

What have we found?

- No gravitational waves yet!
- The mountains are really small
- Pulsars with different histories have different constraints on their deformations
    - Some only require an O(nm) distortion to produce gravitational waves, while others O(μm)