

# Discovery of Ultraviolet Millisecond Pulsations in Pulsar J1023+0038

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- We have discovered Ultraviolet millisecond pulsations with Hubble telescope!

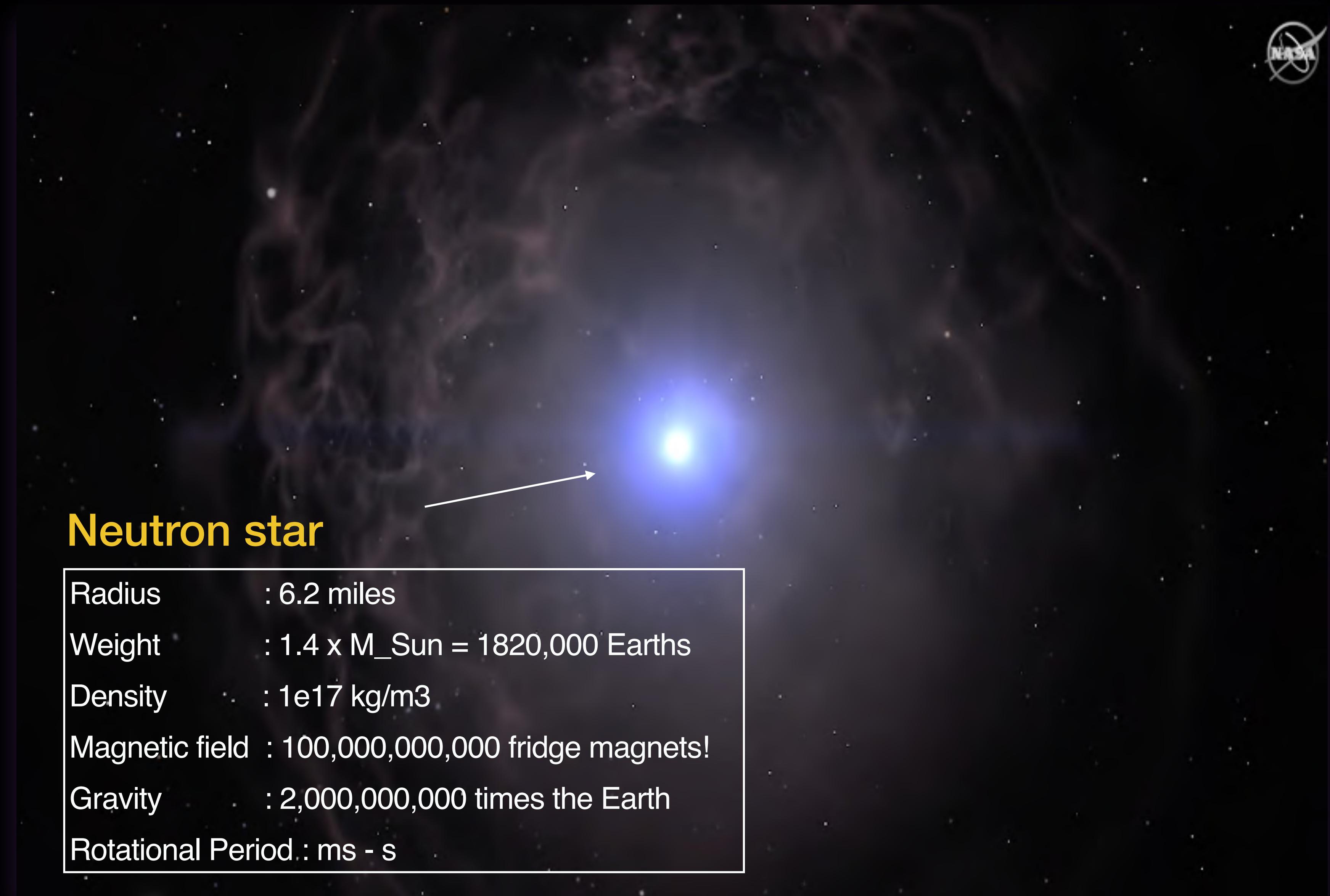
- Pulse period of 1.69 ms

- Fastest ultraviolet pulsar



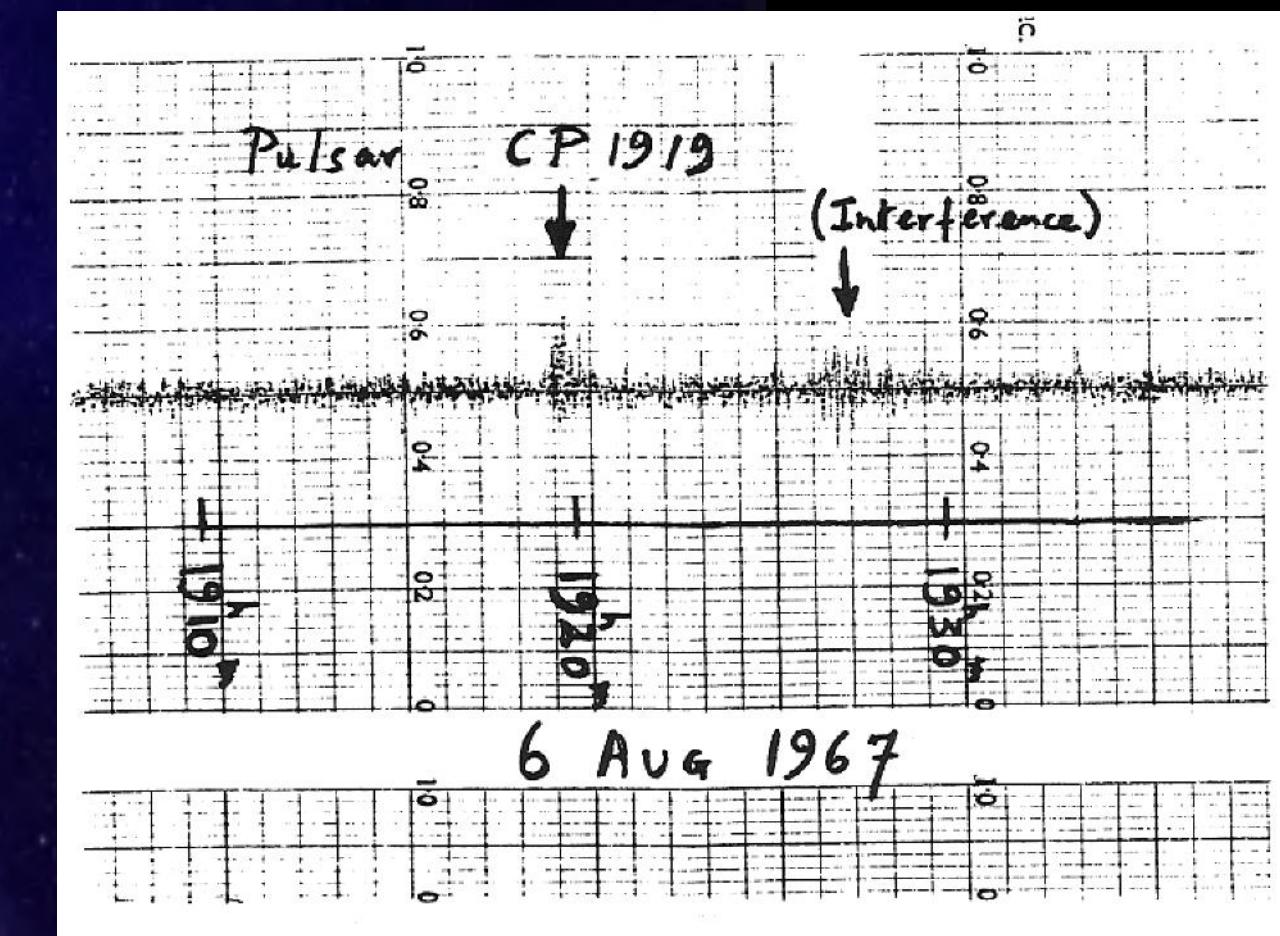
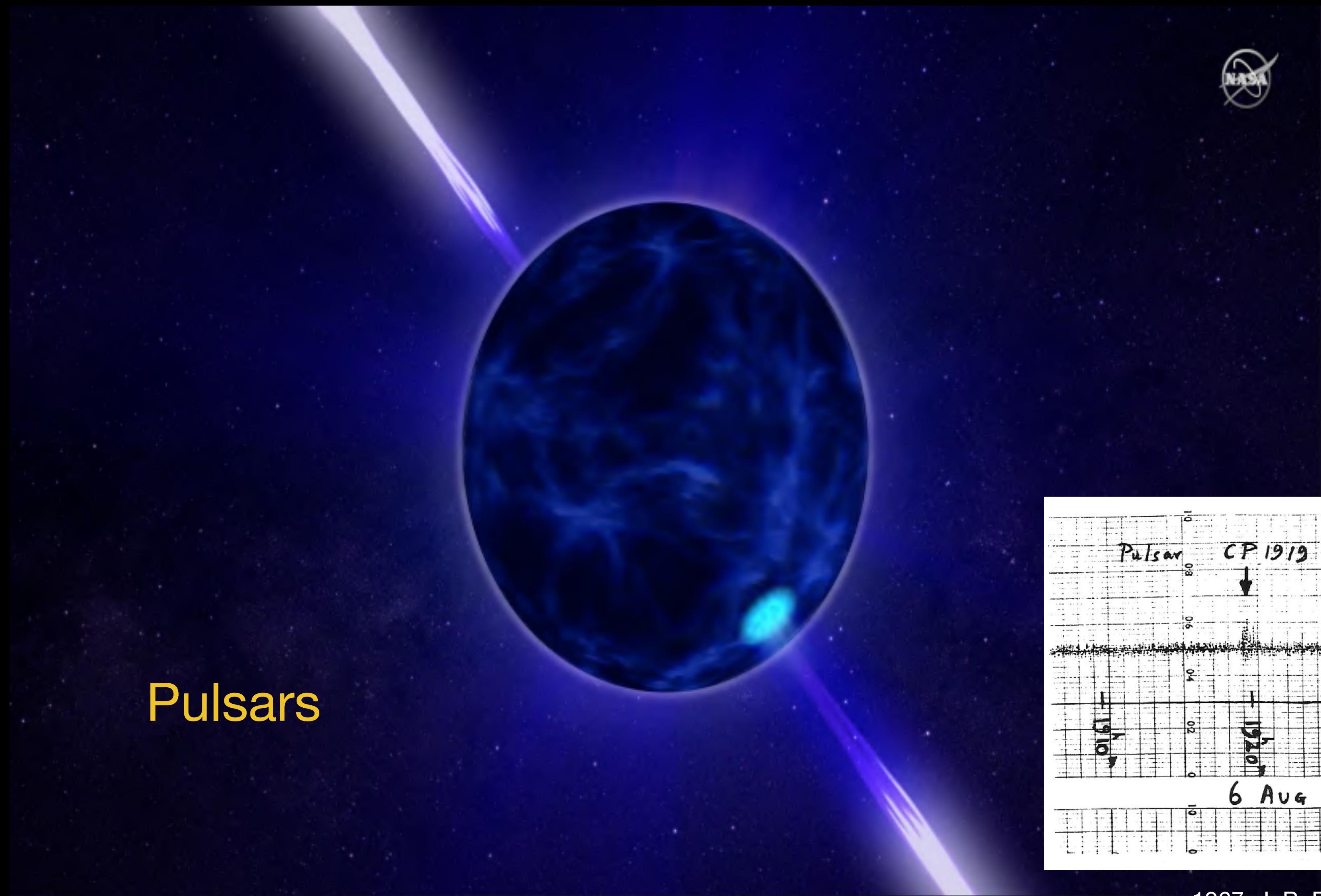
Credit: NASA's Goddard Space Flight Center/Clare Skelly

**A neutron star is born!**



## Neutron star

Radius	: 6.2 miles
Weight	: $1.4 \times M_{\text{Sun}} = 1820,000$ Earths
Density	: $1e17 \text{ kg/m}^3$
Magnetic field	: 100,000,000,000 fridge magnets!
Gravity	: 2,000,000,000 times the Earth
Rotational Period	: ms - s



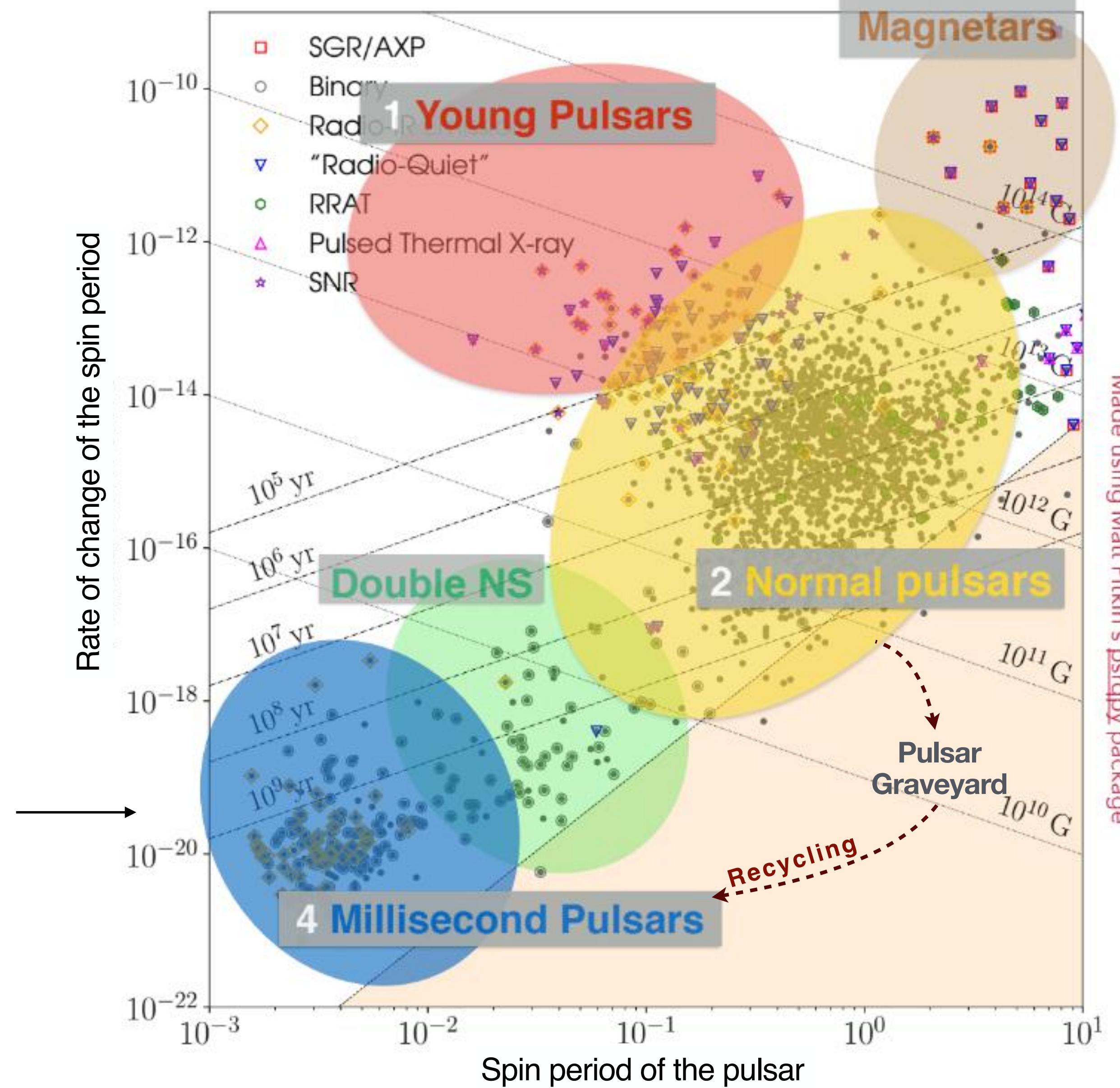
1967, J. B. Burnell,

# Pulsars

Currently known of the **3359** pulsars

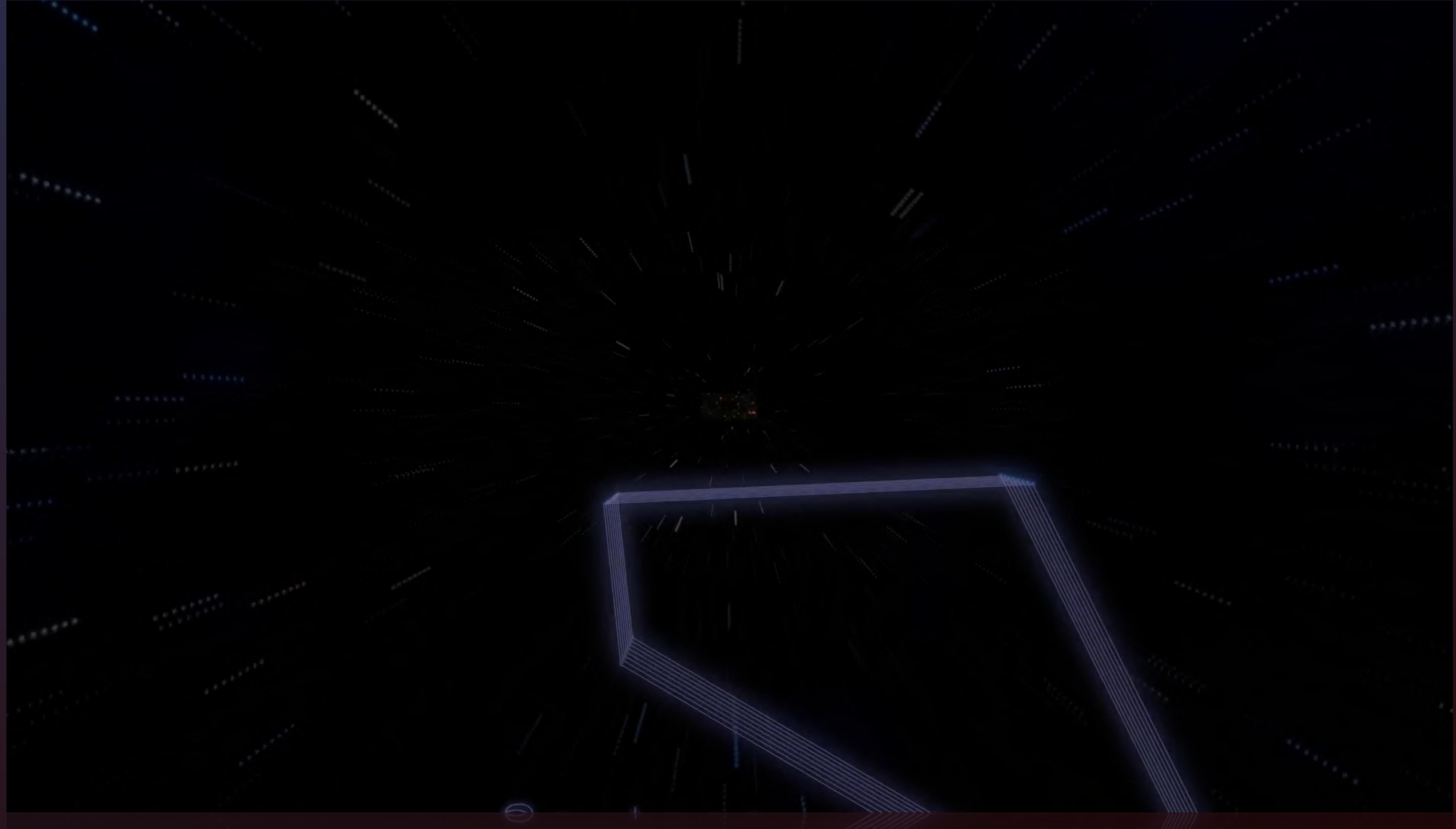
**359** millisecond pulsars ( $F_0 > 50$  Hz)

**Millisecond pulsars are rejuvenated by their companions to rapid spin periods.**



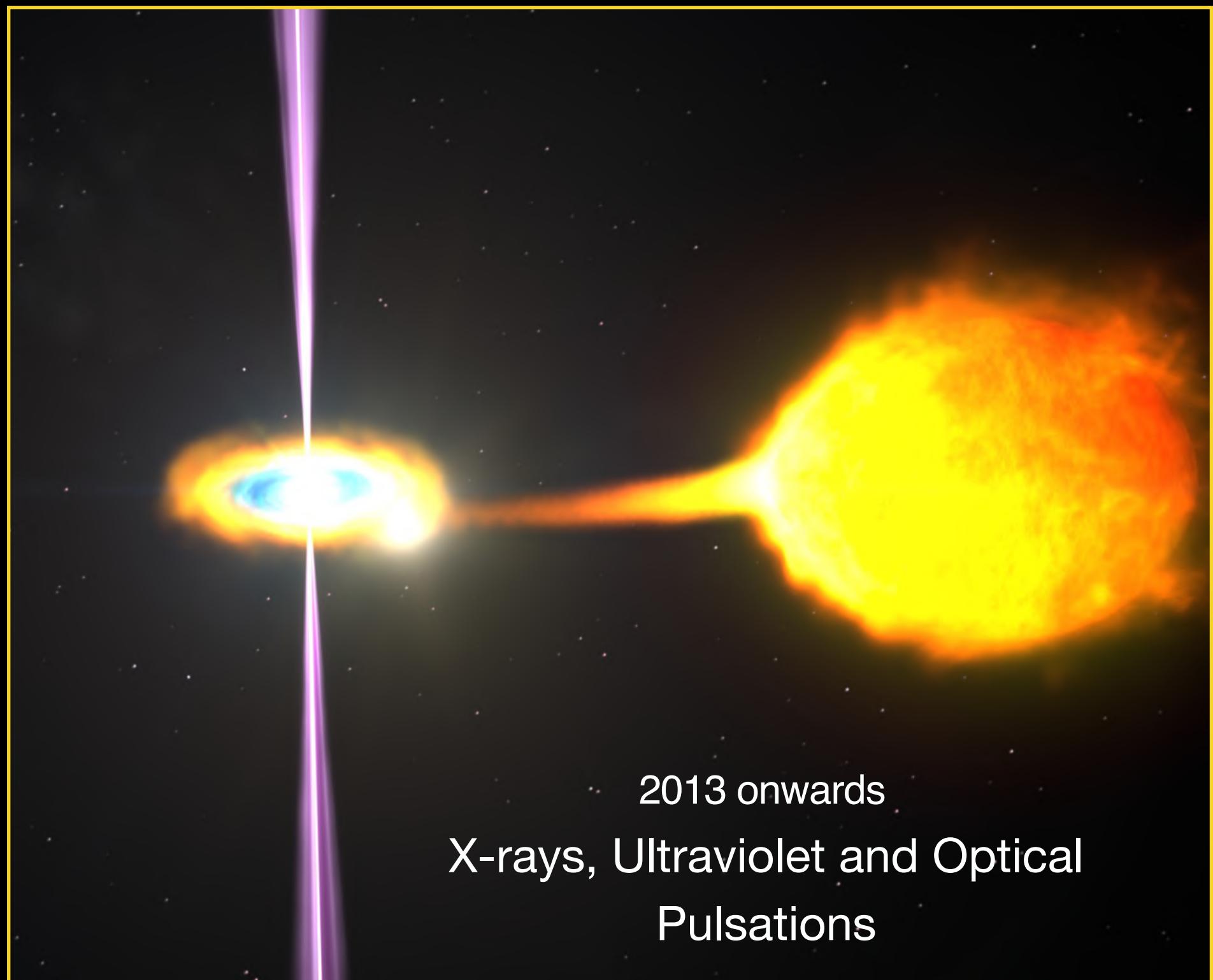
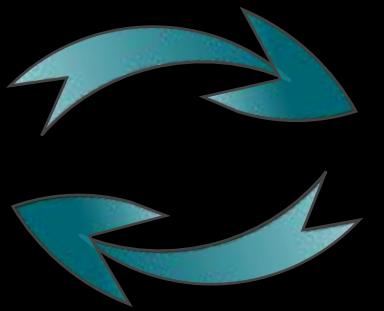
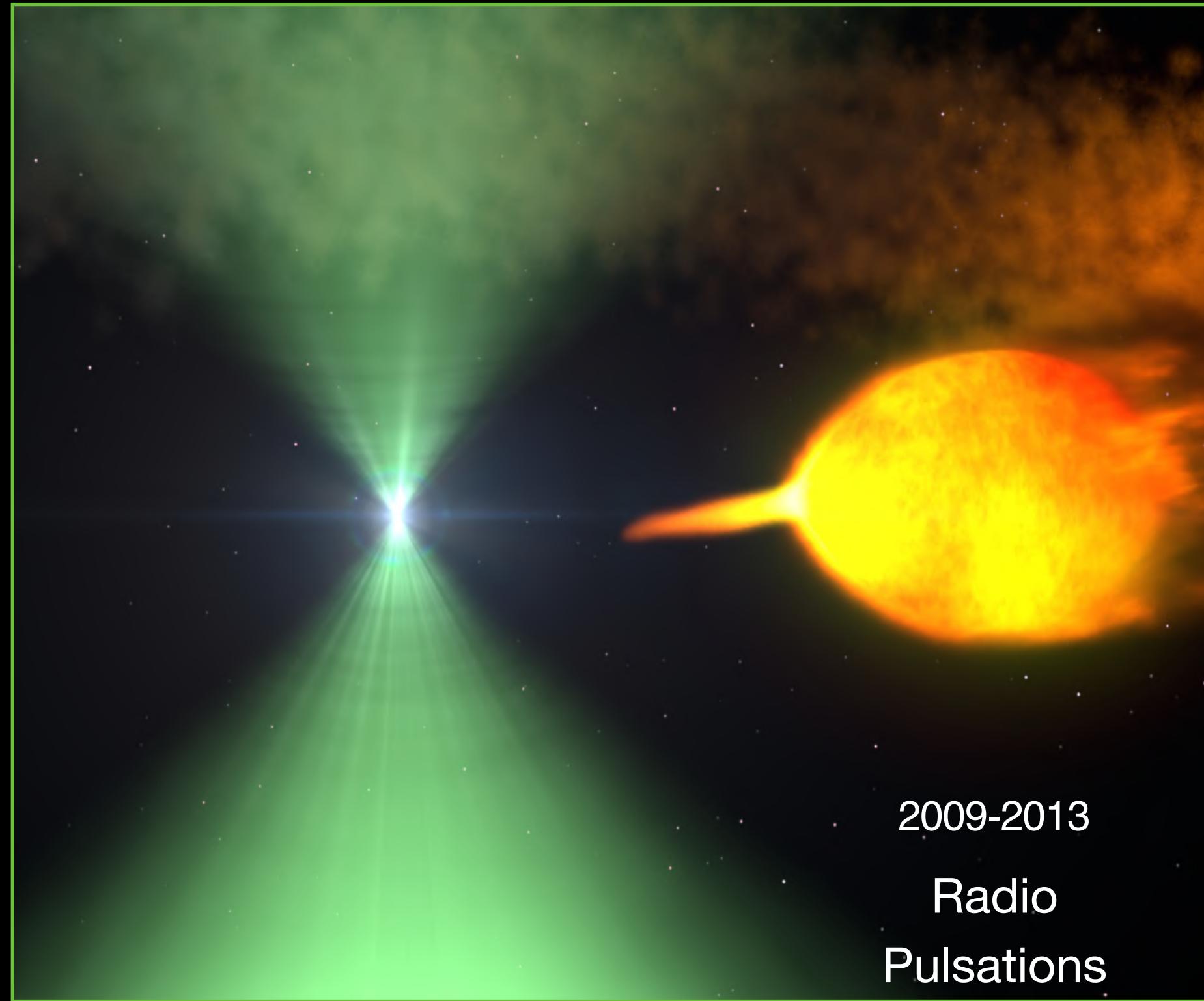
## Pulsar Recycling Mechanism

Alpar, Cheng, Ruderman & Shaham, Nature, 300, 728, (1982), Radhakrishnan & Srinivasan 1982

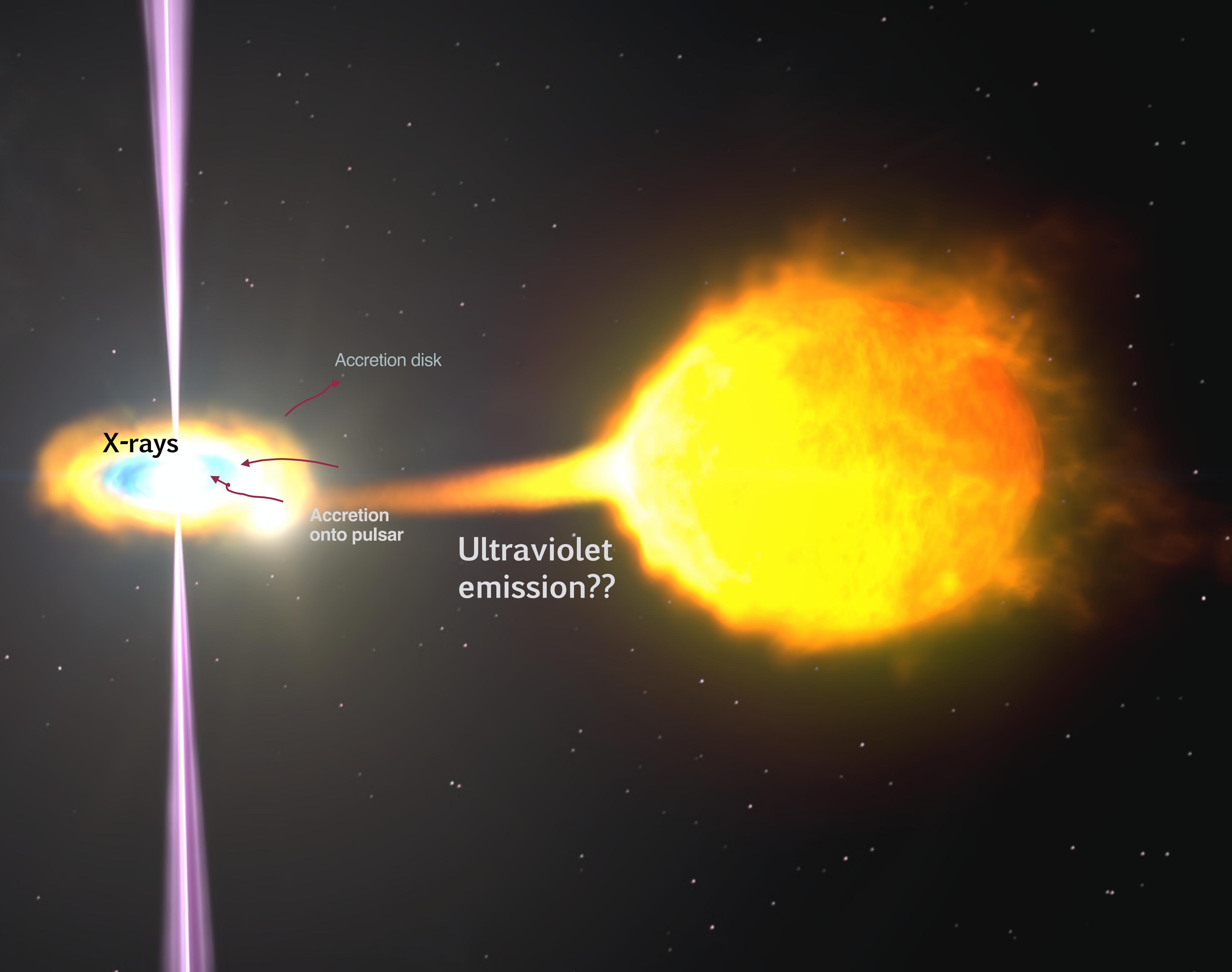


Credit: NASA's Goddard Space Flight Center

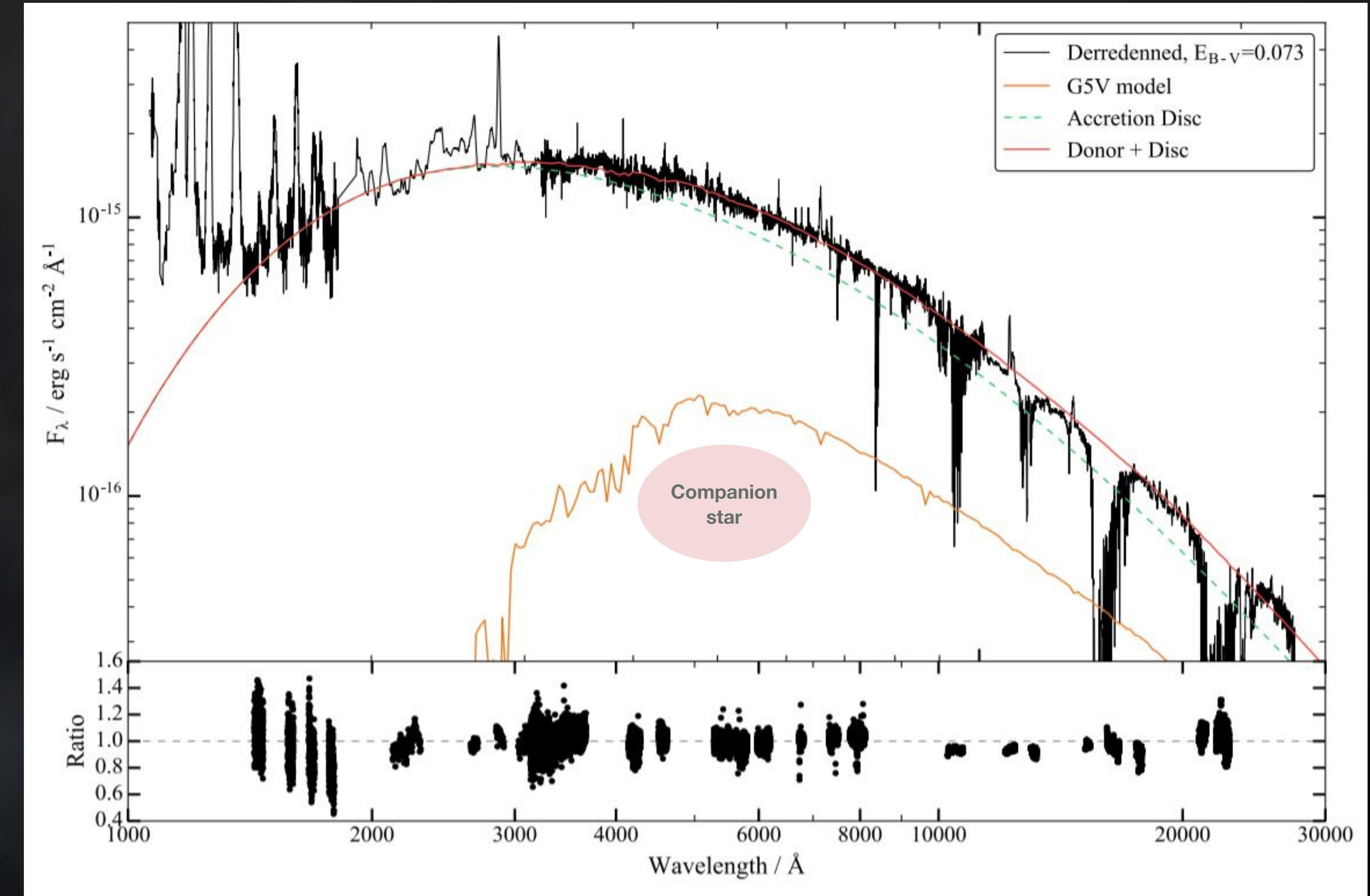
# Transitional Millisecond Pulsars

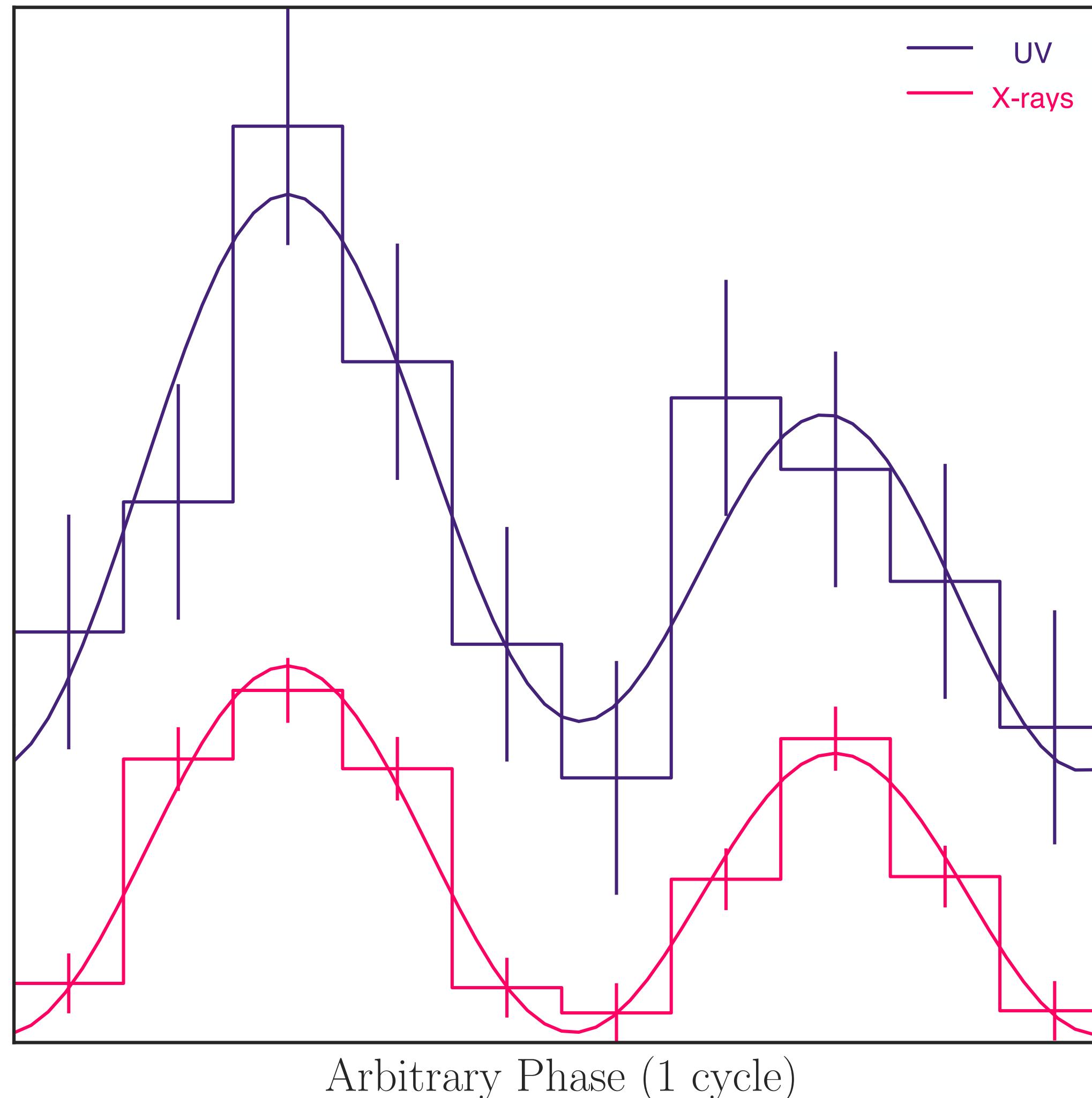


System oscillates between two states on rapid timescales of a few days causing the change in pulsations



# Hubble Spectrum





Detection of UV millisecond pulsations!  
Jaodand 2019; Jaodand, Hernandez et al. 2021

# UV pulsar

Coke et al 1969, Nather et al 1969

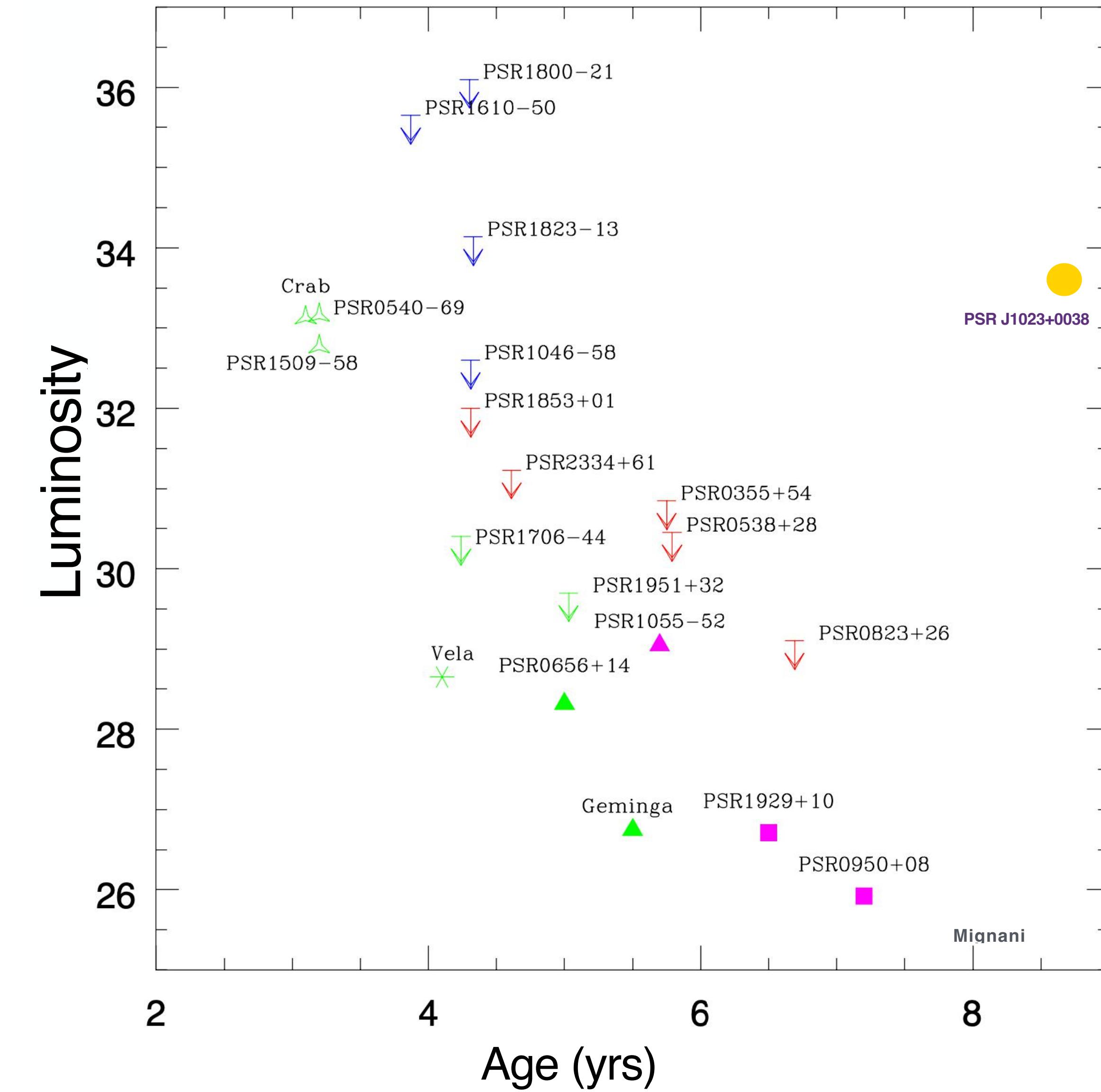
Crab Nebula



NASA, ESA, G. Dubner (IAFE, CONICET-University of Buenos Aires) et al.;  
A. Loll et al.; T. Temim et al.; F. Seward et al.; VLA/NRAO/AUI/NSF;  
Chandra/CXC; Spitzer/JPL-Caltech; XMM-Newton/ESA; and Hubble/STScI

## UV millisecond pulsars -unexplored population?

New surveys such as the proposed UVEX mission can reveal more such systems



- We have discovered Ultraviolet millisecond pulsations with Hubble telescope!

- Pulse period of 1.69 ms

- How do pulsars generate pulsed UV emission?

- Similar phenomena later found in SAX J1808-3548 confirms our discovery

- Future missions can help us discover a new population of UV pulsars