7.62 millisecond eclipsing binary pulsar PSR J2129-0429

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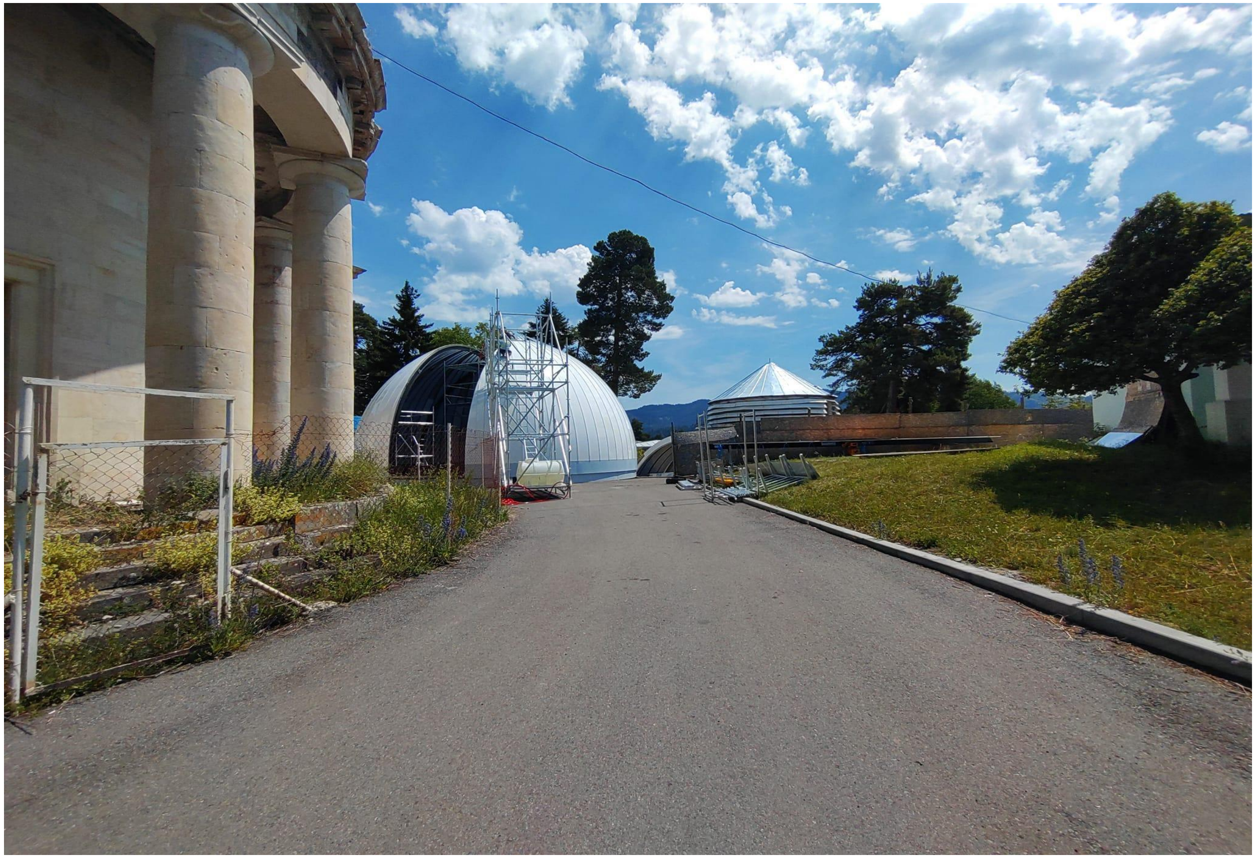
Good news – a new 1.5 m Ritchey - Chretien



Now

Now

Planned – using the new telescope

- Massive stars – Be; LBVs, WR, CBs
- Low and intermediate mass CBs
- CBs with pulsating components;
- Exoplanets….

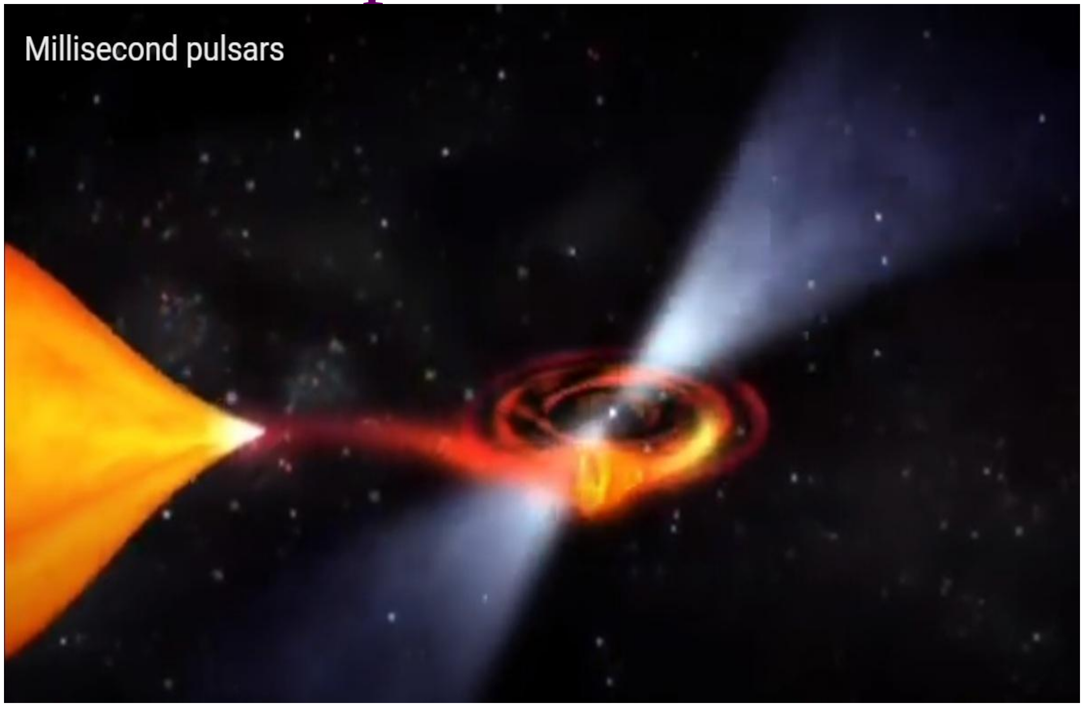
- Millisecond RB and BW pulsars…

- And of course, we are going to use it for GRANDMA

Millisecond Pulsars

- Rotational period less than about 10 milliseconds
- Old neutron stars – have been spun up (“recycled”)
  through accretion in CB
- Low mass x-ray binaries
- Angular momentum can increase rotation rate of the pulsar

Spider Binaries

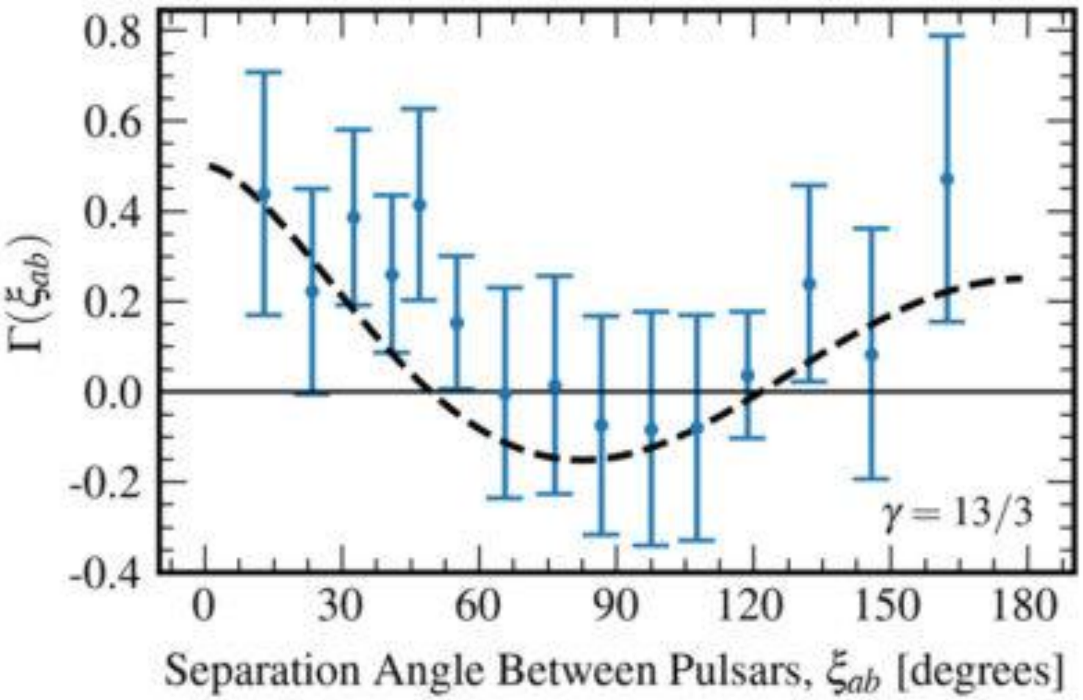


Spider binaries contain a millisecond pulsar and a low-mass companion star in a tight orbit with period P <1 day
Are divided in two main groups: BWs and RBs
In these systems, the pulsar irradiates the companion and drives a stellar wind (Kluzniak et al. 1988; van Paradijs et al. 1988). The relativistic pulsar wind and massive-companion wind collide, forming an intrabinary shock (IBS). These sources emit across the electromagnetic spectrum, with radio and gamma-ray emission from the pulsar itself, optical emission from the companion star, and X-ray emission dominated by the IBS.
In redbacks, the momentum of the companion wind dominates that of the pulsar, causing the IBS to wrap around the pulsar, while in black widows, the IBS wraps around the companion (Romani & Sanchez 2016).

Why spiders?

1. “**background**” of **gravitational waves**

2. short lived state of CBs



Evidence for a gravitational wave background (GWB) comes from correlating changes in pulsar arrival times between all possible pairs of the 67 pulsars — 2,211 distinct pairs in total. The dotted line is the predicted pattern of correlations with increasing angular separation of the pairs in the sky if the pulsars were being affected by passing gravitational waves. The solid line is what is expected if there is no GWB. The blue points are NANOGrav’s measurements, and show the increase in correlation at both small (left) and large (right) separations expected for the GWB signal. (Image credit: NANOGrav collaboration)

RB - Latrodectus Hasselti

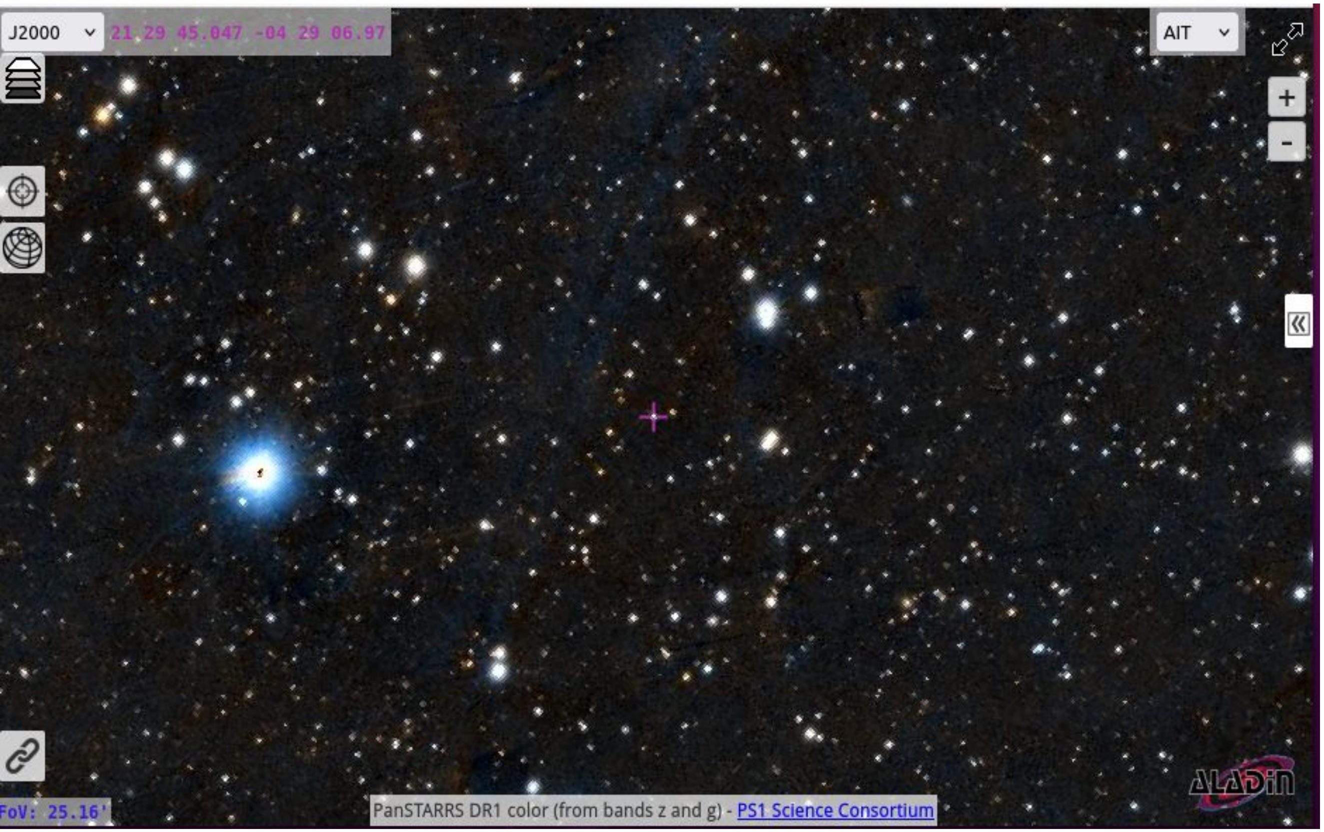
RB companions are non-degenerate;
$M_c \approx 0.2–0.4\ M_\odot$ ($M_c > 0.2\ M_\odot$)

BW – Latrodectus

Hesperus

BW companions may or may not degenerate
$M_c << 0.2\ M_\odot$

RB PSR J2129−0429



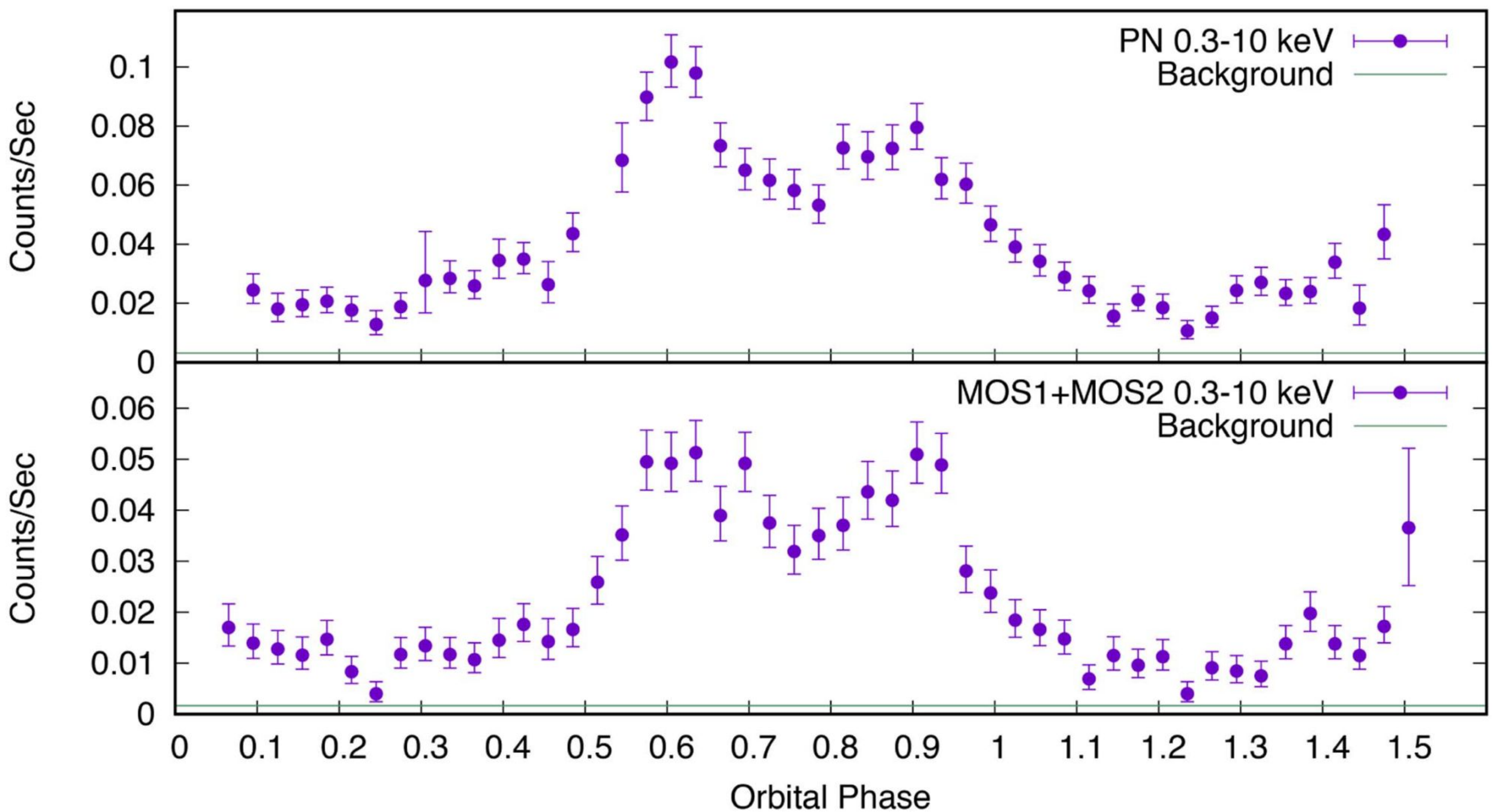
- 7.62 ms
- P= 15.2 hr
- m_V = 16.57 – 16.79 mag

1.74 ± 0.18 $M_\odot$

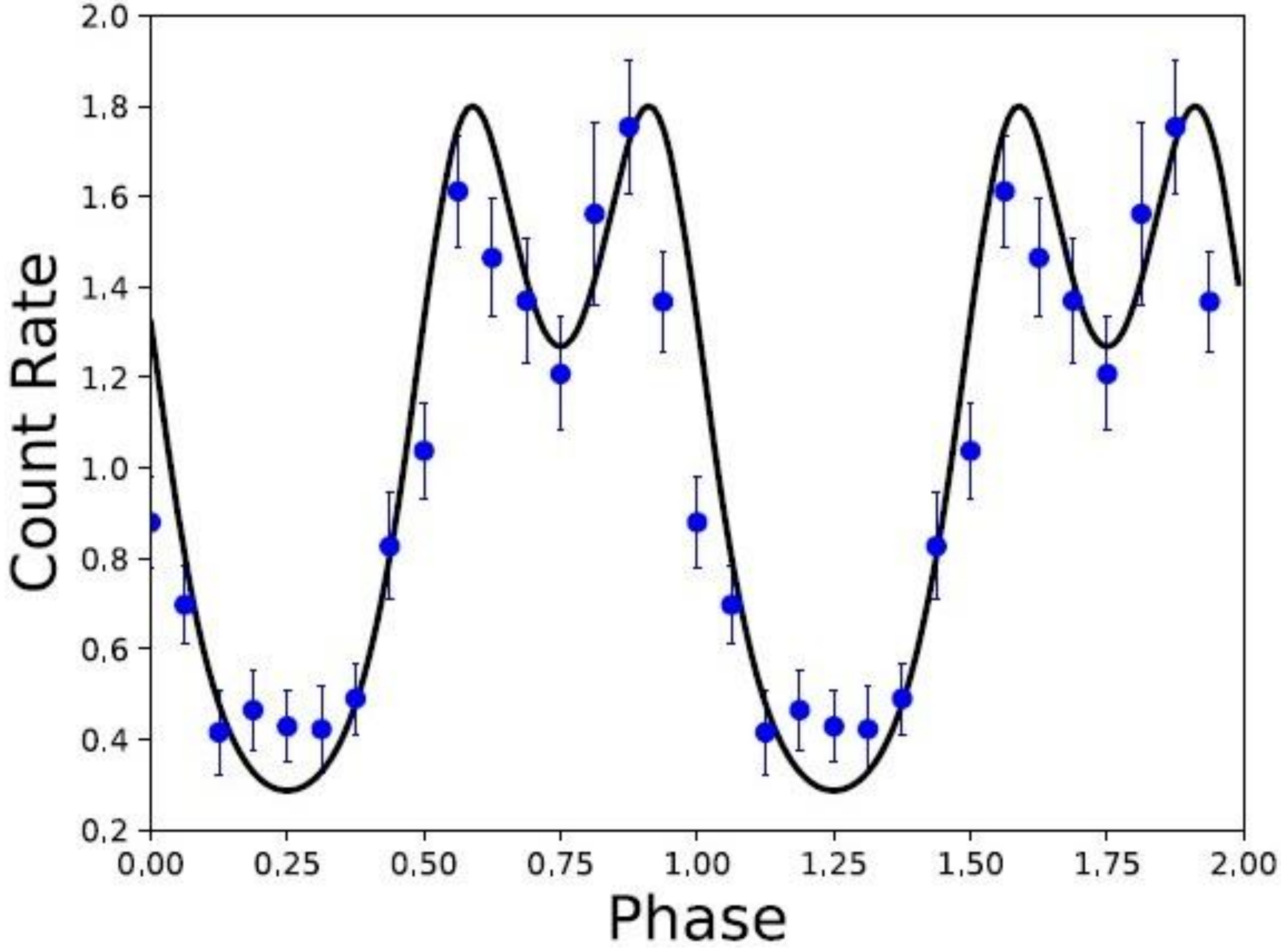
0.44 ± 0.04 $M_\odot$

- Roche-lobe ~ 95%
- 13.1mmag yr−1 decline
- 1.6×10^9G –high surfice magnetic field

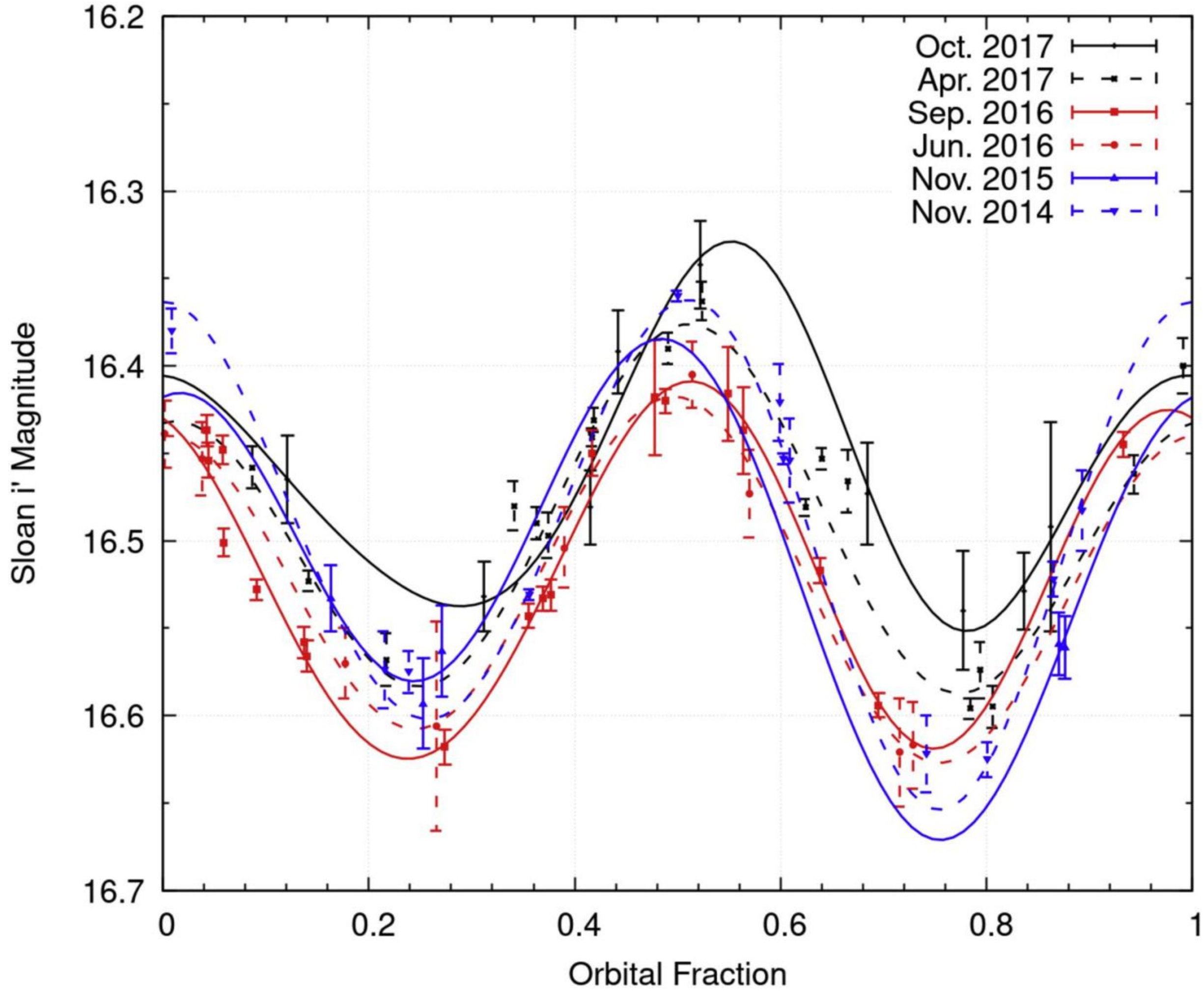
XMM-Newton 0.3–10keV light-curves of PSR J2129−0429



NuSTAR 3–40 keV
observations *of PSR J2129-0429*



But maybe it is not a RB?
LCOGT optical light curves



Light curves for J2129 taken with standard SDSS i′ filters across six epochs, spanning from 2014 November to 2017 October. The trends are similar for the r′ and g′ filters. The data used to create this figure are available (Al Noori, et al., 2018)

RB or Katipo?

1. Modeling shows that it is possible to produce the observed high pulsar mass (about *1.74 solar masses) with some* assumptions under standard recycling scenarios. Other evolutionary scenarios are not ruled out, however. Production of a NS with this mass via Accretion Induced Collapse rather than recycling appears possible, but would require a rapidly rotating WD and high accretion efficiency (Smedley et al. 2015).
2. Another possibility is that the neutron star was born heavy, with a mass near the observed 1.74 $M_\odot$ *(Tauris et al. 2011).* The origin of the 13 mmag yr−1 dimming of the companion of PSR J2129−0429 discovered in Bellm et al. 2016 remains uncertain.
3. If the companion is shrinking, we would expect to see larger changes in the ellipsoidal modulation of the phased light curve than are observed. Cooling of the companion is compatible with these data, but the expected thermal timescales for the system are much longer than the observed yearly variations.
4. Future multi-color observations will be valuable in monitoring the ongoing evolution of this unique system. Further investigation may reveal if PSR J2129−0429 will eventually destroy its companion or if—like the katipo spider found in New Zealand—it is a redback that shuns cannibalism.
5. Can we try to observe in the framework of GRANDMA?

Two Other Bright MS pulsars

- **PSR J1023+0038 (V 17.31)**
- **PSR J1723-2837 (V 15.77)**

Thank you for your attention!