# PULSAR J1411+2551: A NEW LOW MASS DOUBLE NEUTRON STAR SYSTEM


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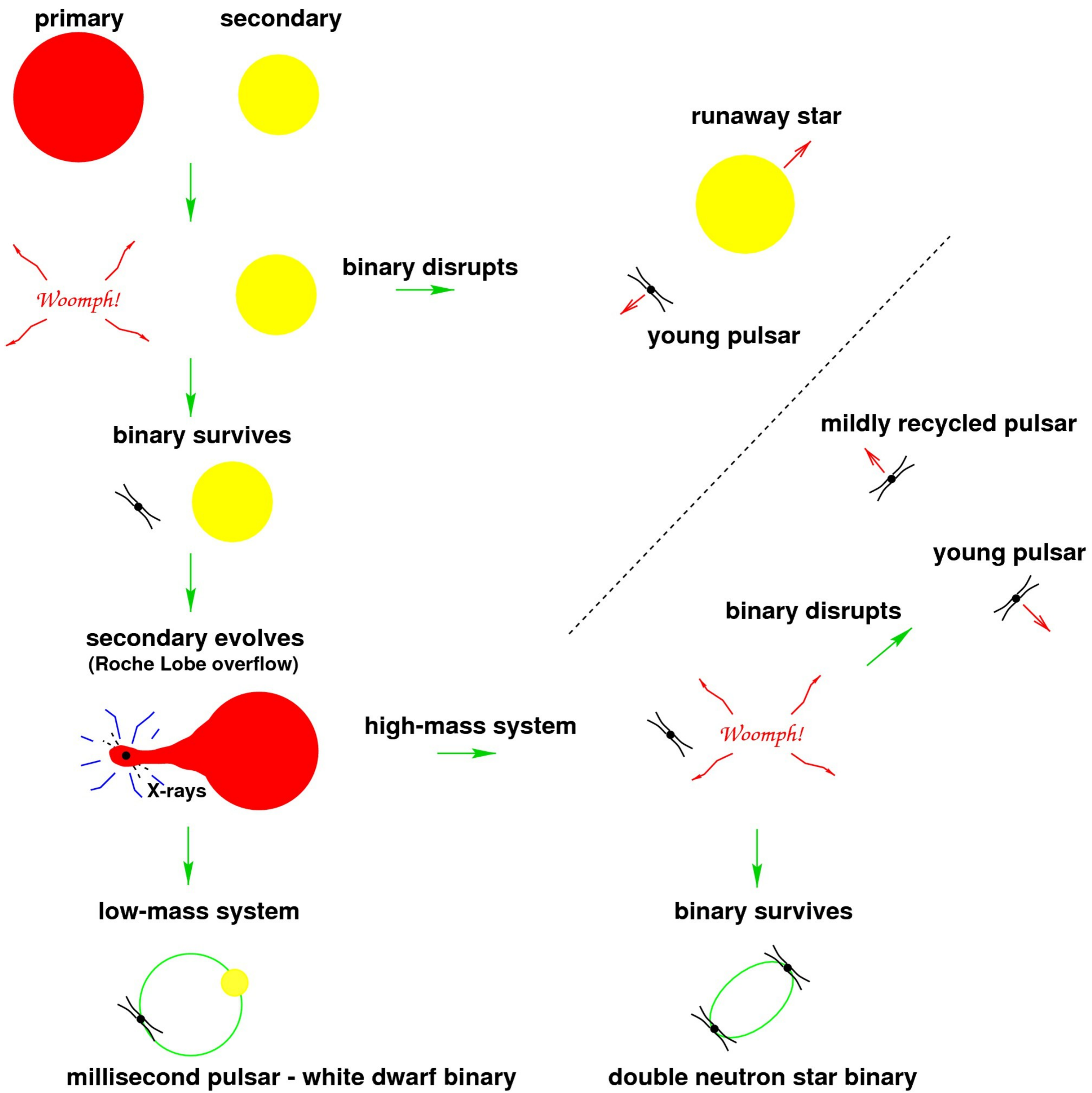
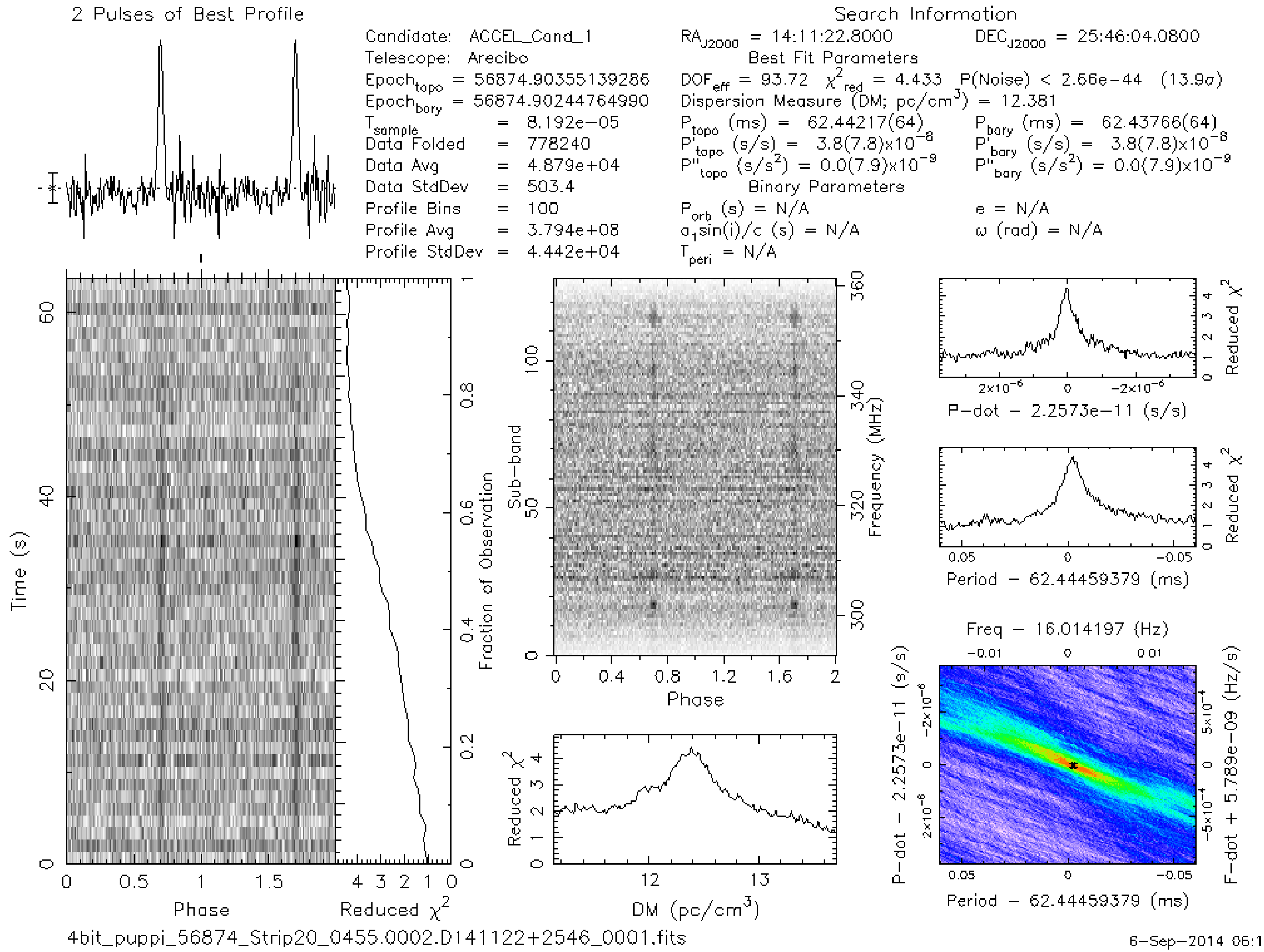
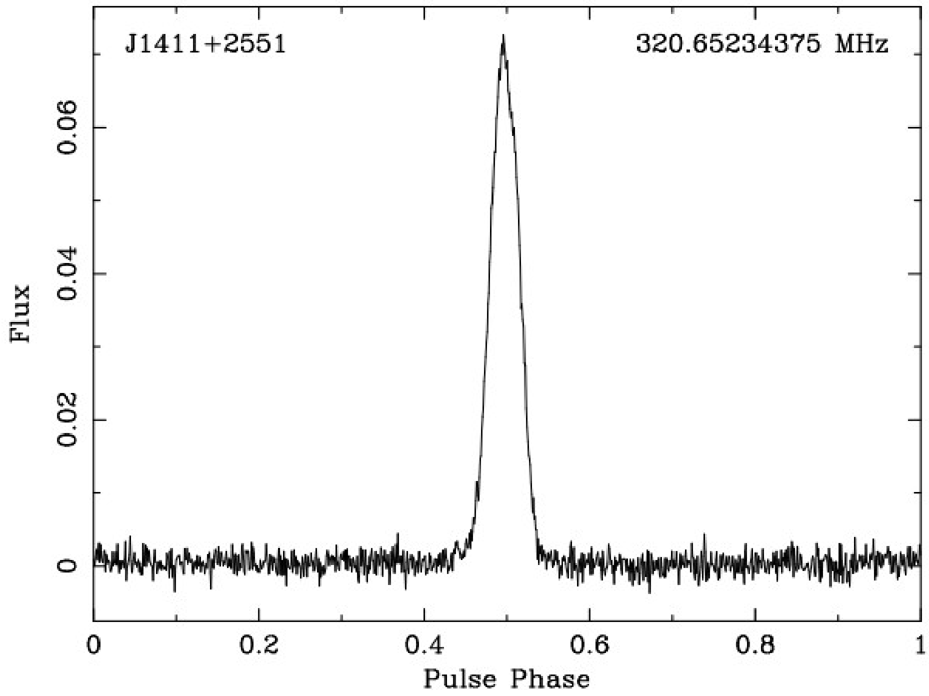
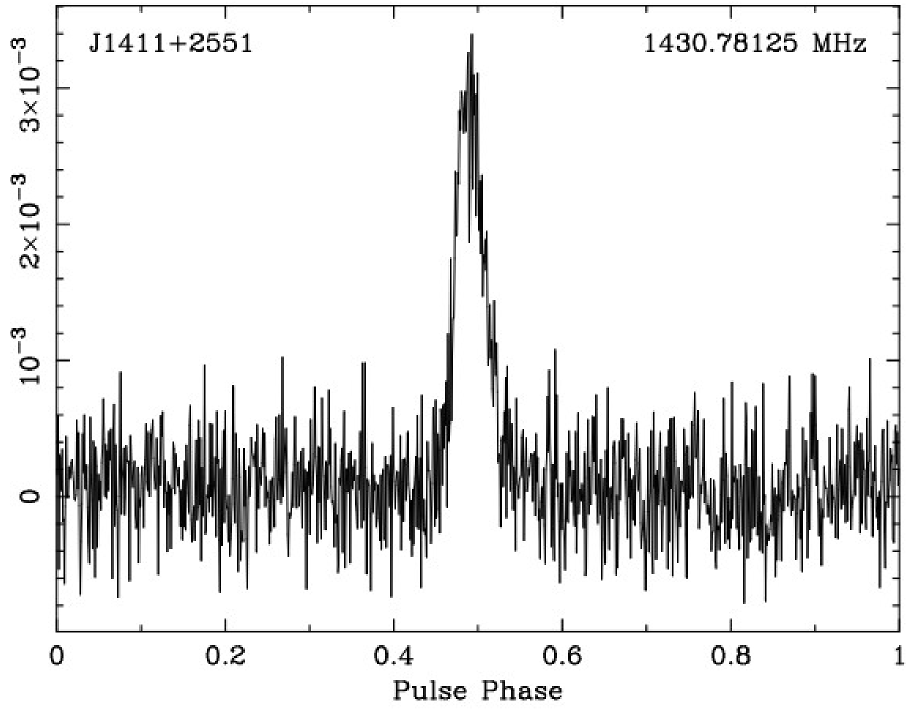

primary
secondary
runaway star
Woomph!
binary disrupts
young pulsar
binary survives
mildly recycled pulsar
young pulsar
binary disrupts
secondary evolves
(Roche Lobe overflow)
high-mass system
Woomph!
X-rays
low-mass system
binary survives
millisecond pulsar - white dwarf binary
double neutron star binary




# AO327 Survey 77 discoveries, 9 MSPs, 11 RRATs

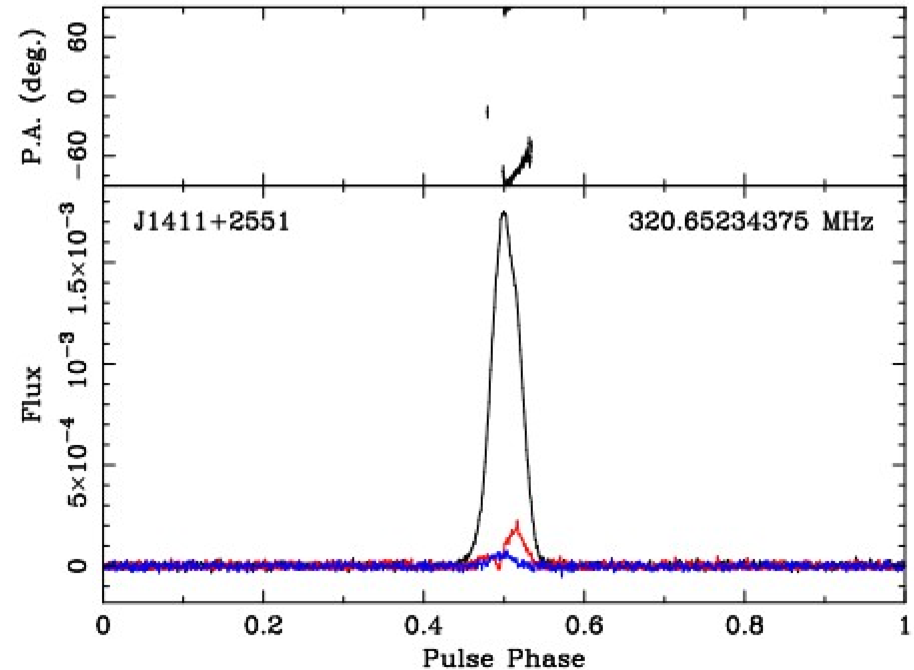



2.5 hour observations
327 MHz obs S/N = 300
L-band obs S/N = 25

| PSR | J1411+2551 |
|---|---|
| Right Ascension, $\alpha$ (J2000) ........... | 14:11:18.866(3) |
| Declination, $\delta$ (J2000) ................ | +25:51:08.39(7) |
| Proper motion in $\alpha$, $\mu_\alpha$ (mas yr$^{-1}$) .... | −3(12) |
| Proper motion in $\delta$, $\mu_\delta$ (mas yr$^{-1}$) ..... | −4(9) |
| Pulsar period, $P$ (s) .................... | 0.062452895517590(2) |
| Period derivative, $\dot{P}$ ($10^{-20}$ ss$^{-1}$) ....... | 9.56(51) |
| Dispersion measure, DM (pc $cm^{-3}$ ) ... | 12.3737(3) |
| **Binary Parameters** | |
| Orbital model ........................ | DD |
| Orbital period, $P_b$ (days) .............. | 2.61585677939(8) |
| Projected semi-major axis, $x$ (lt-s) ..... | 9.205135(2) |
| Epoch of periastron, $T_0$ (MJD) ........ | 57617.04513(1) |
| Orbital eccentricity, $e$ ................ | 0.1699308(4) |
| Longitude of periastron, $\omega$ (°) ......... | 81.5413(2) |
| Rate of advance of periastron, $\dot{\omega}$ (°yr$^{-1}$) | 0.0768(4) |
| **Derived parameters** | |
| Mass function, $f$ ($M_\odot$ ) .............. | 0.1223898(9) |
| Total mass, $M$ ($M_\odot$ ) ................. | 2.538(22) |
| Pulsar mass, $M_p$ ($M_\odot$ ) ............... | < 1.62 |
| Companion mass, $M_c$ ($M_\odot$ ) .......... | > 0.92 |
| Galactic longitude, $l$ .................. | 33.3789 |
| Galactic latitude, $b$ ................... | 72.1009 |
| DM derived distance, $d$ (kpc) ......... | 0.977 |
| Galactic height, $z$ (kpc) ............... | 0.93 |

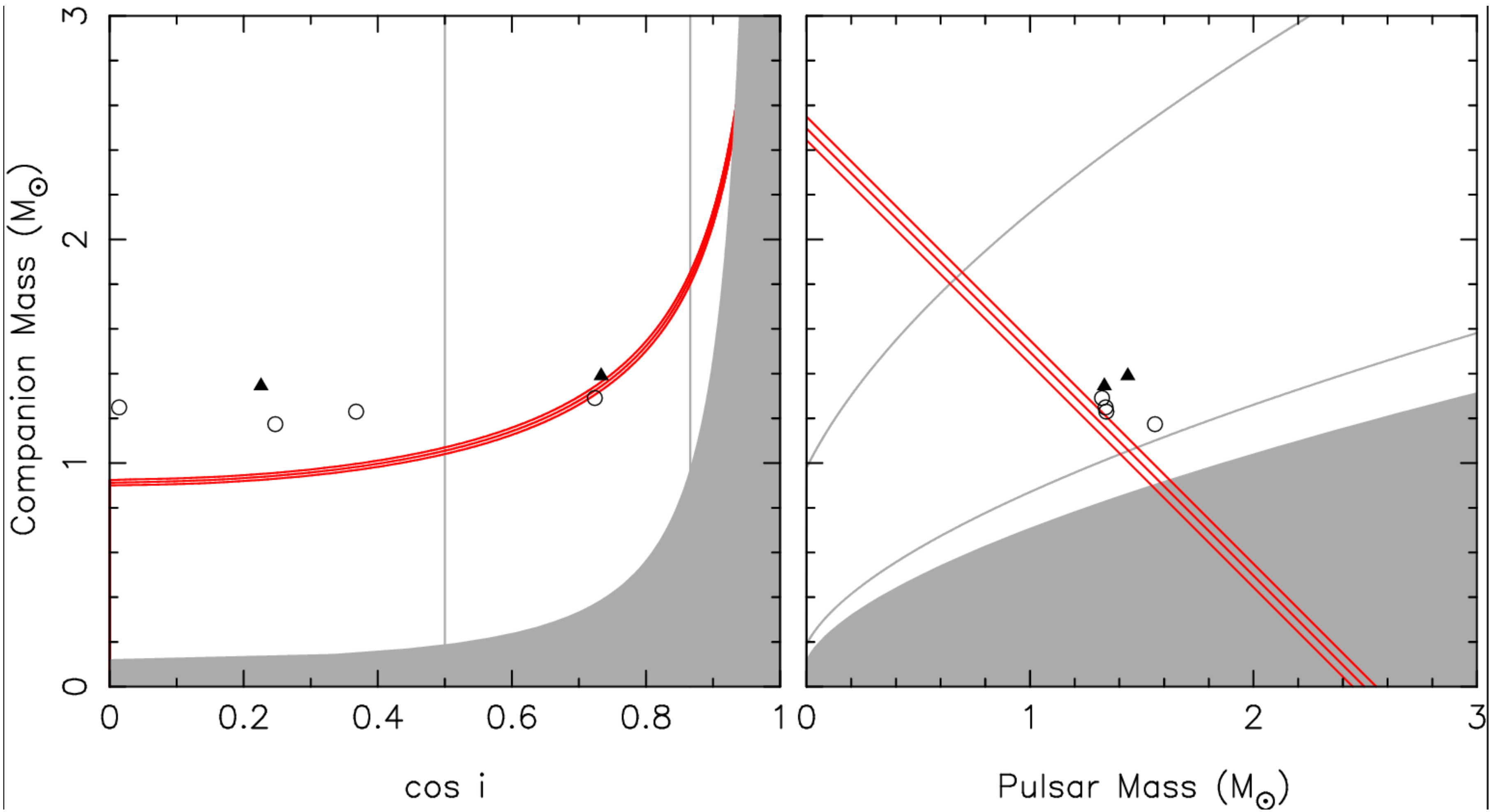
Notes. The distance is derived from the DM using the Cordes & Lazio (2002) model of the Galactic electron density with a ∼25% uncertainty.




$$M = \frac{1}{T_\odot}\left[\frac{\dot{\omega}}{3}(1-e^2)\right]^{\frac{3}{2}}\left(\frac{P_\mathrm{b}}{2\pi}\right)^{\frac{5}{2}}$$

$$M_c > \sqrt[3]{M^2 f(M_p, M_c)} \approx 0.92\mathrm{M}_\odot$$

# Mass vs Mass Plot J1411+2551




- Triangle *e* > 0.2
- Circle *e* < 0.2

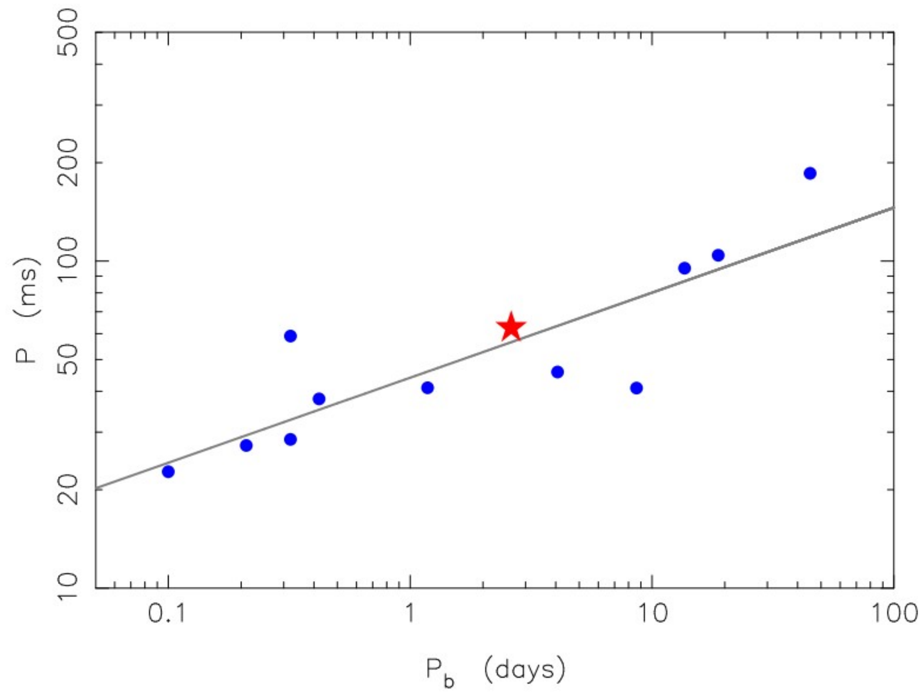



**Figure 3.** The blue points represent the spin period of the recycled pulsars in DNS sytems as a function of their orbital period. PSR J1411+2551 is represented by the red star. The grey line represents Eq. 4. For a detailed discussion, see Tauris et al. (2017).

$$P \approx 44 \text{ ms } \left(P_b/\text{days}\right)^{0.26}.$$

# Search for companion

- Search in 327, 430 MHz, and L-band
- Removing orbital modulation
- Treating $q$ as a free parameter (0.46-1.76)
- No detection

**Table 1.** Double Neutron Star systems known in the Galaxy

| Pulsar | Period (ms) | $P_b$ (days) | $x$ (lt-sec) | $e$ | $M$ ($M_\odot$) | $M_p$ ($M_\odot$) | $M_c$ ($M_\odot$) | References |
|---|---|---|---|---|---|---|---|---|
| J0453+1559 | 45.782 | 4.072 | 14.467 | 0.11251832(4) | 2.734(3) | 1.559(5) | 1.174(4) | 1 |
| J0737–3039A/B | 22.699 / 2773.461 | 0.102 | 1.415 / 1.516 | 0.0877775(9) | 2.58708(16) | 1.3381(7) | 1.2489(7) | 2 |
| **J1411+2551** | 62.452 | 2.615 | 9.204 | 0.1699299(5) | 2.538(22) | - | . | This Letter |
| J1518+4904 | 40.935 | 8.634 | 20.044 | 0.24948451(3) | 2.7183(7) | - | - | 3 |
| B1534+12 | 37.904 | 0.421 | 3.729 | 0.27367740(4) | 2.678463(4) | 1.3330(2) | 1.3454(2) | 4 |
| J1753–2240 | 95.138 | 13.638 | 18.115 | 0.303582(10) | - | - | - | 5 |
| J1755-2550* | 315.195 | 9.696 | 12.283 | 0.08932(3) | - | - | - | 6 |
| J1756–2251 | 28.462 | 0.320 | 2.756 | 0.1805694(2) | 2.56999(6) | 1.341(7) | 1.230(7) | 7 |
| J1811–1736 | 104.1 | 18.779 | 34.783 | 0.82802(2) | 2.57(10) | - | - | 8 |
| J1829+2456 | 41.009 | 1.760 | 7.236 | 0.13914(4) | 2.59(2) | - | - | 9 |
| J1906+0746* | 144.073 | 0.166 | 1.420 | 0.0852996(6) | 2.6134(3) | 1.291(11) | 1.322(11) | 10 |
| J1913+1102 | 27.285 | 0.206 | 1.754 | 0.08954(1) | 2.875(14) | - | - | 11 |
| B1913+16 | 59.031 | 0.323 | 2.342 | 0.6171334(5) | 2.8284(1) | 1.4398(2) | 1.3886(2) | 12 |
| J1930–1852 | 185.520 | 45.060 | 86.890 | 0.39886340(17) | 2.59(4) | - | - | 13 |
| Globular cluster systems | | | | | | | | |
| J1807–2500B* | 4.186 | 9.957 | 28.920 | 0.747033198(40) | 2.57190(73) | 1.3655(21) | 1.2064(20) | 14 |
| B2127+11C | 30.529 | 0.335 | 2.518 | 0.681395(2) | 2.71279(13) | 1.358(10) | 1.354(10) | 15 |

NOTE—1: Martinez et al. (2015), 2: Burgay et al. (2003) & Kramer et al. (2006), 3: Janssen et al. (2008), 4: Wolszczan (1991) & Fonseca et al. (2014), 5: Keith et al. (2009), 6: Ng et al. (2015), 7: Faulkner et al. (2005) & Ferdman et al. (2014), 8: Corongiu et al. (2007), 9: Champion et al. (2004) & Champion et al. (2005), 10: Lorimer et al. (2006) & van Leeuwen et al. (2015), 11: Lazarus et al. (2016), 12: Hulse & Taylor (1975) & Weisberg et al. (2010), 13: Swiggum et al. (2015), 14: Lynch et al. (2012), 15: Anderson et al. (1989) & Jacoby et al. (2006)

* Note: there is some uncertainty on whether these systems are DNSs.

# The Future

- Future observation
  - Proper motion
  -
- Paper on arXiv and **now in ApJ**
  - https://arxiv.org/abs/1711.09804
  - ApJ Letter, 851,L29