The Detectability of Eccentric Binary Pulsars

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  Power in the Fourier spectrum spreads over adjacent bins due to acceleration - height decreases - efficiency factor γ_1.
  Acceleration search can recover this power (partially) - γ_2.
- We extend this work for (i) eccentric binaries
  (ii) NS-NS systems
  (iii) NS-BH systems
  (iv) "acceleration-jerk" search - γ_3.

$$\gamma_1(\alpha_v, T) = \frac{1}{T}\left|\int_0^T \exp\left[\frac{im\omega_p}{c}\left(\left(\int_0^t v_l\, dt\right) - \alpha_v t\right)\right] dt\right|$$

pulsar is detected for such a value of α_v which maximizes γ_1

m^{th}: harmonic number
$\omega_p = 2\pi/P_p$: angular spin frequency of the pulsar
T: duration of the observation
v_l: line-of-sight velocity

$$\gamma_2(\alpha_a, \alpha_v, T) = \frac{1}{T}\Big|\int_0^T \exp\left[\frac{im\omega_p}{c}\left(\left(\int_0^t v_l\, dt\right) - \alpha_a t^2 - \alpha_v t\right)\right] dt\Big|$$

pulsar is detected for such a set of values of α_v, α_a which maximizes γ_2

$$\gamma_3(\alpha_j, \alpha_a, \alpha_v, T) = \frac{1}{T}\left|\int_0^T \exp\left[\frac{im\omega_p}{c}\left(\left(\int_0^t v_l\, dt\right) - \alpha_j t^3 - \alpha_a t^2 - \alpha_v t\right)\right] dt\right|$$

pulsar is detected for such a set of values of α_v, α_a, α_j which maximizes γ_3

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$$\gamma_2(\alpha_a, \alpha_v, T) = \frac{1}{T}\Big|\int_0^T \exp\left[\frac{im\omega_p}{c}\left(\left(\int_0^t v_l\, dt\right) - \alpha_a t^2 - \alpha_v t\right)\right] dt\Big|$$

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$$v_l = \frac{2\pi}{P_o}\frac{a_p^{'}}{\sqrt{1-e^2}}\left[\cos\left(f+\varpi\right) + e\cos\left(\varpi\right)\right]$$

NS-WD binaries:

$m = 4, \ T = 1000$ s.

pulsar	γ_1	γ_2	γ_3
J0437−4715	1.00	1.00	1.00
J0751+1807	0.29	0.64	0.98
J1600−3053	1.00	1.00	1.00
J1603−7202	1.00	1.00	1.00
J1614−2230	0.99	1.00	1.00
J1640+2224	1.00	1.00	1.00
J1713+0747	1.00	1.00	1.00
J1738+0333	0.56	0.95	1.00
J1903+0327	1.00	1.00	1.00

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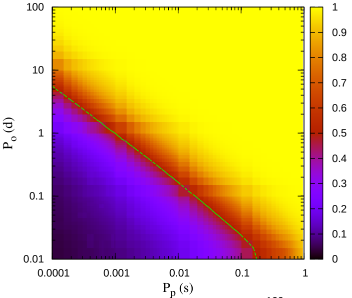
NS-WD binaries: effect of e

$i = 60^\circ$, $\varpi = 60^\circ$, $M_p = 1.4\ M_\odot$, $M_c = 0.3\ M_\odot$, $m = 4$, $T = 1000$ s.

$P_o = 0.1$ days, $P_p = 10$ ms			
e	γ_1	γ_2	γ_3
0.1	0.26	0.47	0.66
0.5	0.30	0.48	0.67
0.8	0.34	0.65	0.70

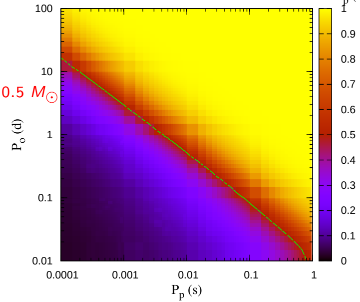
NS-WD binaries: effect of M_c

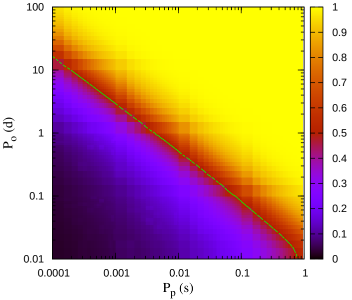
$i = 60^\circ$, $\varpi = 60^\circ$, $M_p = 1.4\ M_\odot$, $e = 0.5$, $m = 4$, $T = 1000$ s.



$M_c = 0.1\ M_\odot$

$M_c = 0.5\ M_\odot$





$M_c = 0.8\ M_\odot$

NS-NS binaries:

$m = 4, \; T = 1000$ s.

DNS	γ_1	γ_2	γ_3
J0737−3039A	0.21	0.41	0.56
J0737−3039B	0.98	1.00	1.00
B1534+12	0.52	0.92	1.00
J1756−2251	0.41	0.85	0.99
J1807−2500B	0.92	1.00	1.00
B1913+16	0.68	0.92	0.94

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NS-NS binaries:

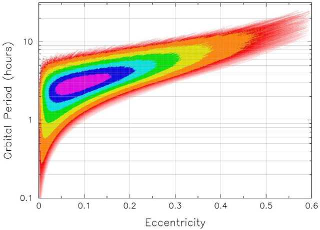
$M_p = 1.35\ M_\odot,\ M_c = 1.25\ M_\odot$

$m = 4,\ i = 60^\circ,\ \varpi = 30^\circ,\ T = 1000$ s

$P_o = 0.1$ days, $P_p = 10$ ms			
e	γ_1	γ_2	γ_3
0.1	0.17	0.34	0.49
0.5	0.19	0.33	0.53
0.8	0.20	0.45	0.59

NS-BH binaries:

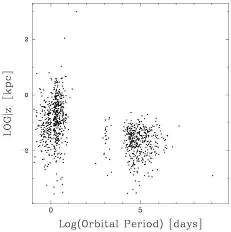
Pfahl, Podsiadlowski, & Rappaport, 2005, ApJ, 628, 343, mild recycling; yellow/magenta $\Rightarrow$ 1/5 in no. density



$M_p = 1.4\ M_\odot$, $M_c = 10\ M_\odot$, $m = 4$, $i = 60^\circ$, $\varpi = 30^\circ$, $T = 1000$ s

$P_o = 0.1$ day, $P_p = 80$ ms			
e	γ_1	γ_2	γ_3
0.1	0.24	0.44	0.63
0.5	0.28	0.45	0.65
0.8	0.32	0.64	0.70

NS-BH binaries:



MSP-BH pulsar in $|z| - P_{\rm o,final}$ parameter space as given by Kiel & Hurley, 2009, MNRAS, 395, 2326.

$M_p = 1.4\ M_\odot$, $M_c = 10\ M_\odot$, $m = 4$, $i = 60^\circ$, $\varpi = 30^\circ$, $T = 1000$ s

$P_o = 1.0$ day, $P_p = 10$ ms			
e	γ_1	γ_2	γ_3
0.1	0.32	0.90	1.00
0.5	0.38	0.91	1.00
0.8	0.46	0.91	1.00

Summary:

- We wanted to explore the detectability of short-period binaries.
- We have extended the work of Johnston & Kulkarni (1991) from circular binaries to eccentric binaries.
- We have explored the possibility of improvement including "acceleration-jerk" search.
- We are studying NS-WD, NS-NS, and NS-BH systems.
- Higher $M_c \Rightarrow$ lower efficiency factor,
  higher $e \Rightarrow$ higher efficiency factor.
- We plan to make the code public and submit the paper soon.
- Long term plan: include in "psrpop" - "psrpopbin"

Thank You