

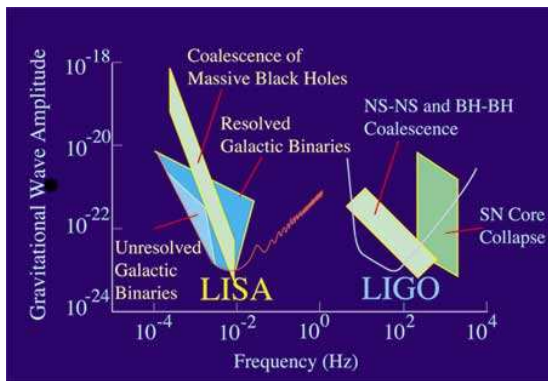
Stellar Mass LISA Sources in Star Clusters

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BH-BH Binaries as Gravitational Wave Sources



- BH-BH binary mergers are LIGO/VIRGO sources
- May be LISA sources at larger separation

- Produced rather inefficiently by stellar evolution (Belczynski et al. 2007, 2008)
- Normally circularized

Dynamical interactions in star clusters can create and modify BH-BH binary populations (Sigurdsson & Phinney 1993)

- Few-body binary formation
- Exchange interactions
- Binary hardening
- Binary disruption

Potential enhancement in LIGO/VIRGO detection rate

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Interactions can impart significant eccentricity to close binaries

- Potential source of eccentric stellar mass binary detections in the LISA band

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We study BH-BH binary population statistics in star clusters

We simulate star cluster dynamics using a Monte Carlo approximation (Hénon 1971, Stodótkiewicz 1982, Giersz 1998, 2001, 2006)

- Weak scattering limit, single interaction is statistically representative of all over Δt
- Correct statistical properties but does not reproduce individual orbits.

Binary interactions simulated using analytic prescriptions (Stodótkiewicz 1986, Giersz 1998, 2001, 2006)

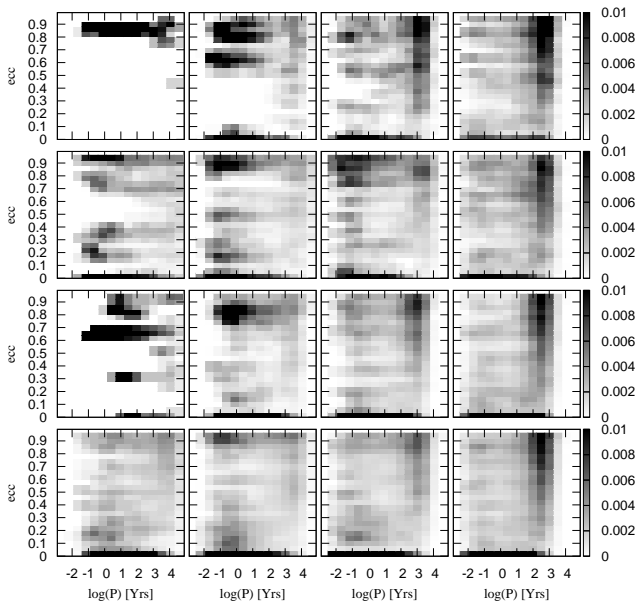
Stellar and binary evolution simulated using BSE recipes (Hurley et al. 2002, Giersz et al. 2008)

- Higher mass BHs at low metallicity

Dynamically Produced BH-BHs

Simulation	N_{BH}	N_{BHBH_p}	N_{BHBH_s}	N_{BHBH_d}
10sol21	1103 ± 18	2 ± 1	0 ± 0	1 ± 1
10sol37	1119 ± 44	3 ± 2	0 ± 0	14 ± 11
10sol75	1104 ± 31	2 ± 1	0 ± 0	52 ± 19
10sol180	1129 ± 22	3 ± 1	0 ± 0	123 ± 27
50sol21	1495 ± 43	13 ± 5	0 ± 1	3 ± 2
50sol37	1515 ± 32	12 ± 4	0 ± 0	50 ± 11
50sol75	1498 ± 28	9 ± 2	0 ± 1	147 ± 28
50sol180	1555 ± 42	9 ± 3	0 ± 0	354 ± 33
10low21	1248 ± 34	2 ± 2	0 ± 1	21 ± 10
10low37	1262 ± 30	4 ± 2	0 ± 1	44 ± 6
10low75	1265 ± 30	5 ± 4	0 ± 1	54 ± 16
10low180	1296 ± 37	3 ± 2	0 ± 1	112 ± 24
50low21	1719 ± 46	8 ± 2	3 ± 2	127 ± 16
50low37	1728 ± 47	17 ± 4	3 ± 2	185 ± 29
50low75	1731 ± 37	16 ± 3	2 ± 1	202 ± 38
50low180	1769 ± 31	9 ± 3	4 ± 3	453 ± 109

BH-BH Binary Statistics



Prospects for Gravitational Wave Detection

Find no mergers in cluster so no LIGO/VIRGO detections

- Dynamical disruption timescale shorter than inspiral timescale (Peters & Mathews 1963, Peters 1964) by several orders of magnitude

Still prospects for LISA detections

- Search clusters between ages of 11.5-14 Gyr for binaries with a combination of period and frequency within the LISA band

$$f_{\max} \simeq \sqrt{\frac{2}{(1-e)^3}}$$

Several simulations have binaries falling into this range, must determine detectability

Place all binaries with correct parameters in the 16 nearest GCs and calculate signal to noise

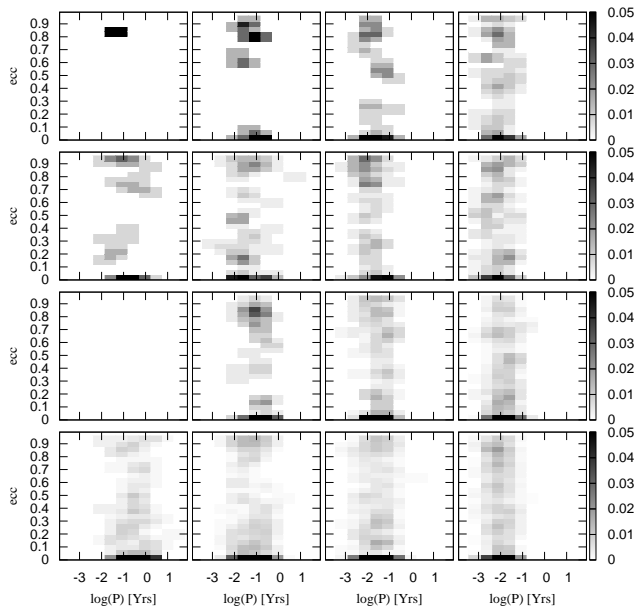
$$\rho^2 = 4 \int_0^\infty \frac{|h(f)|^2}{S_n(f)} df$$

Find two potentially detectable binaries ($\rho \geq 7$)

Simulation	$M_p [M_\odot]$	$M_s [M_\odot]$	P [dy]	e
10low37	23.89	14.26	4.70	0.947
50sol180	5.90	5.62	13.23	0.997

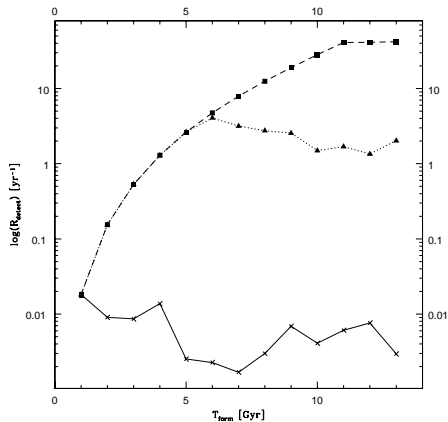
Both have high eccentricity

Escapers



- Many short-period, eccentric binaries escape
- Will merge in a Hubble time
- Will pass through the LISA band

Detection of Escapers



Reasonable prospects for detection
from the next generation of
ground-based detectors

In the process of analysing escapers for LISA detection.

- Star clusters efficiently produce BH-BH binaries through dynamical interactions
- Nearby star clusters have a small chance of producing eccentric, stellar-mass LISA sources
- BH-BH binaries escaping from star clusters produce a reasonable number of ground-based detections and look promising for LISA as well!