Compact binary coalescence parameter estimations for 2.5 post-Newtonian aligned spinning waveforms

(or; Can we measure black hole spin from the ground?)

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Outline

- Status of Gravitational Wave astronomy
- Binary inspiral
- Comparison of 2PN and 2.5PN
- Mass priors
- End of inspiral
- Linear combinations of spins
- Outlook

Status of gravitational wave astronomy

- No detections as of yet (LIGO, Virgo, GEO, Tama)

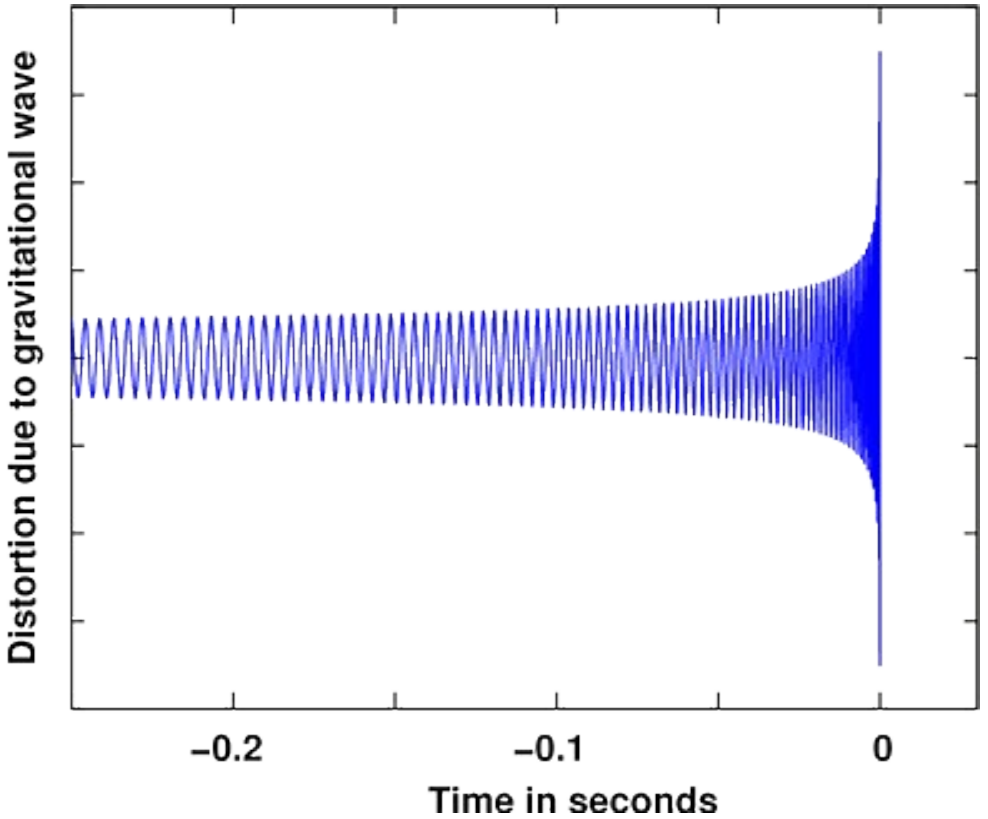
- Upgrade to LIGO due completed 2014-2015, full sensitivity achieved=? detections=?

- Japan ICGT → KAGRA construction started, 6-7 yrs

- Australia no, India maybe (H2)

- LISA, decision from ESA April 2012

Binary inspiral



Post-Newtonian (PN) waveform
Compact objects (100's of orbits per second)
Reduced mass, chirp mass
Aligned spins
Inspiral only

Comparison of 2PN and 2.5PN

	% error in μ	% error in $\mathcal{M}$	absolute error in χ_1	absolute error in χ_2
2 PN	2110	15.7	14.0	44.5
2.5 PN	774	9.75	261.1	430.4

High mass: M_1=15, M_2=10,χ_1=0.95, χ_2=0.95

	% error in μ	% error in $\mathcal{M}$	absolute error in χ_1	absolute error in χ_2
2 PN	104	0.48	0.9	10.4
2.5 PN	69	0.39	1.4	5.0

Low mass: M_1=5, M_2=1.4,χ_1=0.95, χ_2=0.0

Mass priors

PRIOR: Maximum value of $\eta=M_1M_2/(M_1+M_2)^2$ is 0.25

Minimum value is 0

High mass: $M_1=15$, $M_2=10$, $\chi_1=0.95$, $\chi_2=0.95$

$\Delta\chi_1$ from 261.1 to 27.6

$\Delta\chi_1$ from 430.4 to 47.3

Low mass: $M_1=10$, $M_2=1.4$, $\chi_1=0.95$, $\chi_2=0.0$

$\Delta\chi_1$ from 1.9 to 1.2

$\Delta\chi_1$ from 15.5 to 10.6

End of inspiral

Typically taken as Schwarzschild ISCO (550Hz for $M_{Tot} = 8$)

Extremal Kerr has r=M ISCO

Frequency approx 7x Schwarzschild ISCO

	% error in μ	**% error in $\mathcal{M}$**	**absolute error in χ_1**	**absolute error in χ_2**
Schwarzschild ISCO	152	0.82	21.4	30.6
10x ISCO	78	0.48	13.9	21.3

Low mass: M_1=5, M_2=3,χ_1=0.95, χ_2=0.0

Linear combination of spins

High mass: $M_1=15$, $M_2=10$, $\chi_1=0.95$, $\chi_2=0.95$

$\chi=0.86\chi_1+0.52\chi_2$

$\Delta\chi=0.91$

Max χ =1.37

Low mass: $M_1=5$, $M_2=3$, $\chi_1=0.95$, $\chi_2=0.95$

$\chi=0.88\chi_1+0.48\chi_2$

$\Delta\chi=0.31$

Max χ =1.36

Outlook

- 2.5PN is different from 2PN *(we need at least 3PN)*

- Priors will be important for determining spins and masses *(but we need to know which ones)*

- Combinations of spins may be enough to tell us if the system has spin somewhere *(but individual spins hard – can't rule out "super-extremal" objects from data alone)*

- Still many uncertainties *(~five years to go!)*

Thank you

(arXiv: 1203:6603)