Measuring tidal effects

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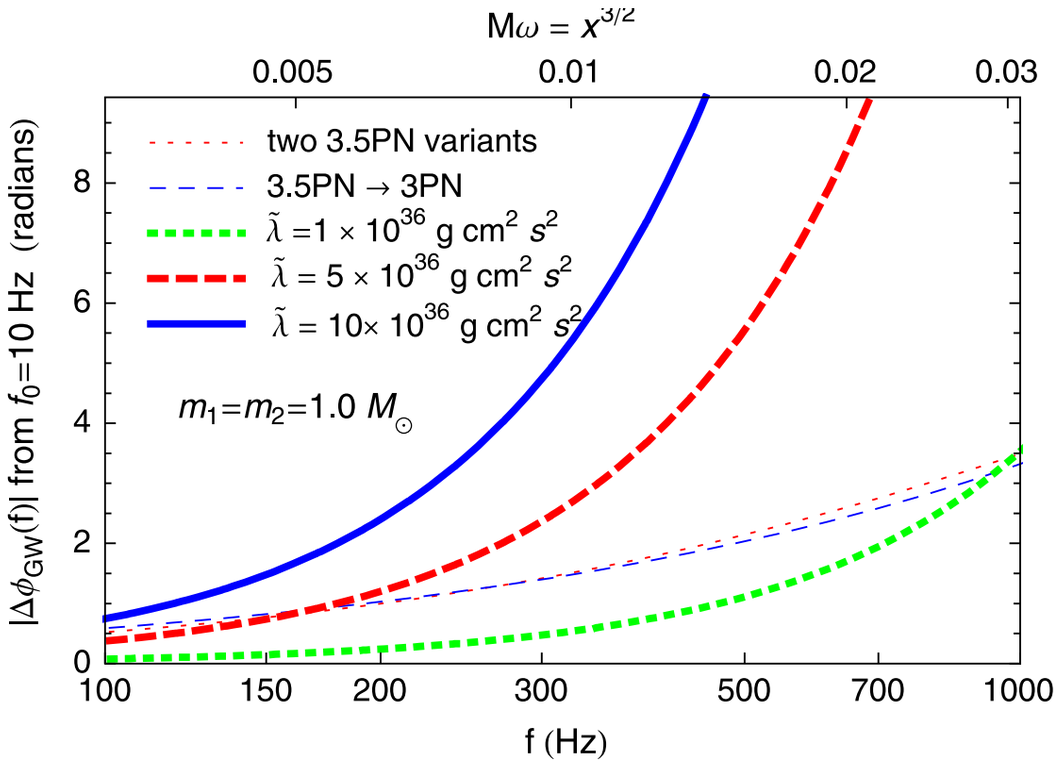
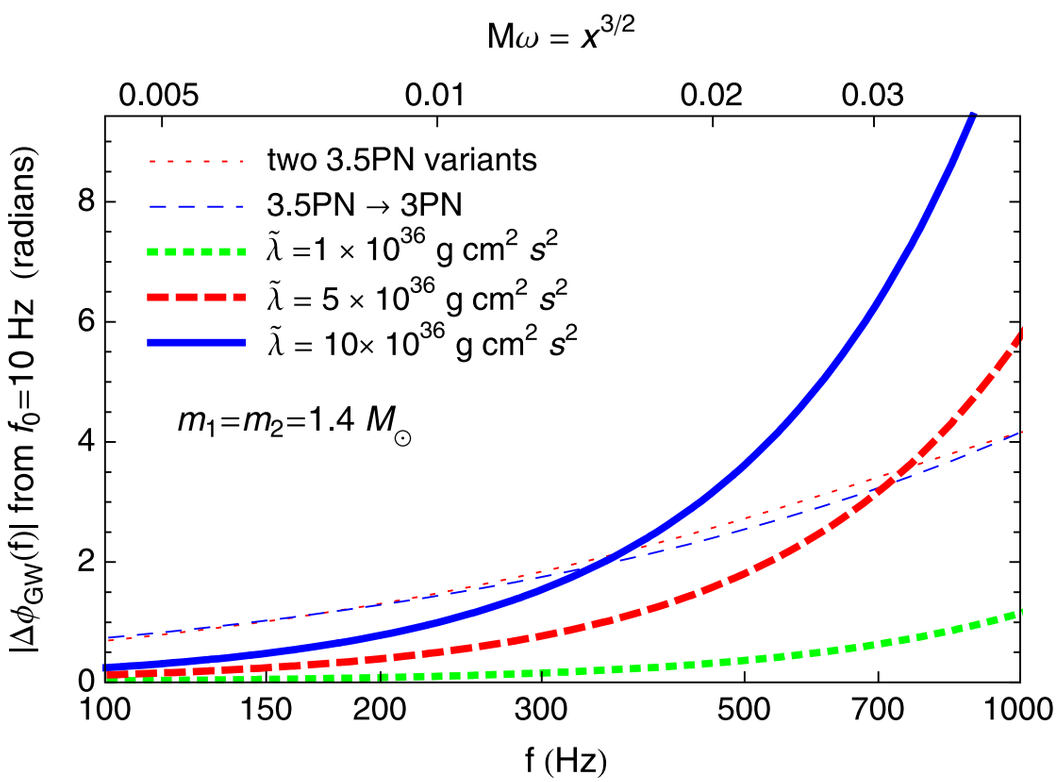
I mostly just pulled up figures in response to discussion during my talk. This is a collection of those figures with references.

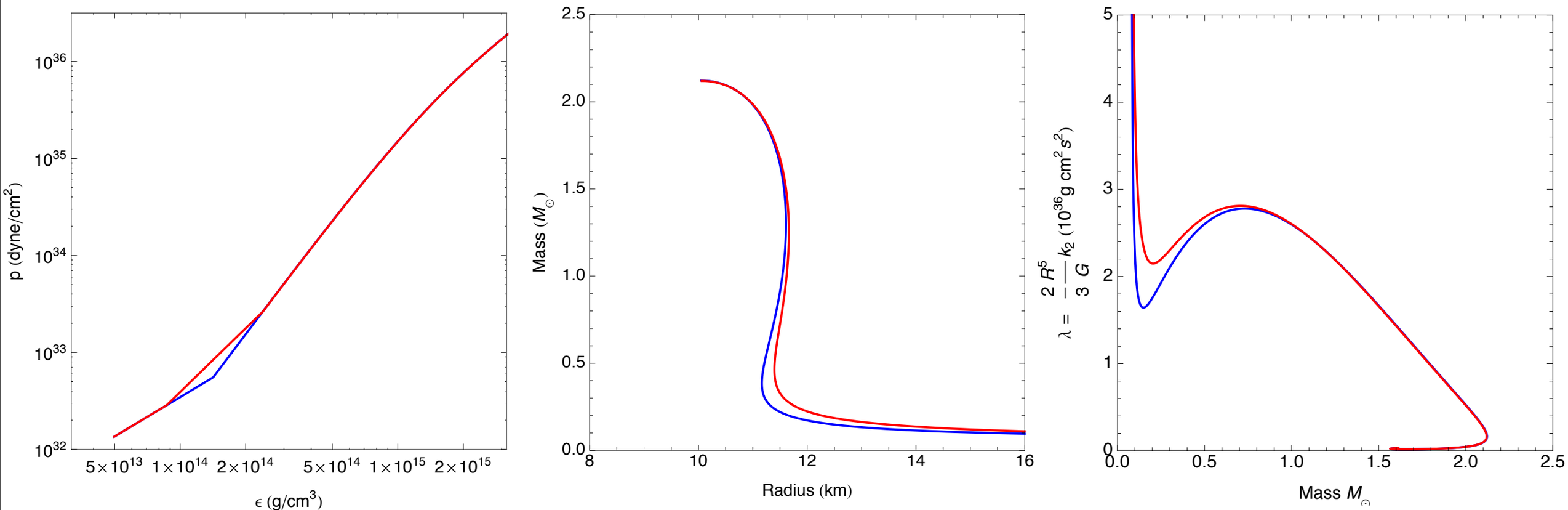


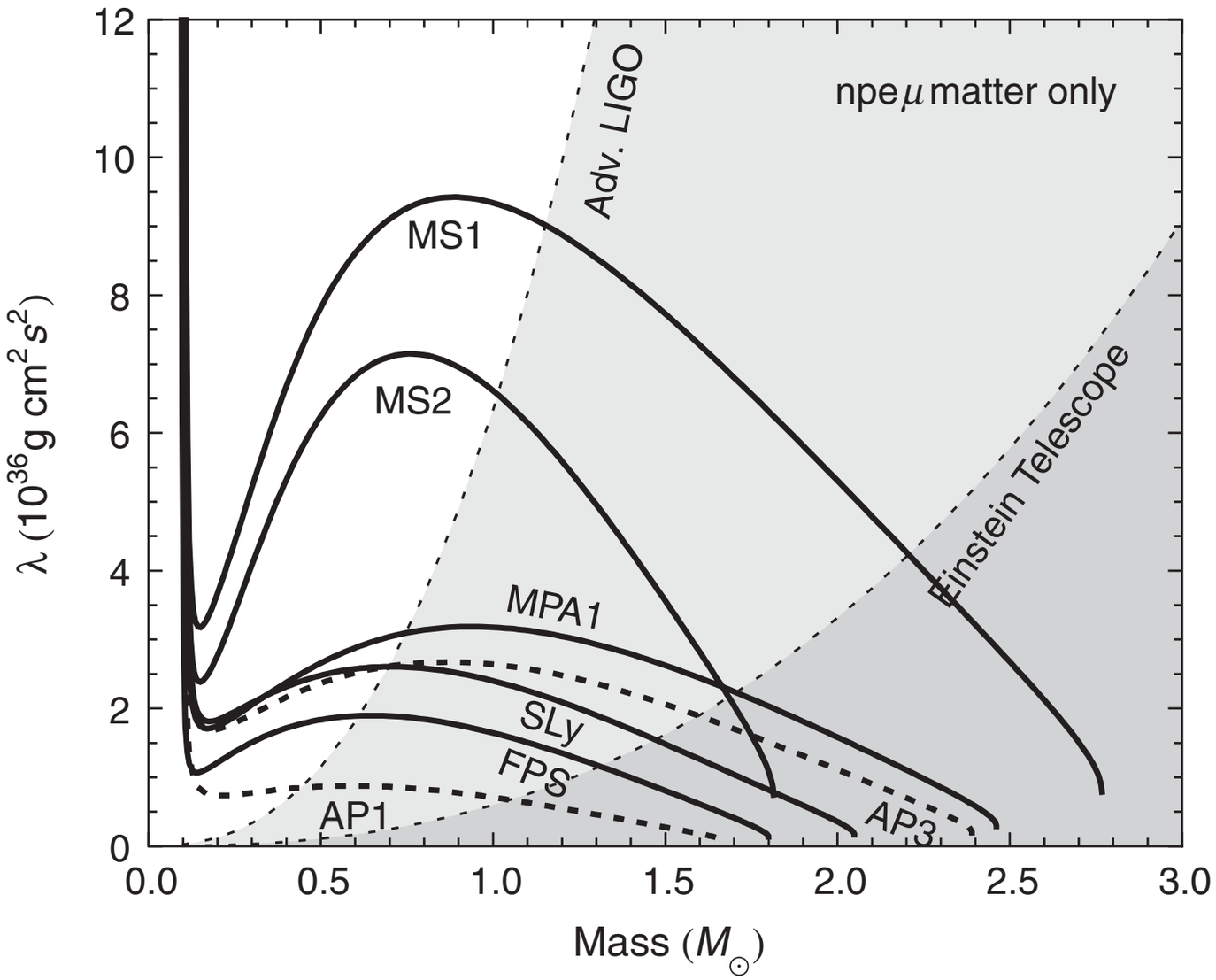


Relative sizes of 3.5PN and Newtonian tidal terms.

Figure from Hinderer et al 2010 http://arxiv.org/abs/0911.3535

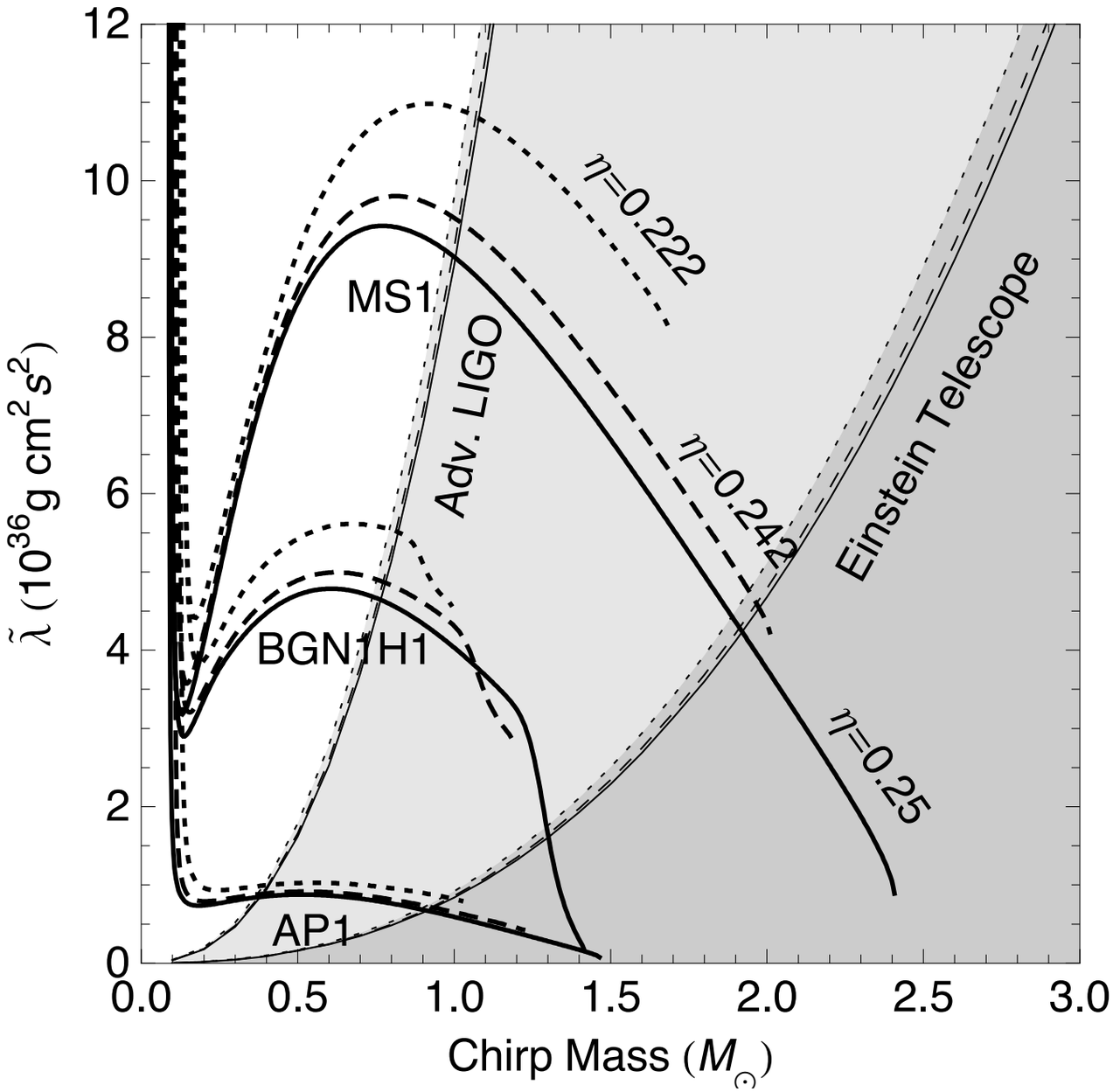
Sensitivity of parameters to low-density variation





Measurement in equal-mass systems using signal below 450Hz marginalized over spin

Figure from Hinderer et al 2010 http://arxiv.org/abs/0911.3535



Measurement with chirp parameters using signal below 450Hz marginalized over spin

Figure from Hinderer et al 2010 http://arxiv.org/abs/0911.3535

Advanced LIGO					
$M\ (M_\odot)$	m_2/m_1	$\Delta\mathcal{M}/\mathcal{M}$	$\Delta\eta/\eta$	$\Delta\tilde{\lambda}(10^{36}\ \mathrm{g\,cm^2\,s^2})$	ρ
2.0	1.0	0.000 28	0.073	8.4	27
2.8	1.0	0.000 37	0.055	19.3	35
3.4	1.0	0.000 46	0.047	31.3	41
2.0	0.7	0.000 26	0.058	8.2	26
2.8	0.7	0.000 27	0.058	18.9	35
3.4	0.7	0.000 28	0.055	30.5	41
2.8	0.5	0.000 37	0.06	17.8	33
Einstein Telescope					
$M\ (M_\odot)$	m_2/m_1	$\Delta\mathcal{M}/\mathcal{M}$	$\Delta\eta/\eta$	$\Delta\tilde{\lambda}(10^{36}\ \mathrm{g\,cm^2\,s^2})$	ρ
2.0	1.0	0.000 015	0.0058	0.70	354
2.8	1.0	0.000 021	0.0043	1.60	469
3.4	1.0	0.000 025	0.0038	2.58	552
2.0	0.7	0.000 015	0.0058	0.68	349
2.8	0.7	0.000 021	0.0045	1.56	462
3.4	0.7	0.000 025	0.0038	2.52	543
2.8	0.5	0.000 020	0.0048	1.46	442

Measurement with chirp parameters using signal below 450Hz marginalized over spin

Table from Hinderer et al 2010 http://arxiv.org/abs/0911.3535

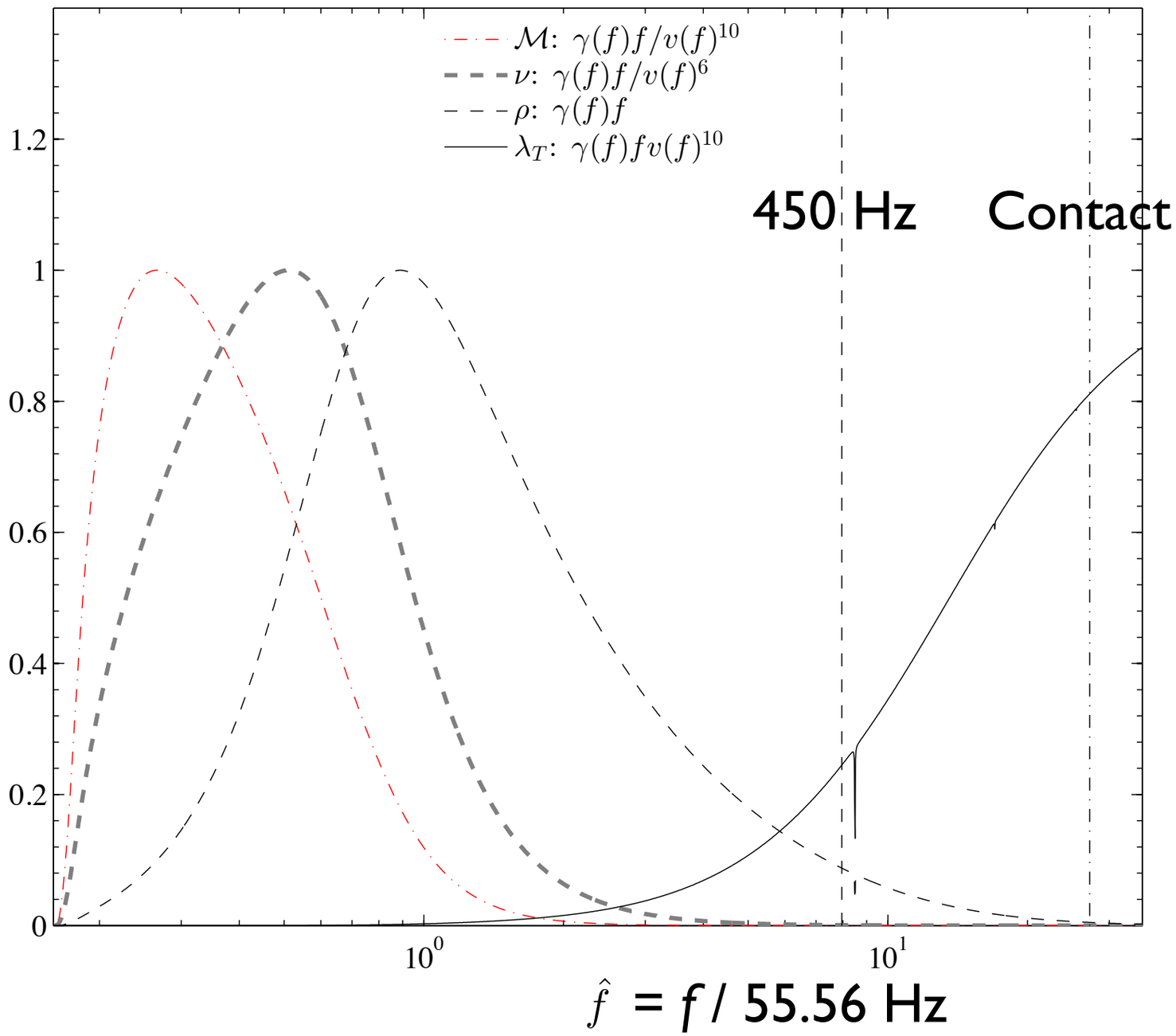
Damour, Nagar, Villain result http://arxiv.org/abs/1203.4352 similar estimate method, extended up to contact frequency (justified from EOB+Tidal/Numerical agreements)

tidal parameters for different EOS

relative error at SNR=1 (multiply by 1/SNR)

EOS	β	R [km]	$\mathcal{C}$	$G\mu_2$ [km^5]	$\hat{\sigma}_{\ln \mathcal{M}}$	$\hat{\sigma}_{\ln \nu}$	$\hat{\sigma}_{G\mu_2}$ [km^5]	$\hat{\sigma}_{\ln G\mu_2}$	$\hat{\sigma}^{450\mathrm{Hz}}_{G\mu_2}$ [km^5]	$\hat{\sigma}^{450\mathrm{Hz}}_{\ln G\mu_2}$
GNH3	$\lvert\beta\rvert < +\infty$	14.19	0.1457	32641.6	0.00415853	3.18959	186 292	5.70720	1 476 380	45.23
	$\lvert\beta\rvert < 8.5$	14.19	0.1457	32641.6	0.00405962	3.09906	182 612	5.59447	1 236 580	37.8835
	$\lvert\beta\rvert < 0.2$	14.19	0.1457	32641.6	0.000447397	0.122751	165 714	5.07679	874 001	26.7757
	$\beta = 0$	14.19	0.1457	32641.6	0.000450135	0.117804	165 652	5.07487	873 019	26.7456
BSK21	$\lvert\beta\rvert < +\infty$	12.57	0.1645	19424.9	0.003946	2.98317	158 080	8.13801	1 539 610	79.2596
	$\lvert\beta\rvert < 8.5$	12.57	0.1645	19424.9	0.0038749	2.91796	155 190	7.98922	1 284 240	66.1132
	$\lvert\beta\rvert < 0.2$	12.57	0.1645	19424.9	0.000434397	0.115657	133 108	6.85246	876 337	45.1141
	$\beta = 0$	12.57	0.1645	19424.9	0.000436901	0.110806	133 046	6.84928	875 290	45.0603
BSK20	$\lvert\beta\rvert < +\infty$	11.75	0.1760	12054.4	0.00384331	2.88426	148 380	12.3092	1 575 360	130.687
	$\lvert\beta\rvert < 8.5$	11.75	0.1760	12054.4	0.00378349	2.82927	145 750	12.0910	1 311 380	108.788
	$\lvert\beta\rvert < 0.2$	11.75	0.1760	12054.4	0.000428026	0.112247	118 815	9.85656	877 640	72.8064
	$\beta = 0$	11.75	0.1760	12054.4	0.000430414	0.107437	118 751	9.85125	876 558	72.7166
SLy	$\lvert\beta\rvert < +\infty$	11.74	0.1766	11244.8	0.00383898	2.8801	148 911	13.2426	1 579 310	140.448
	$\lvert\beta\rvert < 8.5$	11.74	0.1760	11244.8	0.00377961	2.82552	146 254	13.0064	1 314 390	116.888
	$\lvert\beta\rvert < 0.2$	11.74	0.1760	11244.8	0.000427755	0.112104	118 271	10.5179	877 784	78.0612
	$\beta = 0$	11.74	0.1760	11244.8	0.000430139	0.107295	118 206	10.5121	876 697	77.9646
APR	$\lvert\beta\rvert < +\infty$	11.37	0.1819	9709.13	0.00379747	2.84028	142 857	14.7136	1 586 810	163.434
	$\lvert\beta\rvert < 8.5$	11.37	0.1819	9709.13	0.00374226	2.78947	140 408	14.4615	1 320 100	135.964
	$\lvert\beta\rvert < 0.2$	11.37	0.1819	9709.13	0.000425161	0.110728	112 643	11.6018	878 055	90.436
	$\beta = 0$	11.37	0.1819	9709.13	0.000427498	0.105935	112 580	11.5953	876 961	90.3233

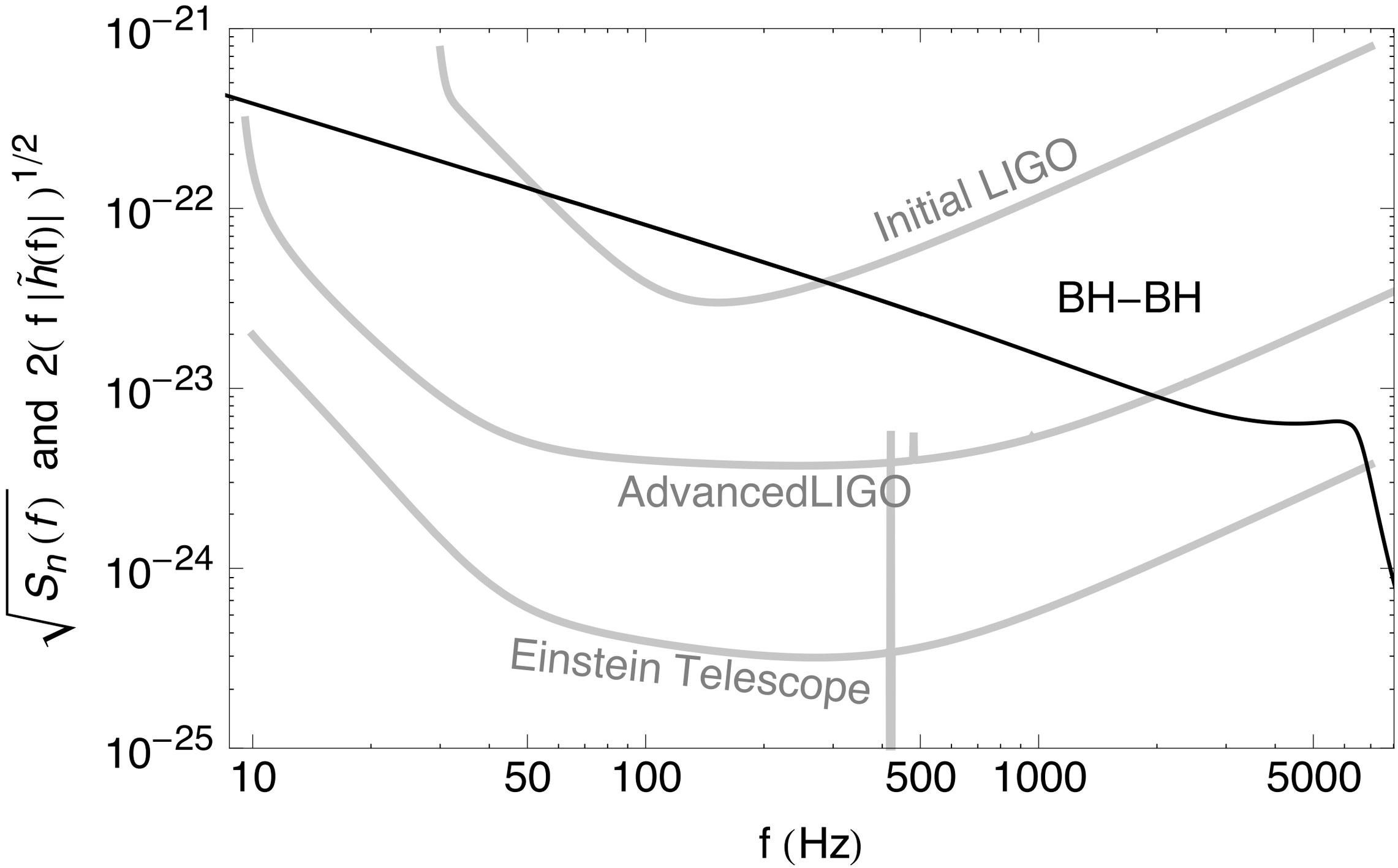
different spin priors



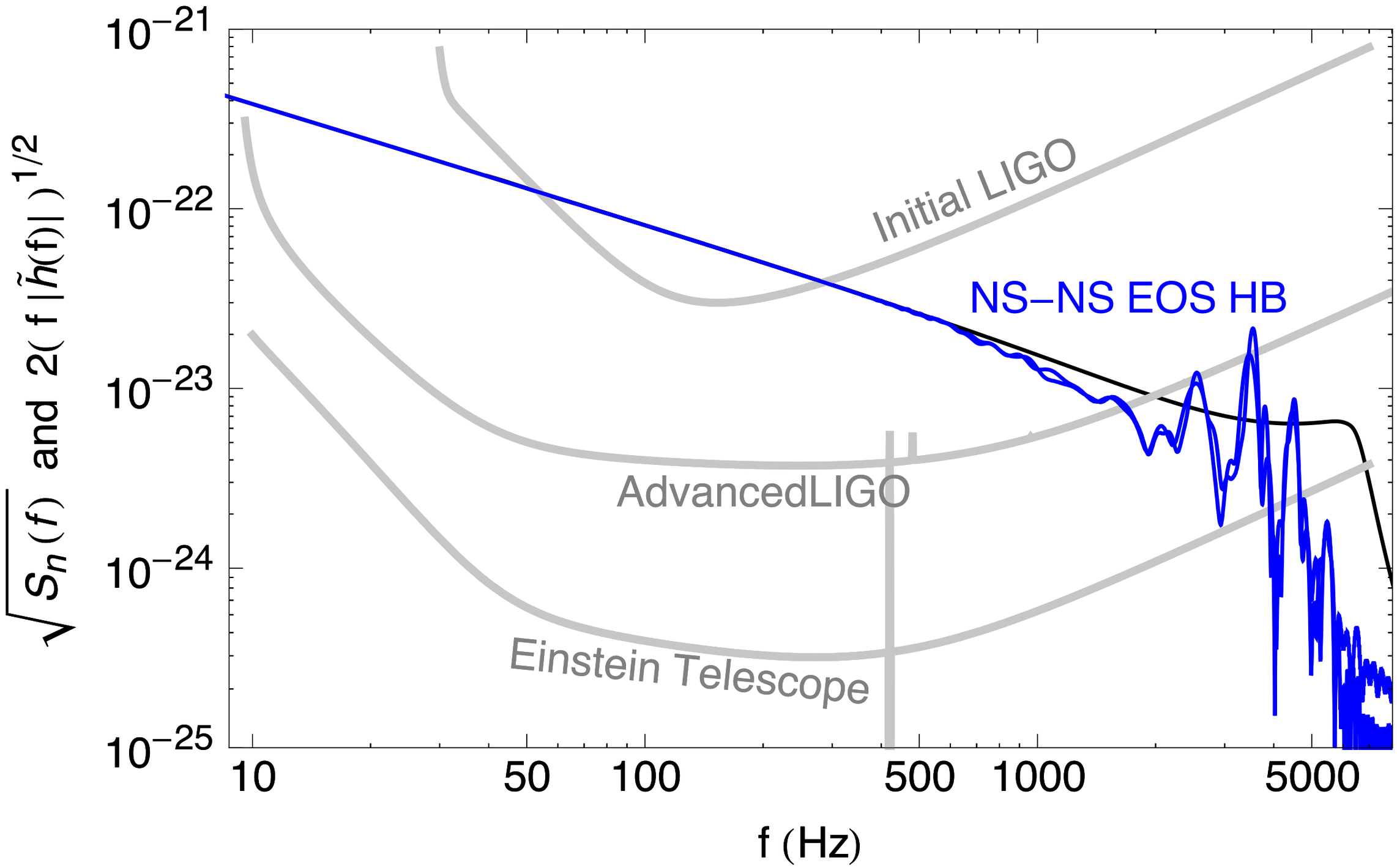
Frequencies contributing to measurement

Damour Nagar Villain http://arxiv.org/abs/1203.4352

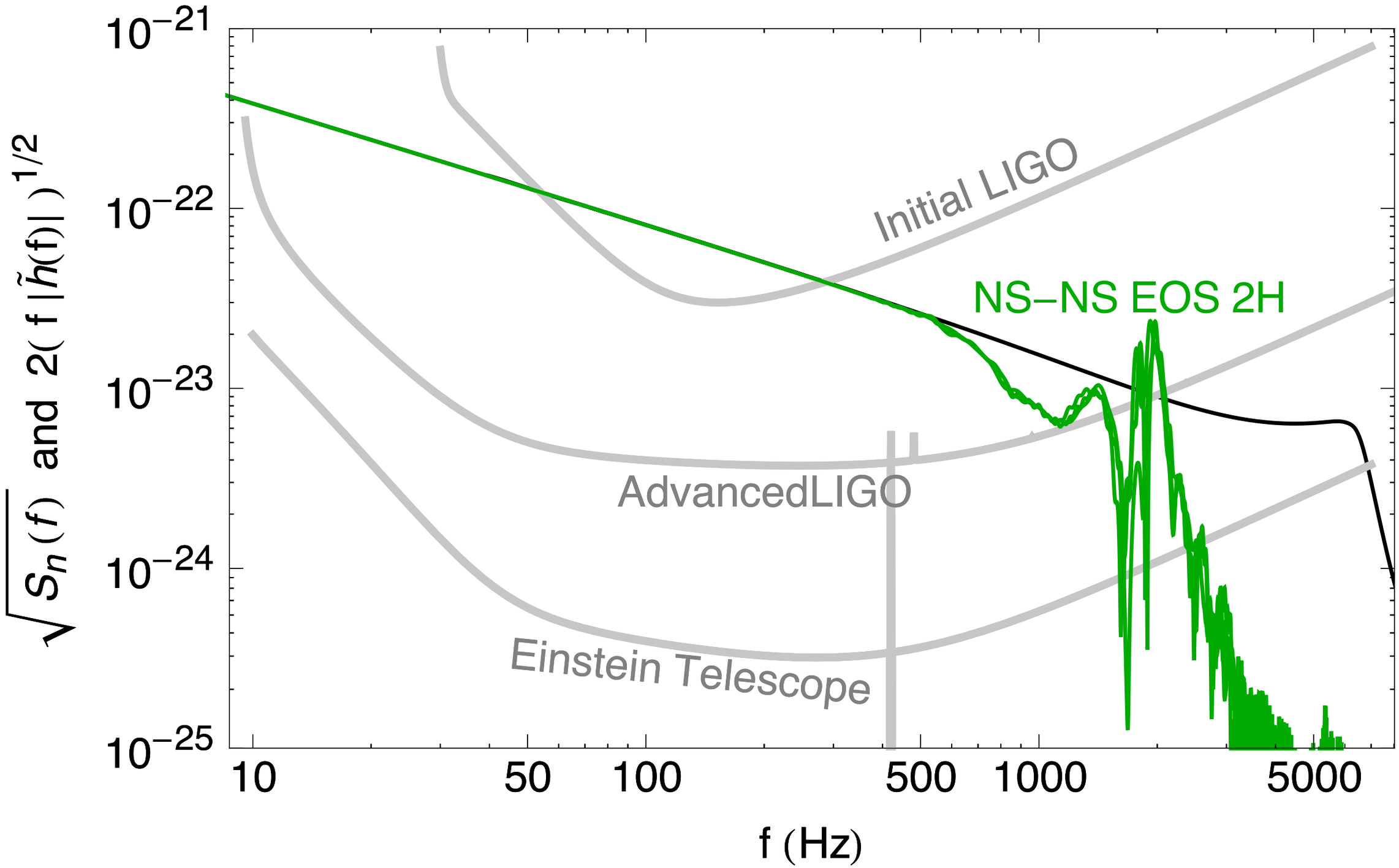
Spectra of 100 MPc D_{eff} 1.35-1.35 M_{sun} mergers



Spectra of 100 MPc D_{eff} 1.35-1.35 M_{sun} mergers



Spectra of 100 MPc D_{eff} 1.35-1.35 M_{sun} mergers



SNR of differences between waveforms

Advanced LIGO high-power detuned

EOS	H	HB	B
2H	2.162 ± 0.030	2.210 ± 0.036	2.234 ± 0.035
H	-	0.896 ± 0.099	1.0452 ± 0.087
HB	-	-	0.580 ± 0.168

Einstein Telescope configuration D

EOS	H	HB	B
2H	20.352 ± 0.314	20.739 ± 0.369	20.890 ± 0.360
H	-	7.740 ± 0.914	9.130 ± 0.866
HB	-	-	5.095 ± 1.490

Hybrid waveform model estimates

$$\langle \delta R \rangle \Big|_{R_{avg}} \simeq \frac{R_1 - R_2}{\left\langle h(R_1) - h(R_2) \middle| h(R_1) - h(R_2) \right\rangle^{1/2}}$$

$\langle \delta R \rangle$, R is radius of isolated neutron star

	Broadband AdLIGO	ET-D
$R = 10.8$	± 0.9 km	± 0.09 km
$R = 11.9$	± 0.8 km	± 0.10 km

Radius can be constrained with a strong Advanced LIGO signal
(in high-power detuned configuration)
based on numerical waveform alone.

Systematics from different numerical simulations with same EOS ~ 0.1 km
Other sources: parameterization choice, discrete parameter sampling

Error from multiple events randomly distributed up to D_{eff} 800 MPc relative to error in D_{eff} 100 MPc event