Chirp mass - luminosity distance distributions of the GW sources

Distinguishability of models

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Overview

- The model space
- Likelihood of the models
- Method of distinguishing
- Thresholds of distinguishability

Binary system's parameters

Chirp mass : $\mathcal{M} = \frac{(m_1 m_2)^{3/5}}{(m_1+m_2)^{1/5}}$

Luminosity distance : $D_L(z) = (1+z) D_H \int_0^z \frac{dz'}{E(z')}$

$$E(z) = \sqrt{\Omega_m (1+z)^3 + \Omega_\Lambda}, \; D_H = \frac{c}{H_0}$$

SNR > 8

The detector configuration

- Which model is preferred by the up-to-date observations ?
- Is the detector capable of differentiating between models ?

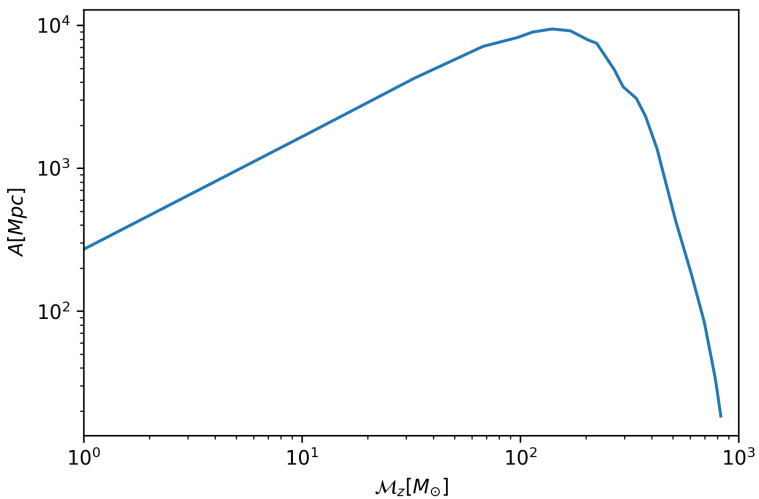

Figure: Twice the horizon luminosity distance for Advanced LIGO H1 (Martynov et al. 2016) .

The models

- Field evolution - `StarTrack` code, both $Z = 0.1Z_{\odot}$ and $Z = 1Z_{\odot}$ (Dominik et al. 2012)
- Globular Clusters - MOCCA code (Askar et al. 2017)
- Chemically homogeneus evolution - Default (Mandel & de Mink 2016)

Likelihood of the models

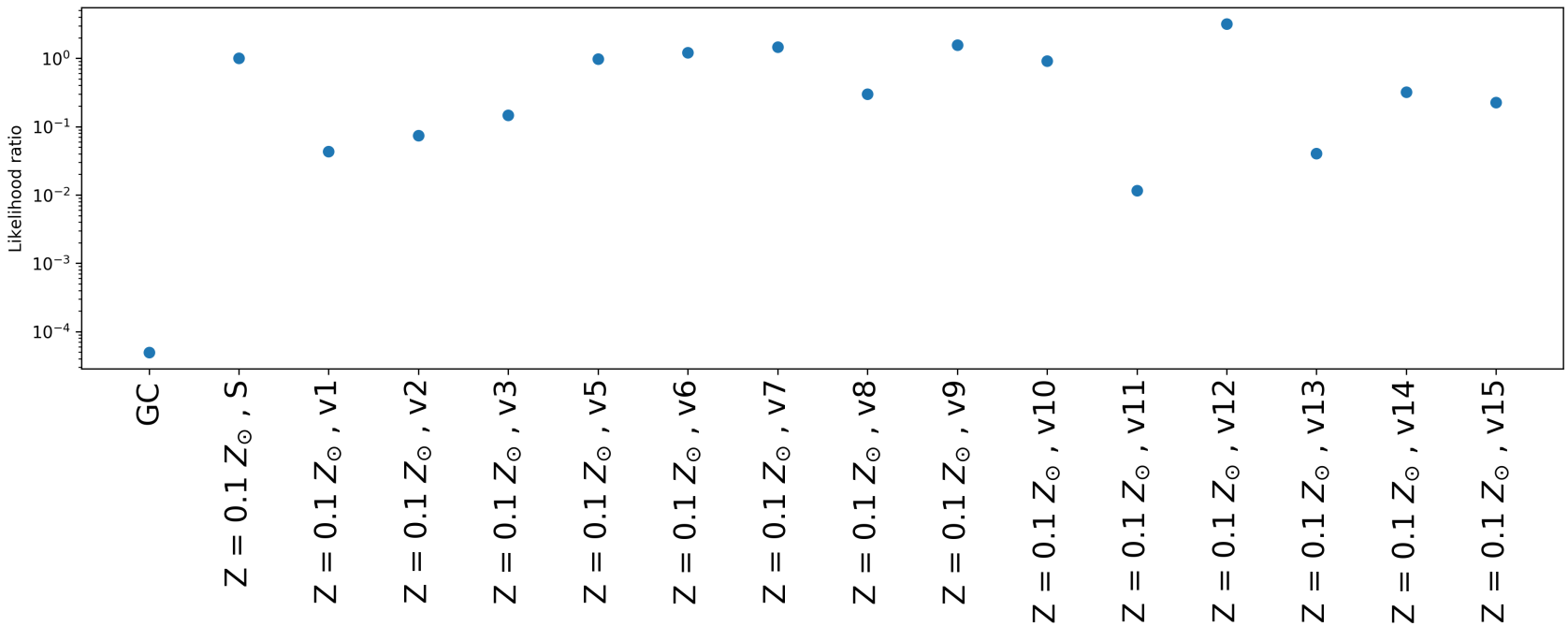

Figure: Likelihood for 16 models that could account for all the observations. Normalised with Standard StarTrack model.

Bayesian statistics

$P(M_i \mid O)$ probability that model M_i is correct, given observation O

$P(O \mid M_i)$ probability of observing O, given that model that model M_i is correct

$P(M_i)$ prior probability that model M_i i is correct

Bayes Factor $F_{ij} := \frac{P(M_i|O)}{P(M_j|O)} = \frac{P(O|M_i)}{P(O|M_j)}$

Mean: $F_{ij} > 1$

no symmetry: $F_{ij} \neq F_{ji}^{-1}$

Threshold of distinguishability with α : smallest number of observations for which (1 - α) $\times$ 100% F_{ij} is greater than 1.

Thresholds of distinguishability

-	GC	S	V1	V2	V3	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
GC	-	28	13	35	35	45	35	28	8	22	45	22	35	6	45	35
S	8	-	74	58	10	n	n	155	10	95	1832	533	n	5	35	255
V1	5	22	-	28	6	22	22	17	5	17	22	45	22	3	17	22
V2	10	74	874	-	10	74	74	45	6	35	155	95	121	4	45	121
V3	28	n	35	255	-	n	n	n	13	n	n	58	1431	8	n	417
V5	8	n	74	58	10	-	n	155	10	95	2344	533	n	5	35	255
V6	8	n	74	45	10	n	-	121	10	95	874	533	2344	5	28	199
V7	8	n	45	45	13	n	n	-	13	155	1431	417	n	5	35	255
V8	5	58	8	10	22	45	58	74	-	121	35	35	35	10	17	28
V9	8	n	45	45	13	n	n	n	13	-	1118	326	n	5	45	255
V10	8	326	155	74	10	417	417	121	8	58	-	417	n	5	22	683
V11	4	5	8	5	3	5	5	5	6	5	5	-	5	3	4	8
V12	8	326	95	58	8	326	533	95	8	74	255	874	-	4	28	199
V13	10	35	6	13	121	35	45	58	683	58	28	13	28	-	22	22
V14	10	n	155	n	17	n	n	326	8	121	n	121	n	5	-	874
V15	8	121	74	35	8	95	121	74	8	58	199	2344	417	4	17	-

Table: The table of the thresholds with $\alpha = 0.1$. Displayed vertically are the tested model. Displayed horizontally are the models assumed to be correct, i.e. used to generate data O_i.

Summary

- Most likely model: full conservative mass transfer, but the preference is weak.
- With 100 observations 65% are distinguishable
- With 1000 observations 87% are distinguishable.
- More in an upcoming paper.

Thank you for your attention.

References I

Askar, A., Szkudlarek, M., Gondek-Rosińska, D., Giersz, M., & Bulik, T. 2017, MNRAS, 464, L36

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Mandel, I. & de Mink, S. E. 2016, MNRAS, 458, 2634

Martynov, D. V., Hall, E. D., Abbott, B. P., et al. 2016, Phys. Rev. D, 93, 112004