

Differences of definition of binary range between Advanced LIGO and LCGT

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1 Introduction

In this report, differences of the definition of the binary range between Advanced LIGO and LCGT are summarized. There are three differences; a threshold of signal to noise ratio (S/N), a definition of S/N, directions of an interferometer and a binary. This report is based on the presentation slides for LCGT design meeting (9th April 2004, JGW-G0400128, in Japanese). There are minor corrections.

2 Threshold of S/N

The thresholds of S/N are 10 and 8 in LCGT on 2004 and Advanced LIGO, respectively. However, on 2009, the LCGT threshold became also 8.

3 Definition of S/N

The definition of S/N in Advanced LIGO is the output of the matched filter ρ in Eq. (3.16) of Ref. [1] and Eq. (3.1) of Ref. [2]. On the other hand, that in LCGT is $\rho/\sqrt{2}$. The reason is that the expectation value of ρ in the presence of only Gaussian noise is $\sqrt{2}$ (please check the sentences after Eq. (8) of Ref. [4]).

4 Directions of interferometer and binary

The S/N depends on the directions of an interferometer and a binary. In LCGT, S/N with the best directions are adopted. On the contrary, in Advanced LIGO, the average S/N is adopted. It must be noted that the definition of the average is not unique. In Advanced LIGO, the definition is based on the Monte Carlo analysis in Ref. [1] (Secs.

III.E,V.A,V.B). The universe expansion is not taken into account. It is assumed that the number of binary coalescences per unit volume per unit time is a constant \dot{n} . The expected number of detections per unit time is \dot{N} . The average range in Advanced LIGO is the radius of a sphere of which the volume is equal to \dot{N}/\dot{n} . This average range is 0.44 times¹ smaller than that of LCGT².

5 Summary

Recently, the threshold of S/N in LCGT became 8 which is as same as that of Advanced LIGO. However, the difference of the definition of S/N remains. Moreover, we must take the definition of the direction average into account. The binary range of Advanced LIGO is $0.44 \times \sqrt{2} \sim 0.62$ times smaller than that of LCGT³.

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References

- [1] Lee Samuel Finn and David F. Chernoff, Phys. Rev. D 47 (1993) 2198.
- [2] Lee Smauel Finn, Phys. Rev. D 53 (1996) 2878.
- [3] Lee Samuel Finn, arXiv:gr-qc/0104042 (2001).
- [4] Hirotaka Takahashi *et al.*, Phys. Rev. D 70 (2004) 042003.

¹In Advanced LIGO, the range is $\mathcal{R} = r_0(3*1.84)^{1/3}$ [Eqs. (5.2c) and (5.3) in Ref. [1]]. On the other hand, in LCGT, the range is $4r_0$ because the maximum absolute value of the angular dependence Θ in Eq. (3.31) of Ref. [1] is 4. Thus, the ratio of the range of Advanved LIGO to that of LCGT is $(3 * 1.84)^{1/3}/4 \sim 0.44$.

²If the approximated formula, Eq. (3.11) in Ref. [2] is adopted, this value is $1/14^{1/3} \sim 0.415$.

³If the approximated formula, Eq. (3.11) in Ref. [2] is adopted, this value is $1/14^{1/3} \times \sqrt{2} \sim 0.587$.