

Working Title

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Abstract

1 Introduction

The detection of gravitational waves (GW) in February (ref) opened a new era of astronomy; however, it is only in sync with electromagnetic astronomy that the most physics can be discovered. Electromagnetic counterparts are expected from binary sources involving matter i.e. neutron star-neutron star and neutron star-black hole. Because of this, GW detectors will work in conjunction with electromagnetic telescopes to observe a GW source. Some of these will yield weak, nearly isotropic electromagnetic counterparts and others will not. GW detectors will identify sources characterized by its chirp mass:

$$M_c = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)} \quad (1)$$

Figure 1 is the full data set in terms of chirp mass. The electromagnetic counterparts events are separated from the other events by color. This report is organized as follows. Section 2 describes the development of the chirp mass distribution, Section 3 describes a

electromagnetic followup classifier based on the data, and Section 4 will state our conclusions. See Section ?? and Appendix A. Example text citation is Dominik et al. (2012), or in parenthesis with a page number (Dominik et al. 2012, pg 2).

2 Chirp Mass Distribution

2.1 The Likelihood of Fitting Parameters

The likelihood of each fitting parameter is:

$$P(\{d\}|\lambda) = \frac{1}{n!} \prod_k E(x)r(x_k)p_{smooth} \exp\left\{-\int E(x)r(x_k)dx\right\} \quad (2)$$

where p_{smooth} is the smoothing prior, defined to be:

$$p_{smooth} = \exp\left\{-\int \left[\frac{d^3(\ln r)}{d(\ln x)^3}\right]^2 d(\ln x)\right\} \quad (3)$$

3 Classifying GW Events that have Electromagnetic Counterparts

3.1 Overview

The GW observatory, the Laser Interferometer Gravitational Wave Observatory (LIGO), can provide very rapid mass estimates of candidate GW events. Since most of these detections are mostly binary black holes and electromagnetic followup is extremely expensive, only a few events can be followed up. We have therefore trained a classifier to determine if an event will have a electromagnetic followup. We trained this classifier on the first half of the data. We simply took the mid-way point between the maximum chirp mass for the electromagnetic counterpart group and the other group. This is shown in Figure 2. This was then used on the whole dataset as shown in Figure 3.

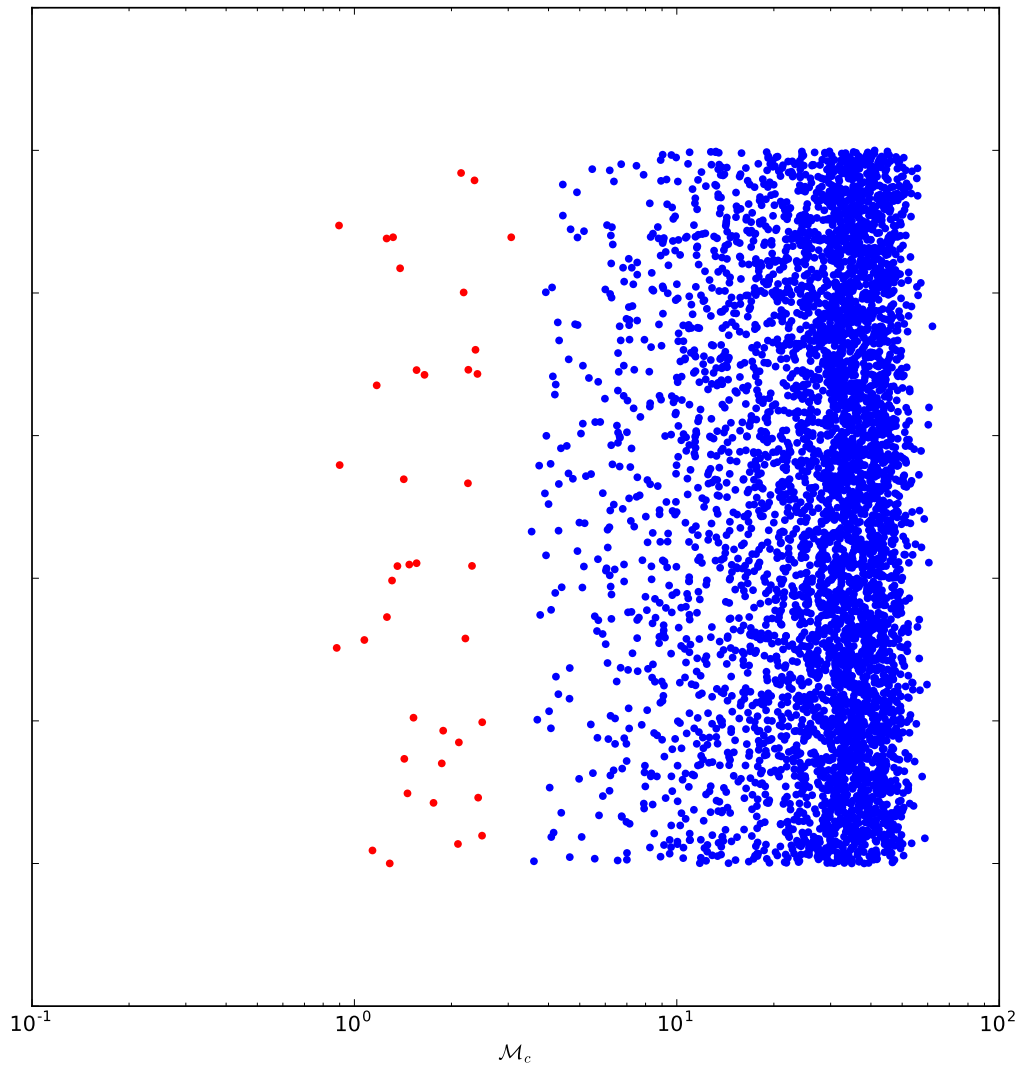


Figure 1: This figure shows all the 5000 events' chirp mass. Here the y-axis is a uniform random number between zero and one. The events that have an electromagnetic counterpart are in red, and the events without a electromagnetic counterpart are in blue.

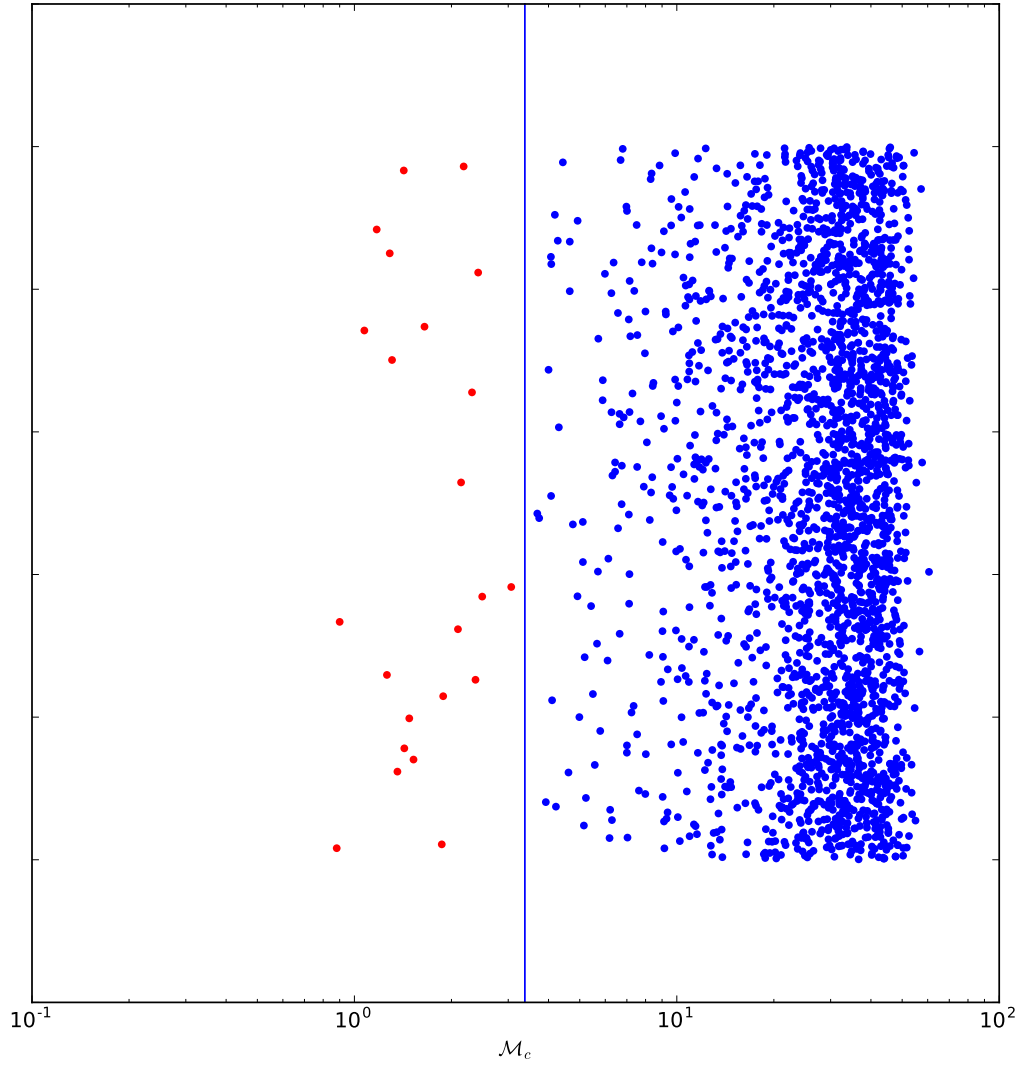


Figure 2: This shows the first half of the data with the same two groups as before. The vertical line indicates the division between the two groups.

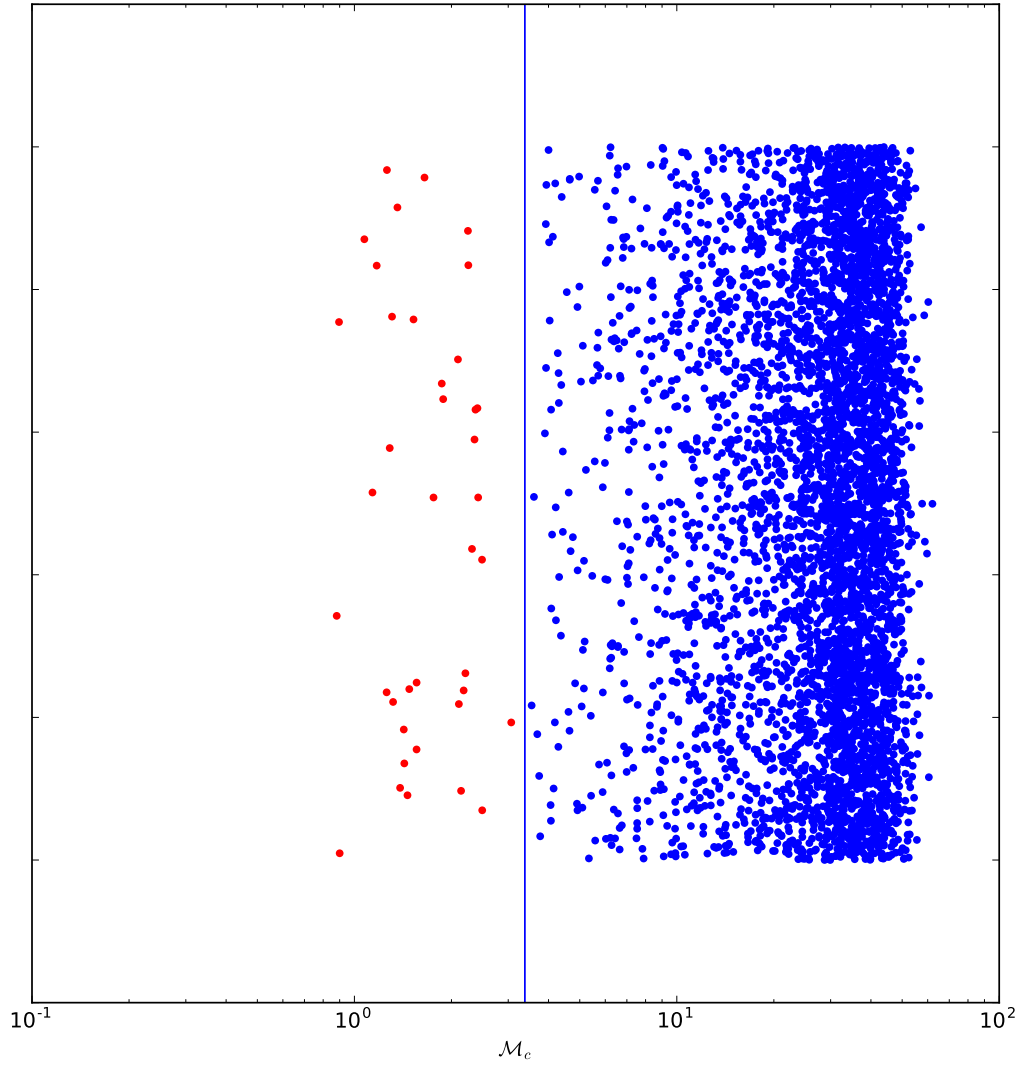


Figure 3: This shows the full set of the data with the dividing line trained by half the data.

3.2 Method

The classifier was constructed simply by taking the minimum chirp mass event of the other group (no electromagnetic counterparts) and the maximum chirp mass event of the electromagnetic counterpart group and finding the distance between those two events. This trained for the first half of the dataset. The result can be seen in Figure 2; the vertical line represents half the distance between the maximum chirp mass of the electromagnetic counterpart group and the other group.

4 Conclusions

References

¹M. Dominik, K. Belczynski, C. Fryer, D. E. Holz, E. Berti, T. Bulik, I. Mandel, and R. O’Shaughnessy, “Double Compact Objects. I. The Significance of the Common Envelope on Merger Rates”, *ApJ* **759**, 52, 52 (2012).

Appendices

A Example