Gravitational Waves From Eccentric Binary Systems

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Overview

- Eccentricity and gravitational wave emission
- Example systems
- Aggregate data
- Luminosity function

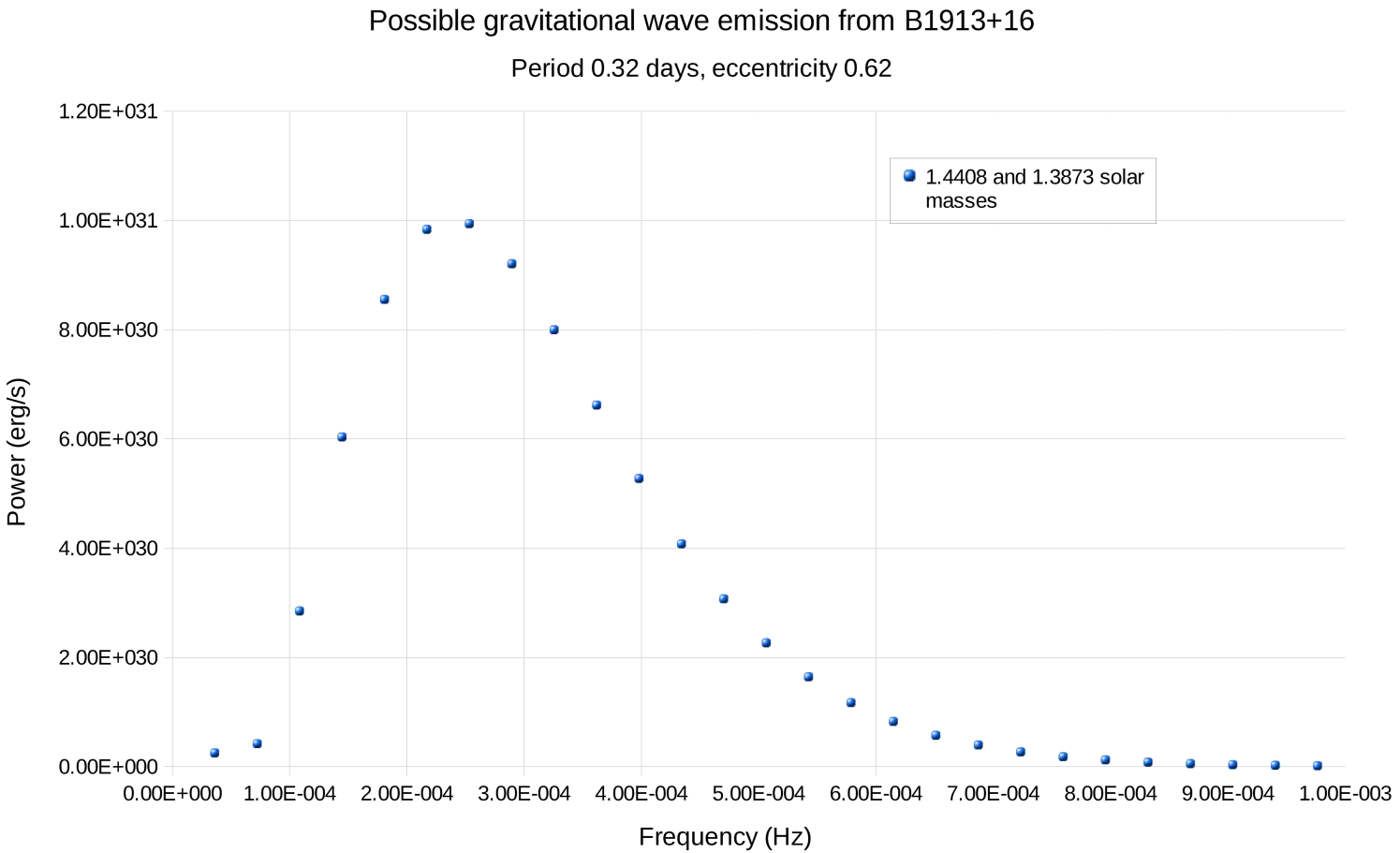
Eccentricity and gravitational wave emission

- Reference: Peters and Mathews 1963
- At harmonic number n,

$$P(n) = \frac{32}{5}\frac{G^4}{c^5}\frac{m_1^2 m_2^2 (m_1 + m_2)}{a^5} g(n, e) \tag{1}$$

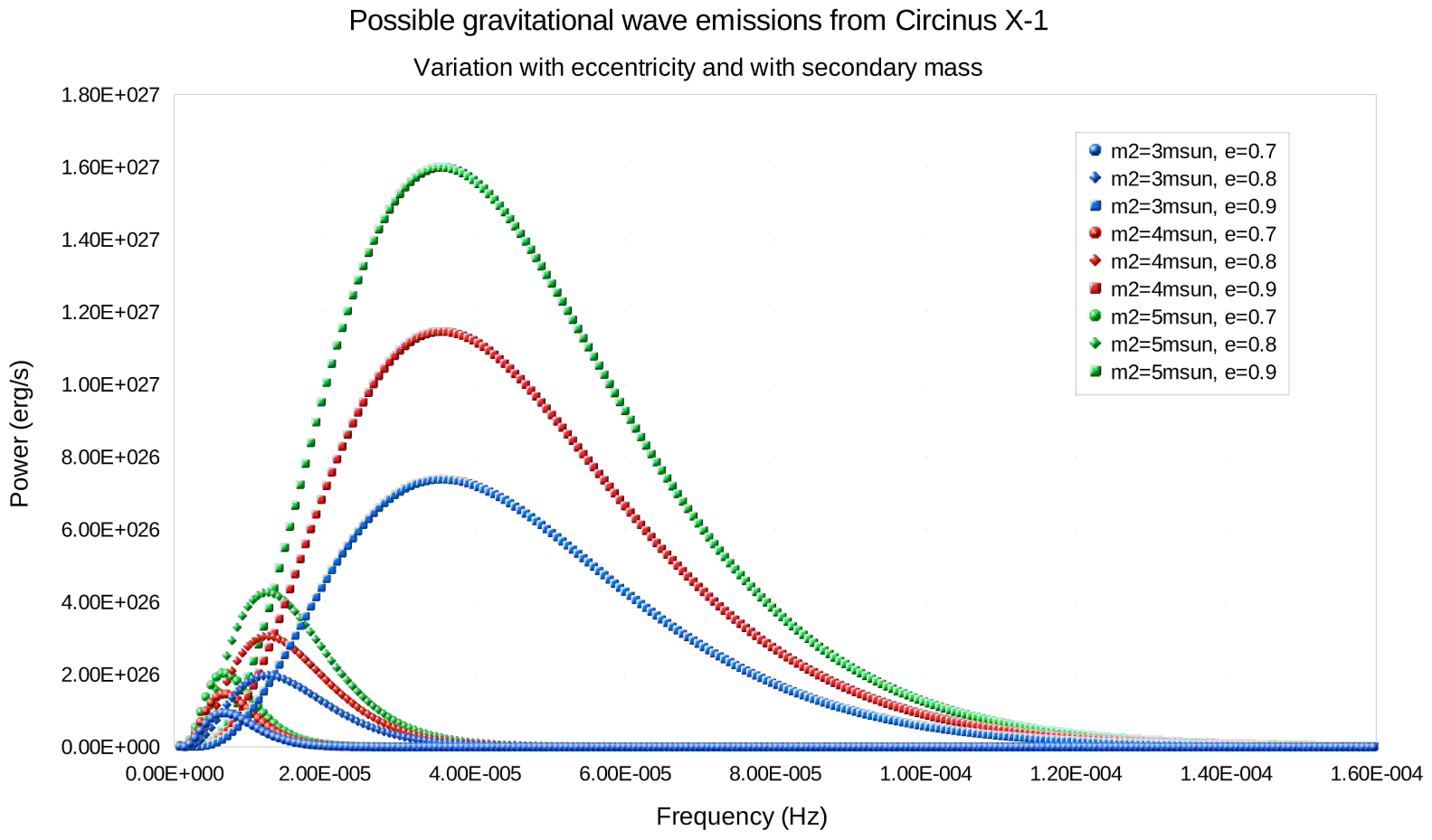
- Apply to known eccentric binaries
  WARNING: CONTAINS ASTRONOMY!

Example 1- PSR 1913+16, Radio pulsar binary



- Period 0.32 days, eccentricity 0.62, masses $1.4408 \pm 0.0003 M_{\odot}$ and $1.3873 \pm 0.0003 M_{\odot}$
- Orbital parameters from Hulse and Taylor 1975, Weisberg and Taylor 2003

Example 2- Circinus X-1, LMXB



- Period 16.6 days, eccentricity 0.7-0.9, masses 1.4$M_\odot$ (assumed) and 3-5$M_\odot$
- Orbital parameters from Stewart et al 1991

Example 3- XTE J0421+560, HMXB

- Nature of compact object subject to debate
- Belloni et al 1999- peak X ray emission too high for WD accretion/thermonuclear burning
- X ray emission during outburst obscured by shielding- NS or BH with $20M_{\odot}$ supergiant
- Barsukova et al 2005- no motion in HeI line from supergiant, fast moving HeII emitter
- supergiant at least $12M_{\odot}$ and WD 25 times smaller
- Measurement of GW could be useful in finding out which is the case

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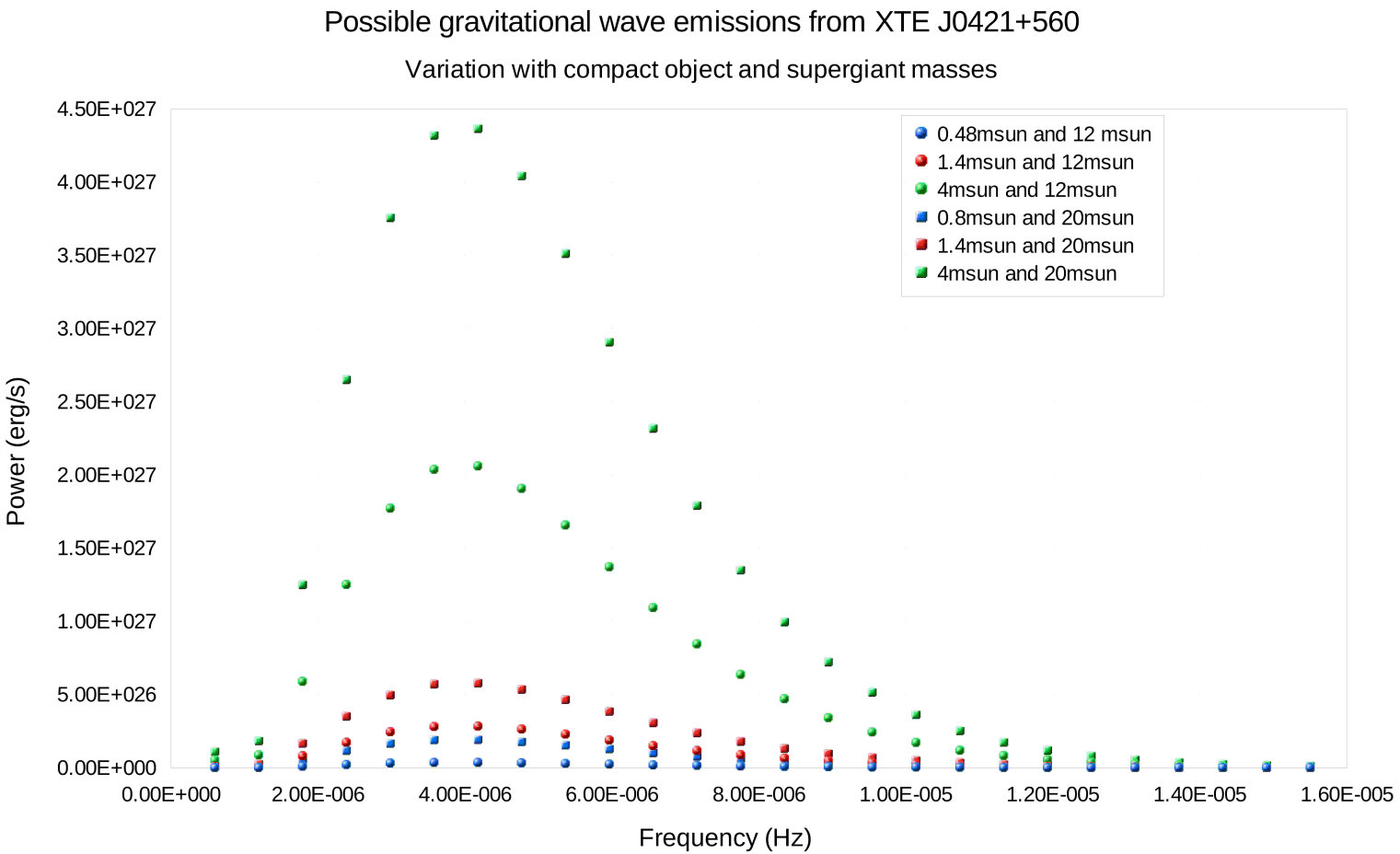

- WD, NS and $4M_{\odot}$ compact object with 12 $M_{\odot}$ (lower limit) and $20M_{\odot}$ supergiant
- Period 19.41 days, eccentricity 0.62, parameters from Barsukova at el 2005, Belloni et al 1999

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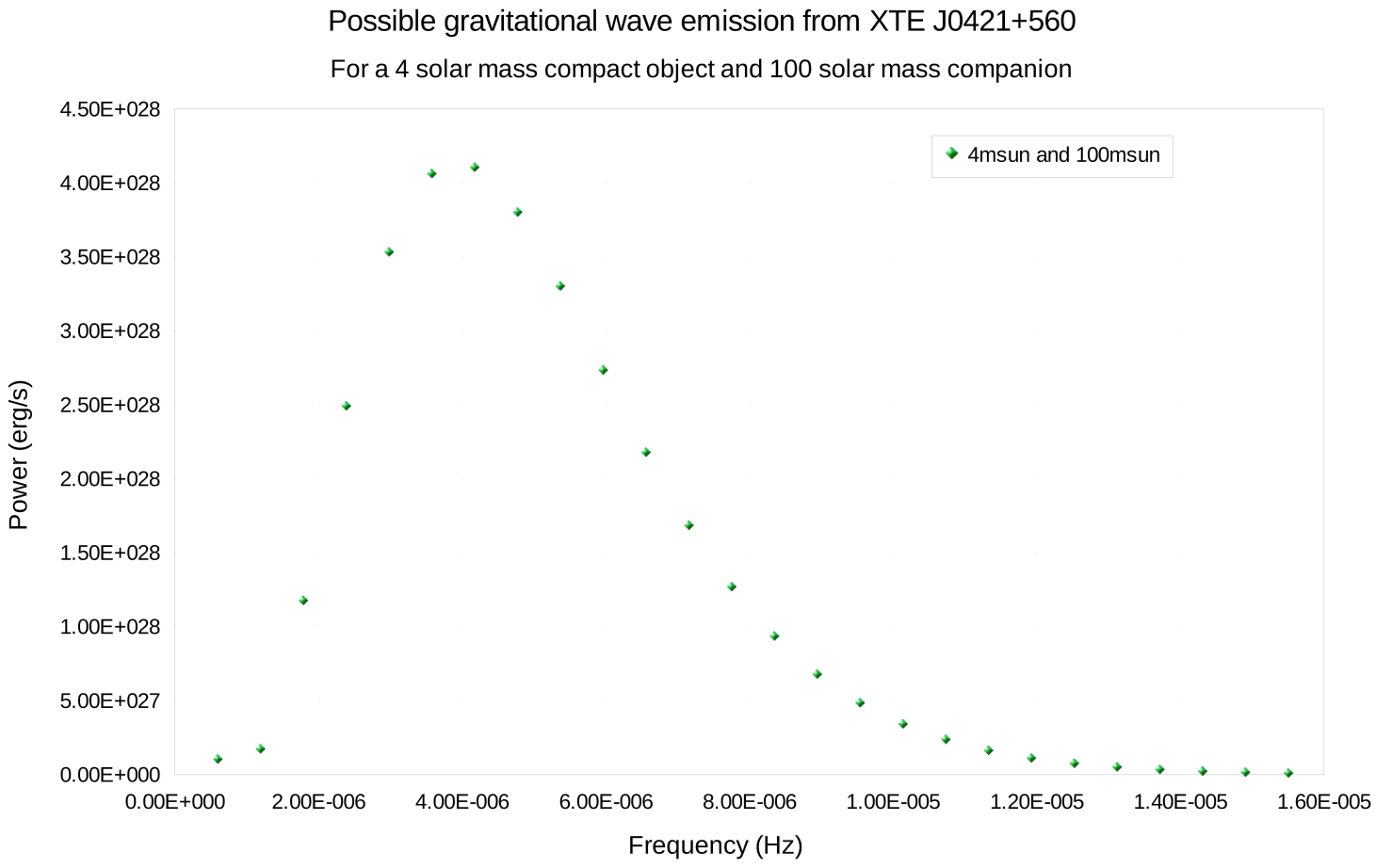

- $4M_{\odot}$ compact object and $100M_{\odot}$ supergiant

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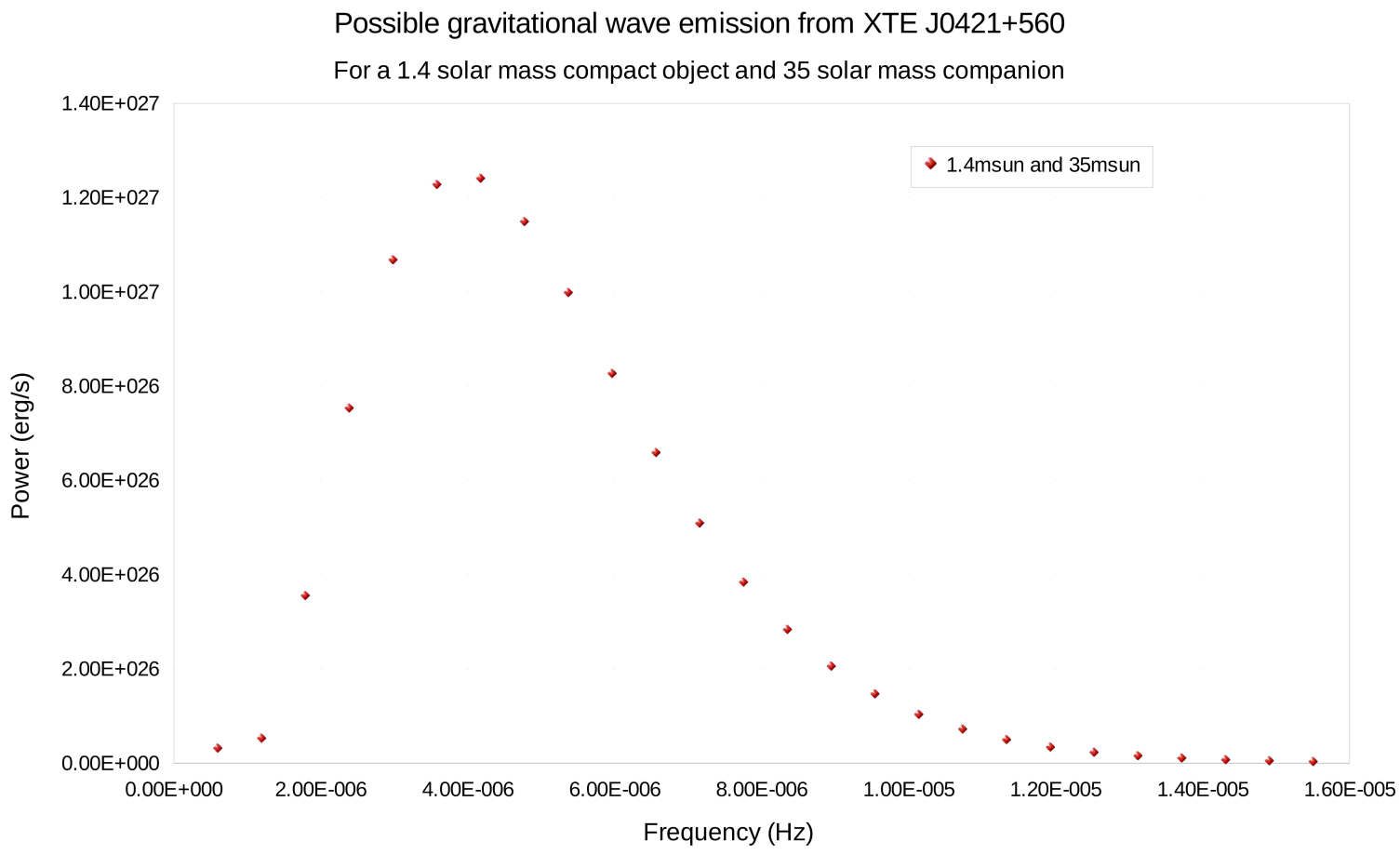
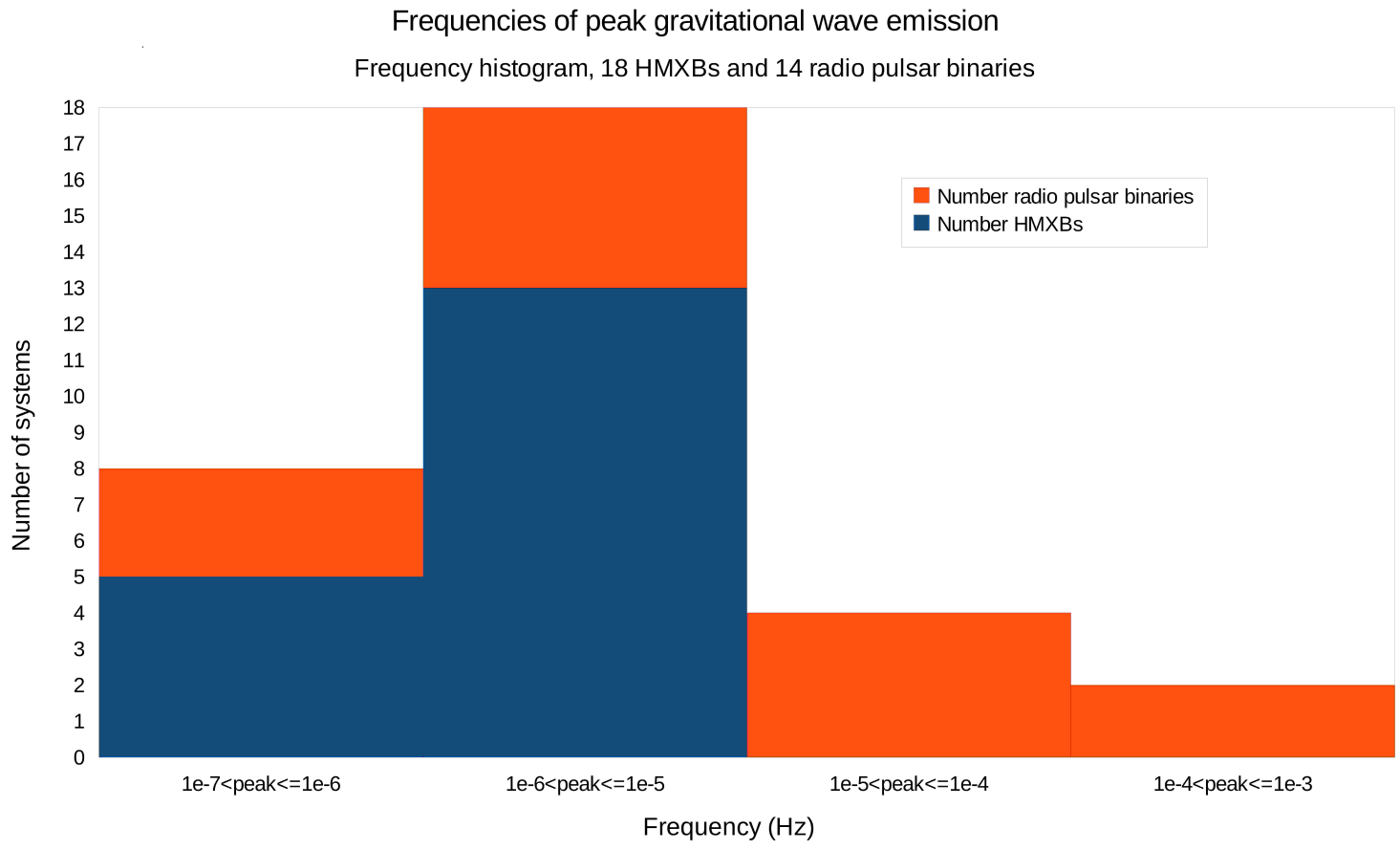


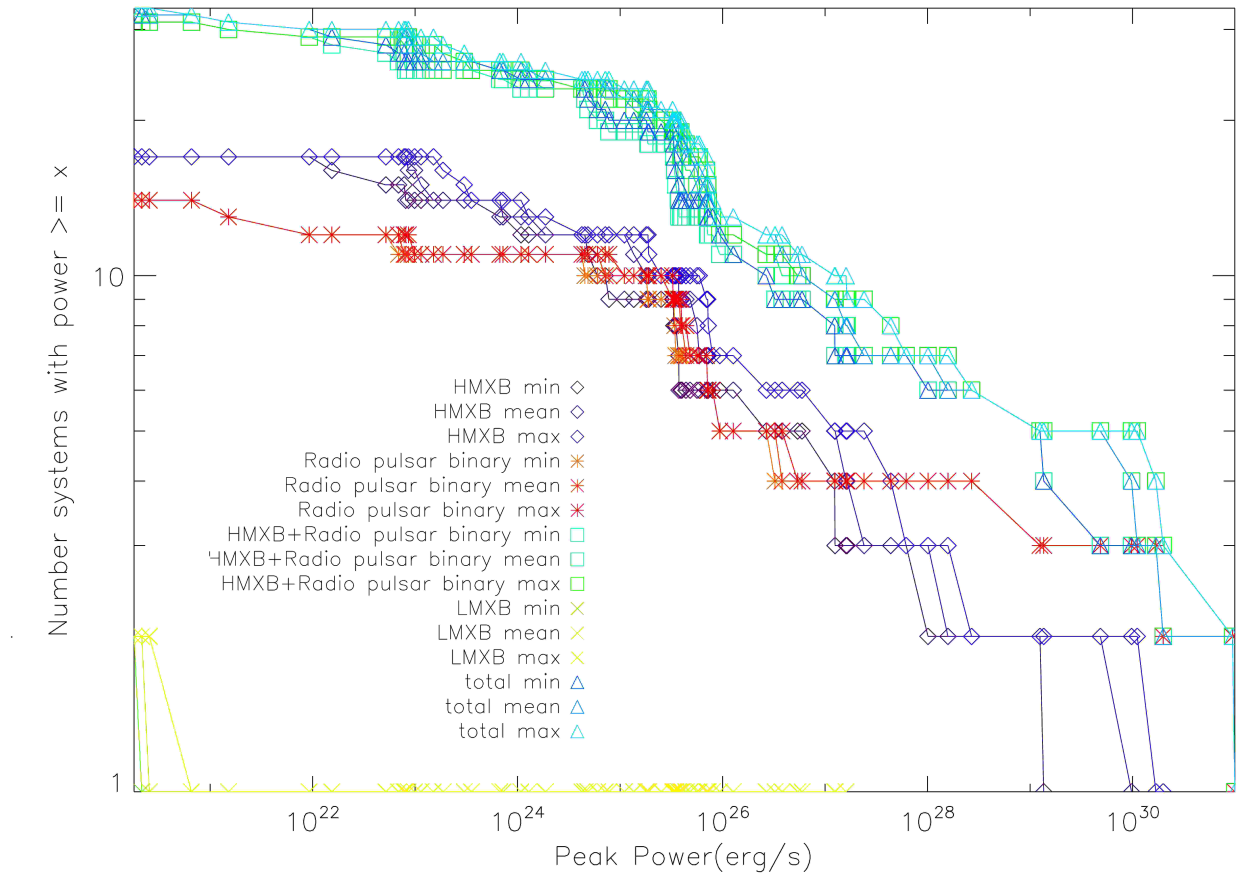
- $1.4M_{\odot}$ NS and $35M_{\odot}$ supergiant

Aggregate data



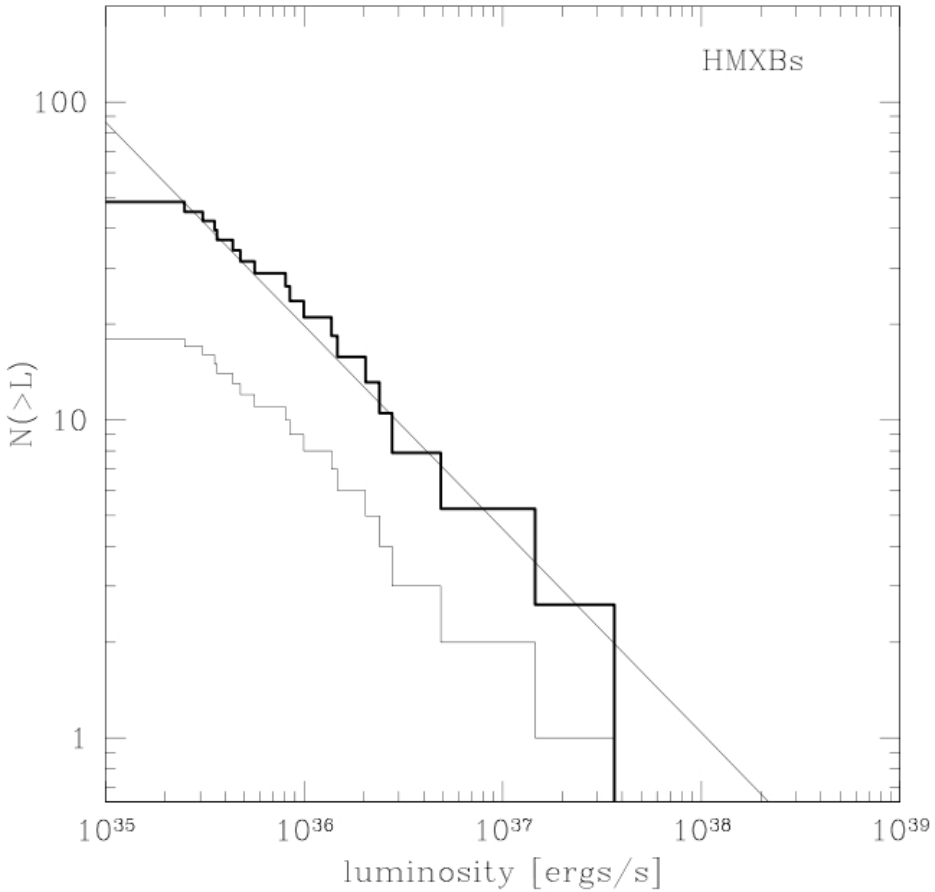
- 18 HMXB, 14 radio pulsar binaries with eccentricity >0.2
- Liu et al 2006 and http://www.johnstonsarchive.net/relativity/binpulstable.html

Gravitational wave luminosity function



- 2 LMXB, 18 HMXB, 14 radio pulsar binaries with eccentricity >0.2
- Liu et al 2005, Liu et al 2006 and http://www.johnstonsarchive.net/relativity/binpulstable.html

Comparison to X ray luminosity function



- From Grimm et al 2003

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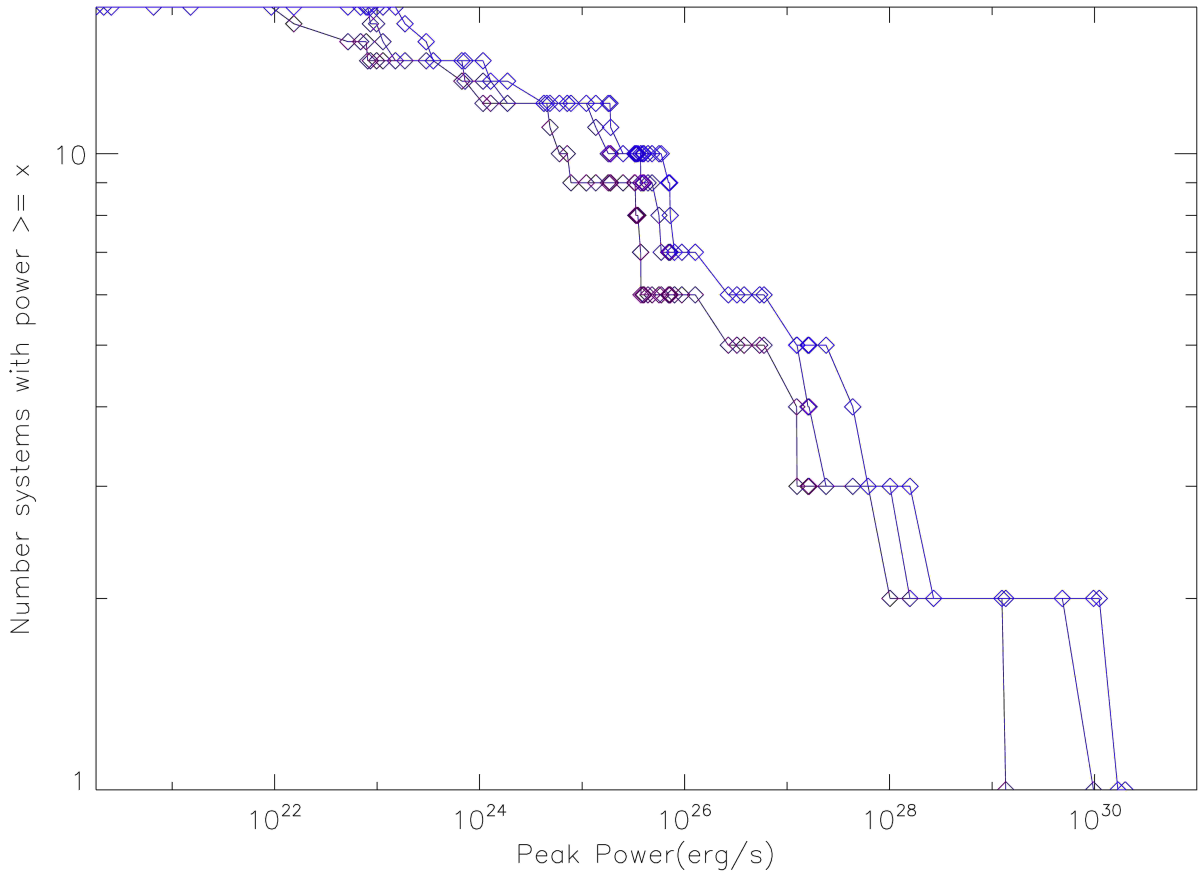

- Shape of X ray LF and calculated HMXB GW LF very similar

Conclusion

- Gravitational wave measurements could help determine the orbital parameters of binary systems
- The more eccentric the binary, the more powerful and higher frequency the peak output
- Known galactic eccentric binaries have GW peak emission in 10^{-7} to 10^{-3} Hz range, 10^{-6} to 10^{-5} band highest numbers
- Theoretical galactic luminosity function for GW from eccentric binaries can be calculated
- GW luminosity function for HMXB similar shape to X ray luminosity function

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References

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