Finding Optimal Input Parameters for BayesWave

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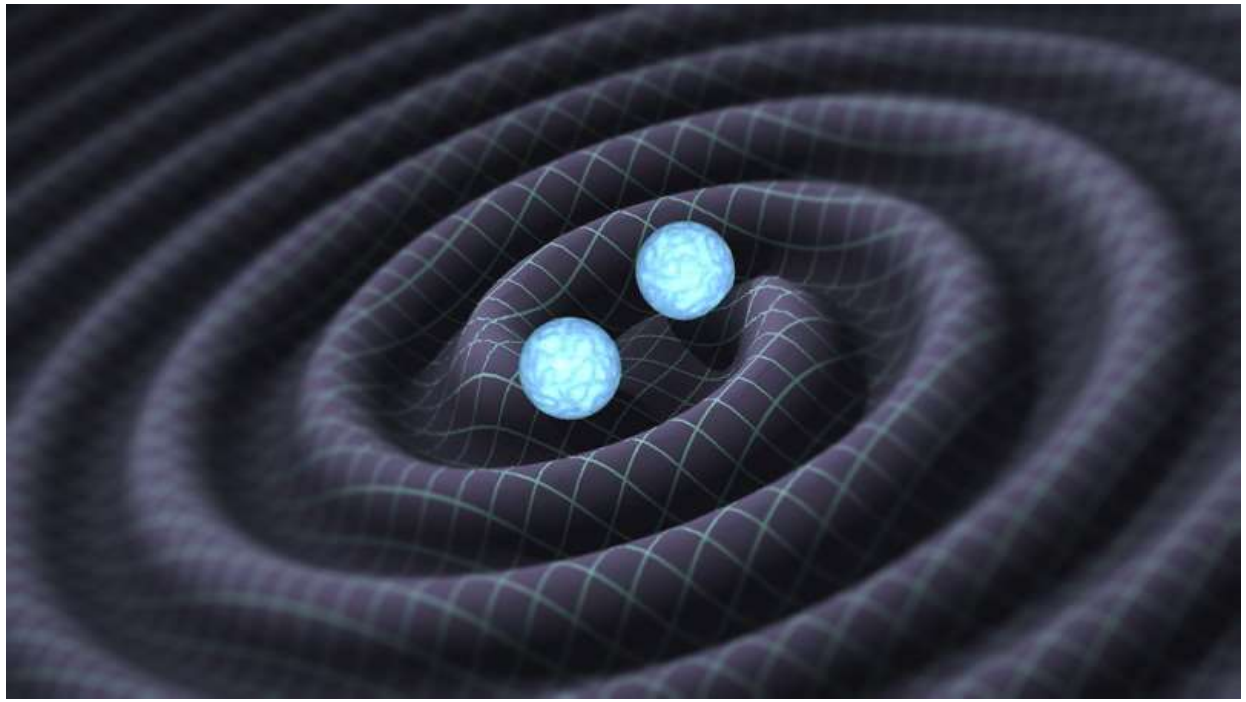
What are Gravitational Waves?

- Ripples in spacetime
- Einstein's general relativity
- Stretch and squash of space
- Gravitational wave sources
  - Compact Binary Inspiral



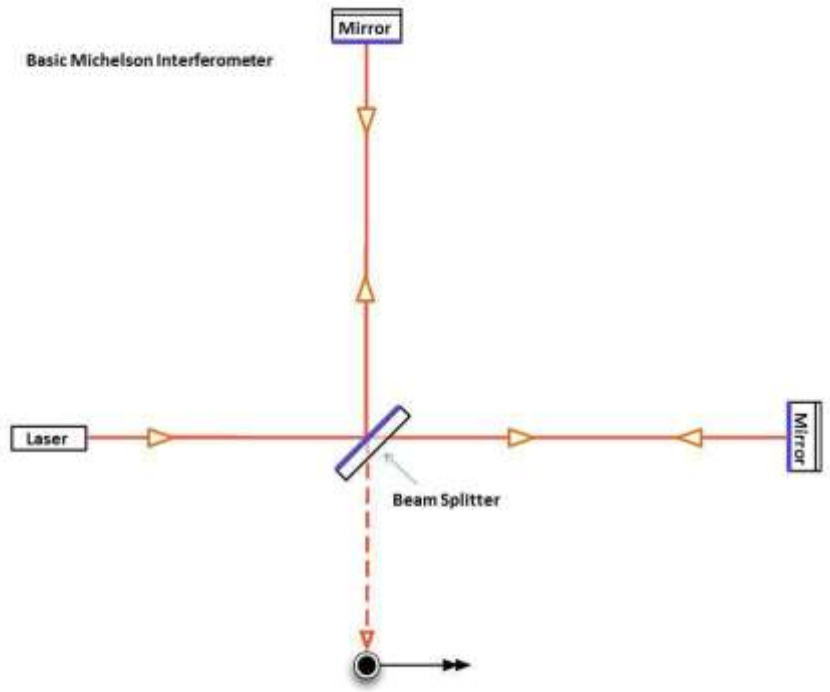
LIGO: The Gravitational Wave Observatory

- Laser Interferometer Gravitational-wave Observatory (LIGO)
- Washington and Louisiana Interferometers (Abbott, 2009)
- First detection: September 14, 2015 (Abbott, 2016)

LIGO's Hanford and Livingston observatories
https://www.ligo.caltech.edu/images?category=photograph

LIGO: The Gravitational Wave Observatory

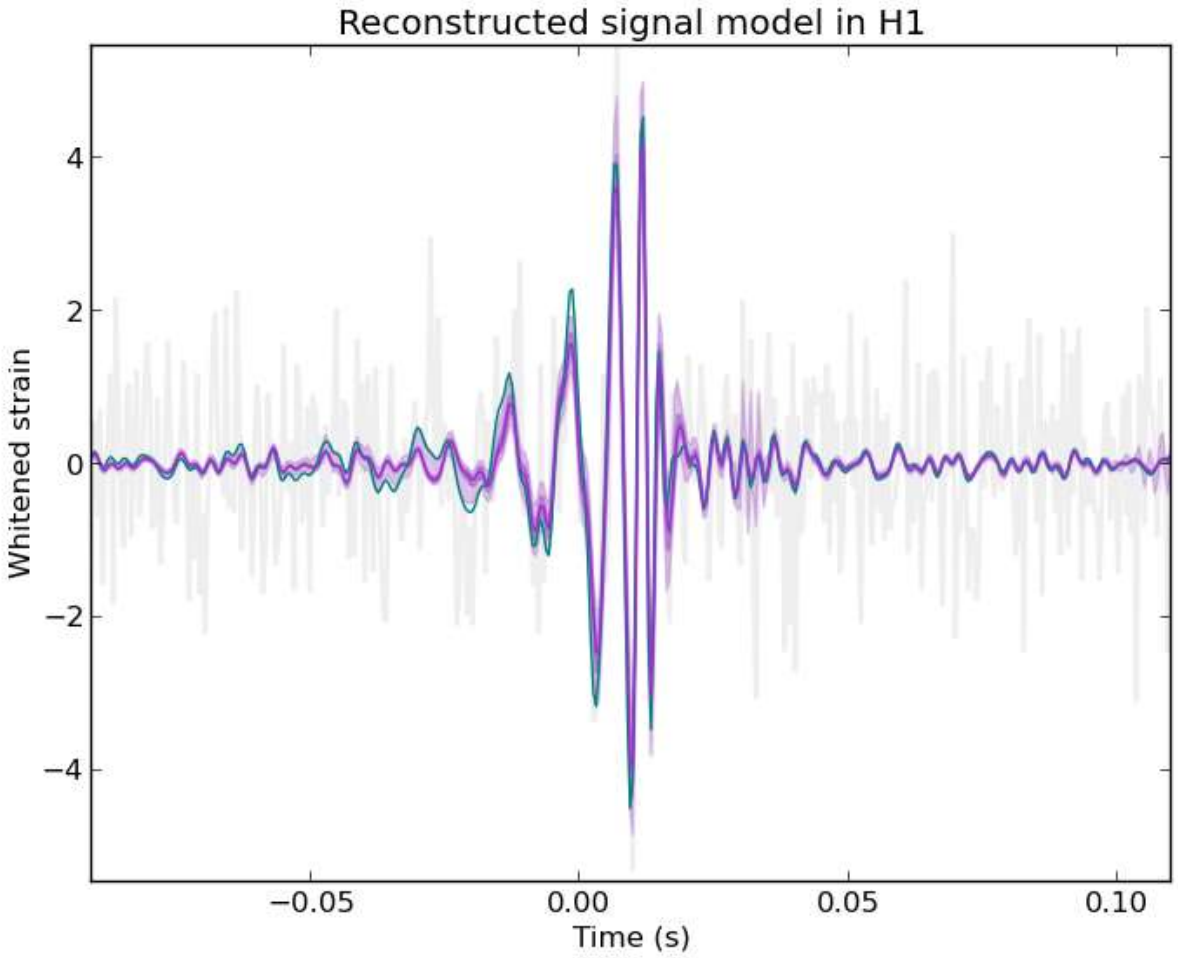
- Laser Interferometer Gravitational-wave Observatory (LIGO)
- Michelson Interferometer
  - L-shaped
  - Mirrors reflect light to create interference
  - Photodetector measures interference



Basic Michelson Interferometer
https://www.ligo.caltech.edu/system/media_files/binaries/237/medium/Basic_michelson_labeled.jpg?1435862648

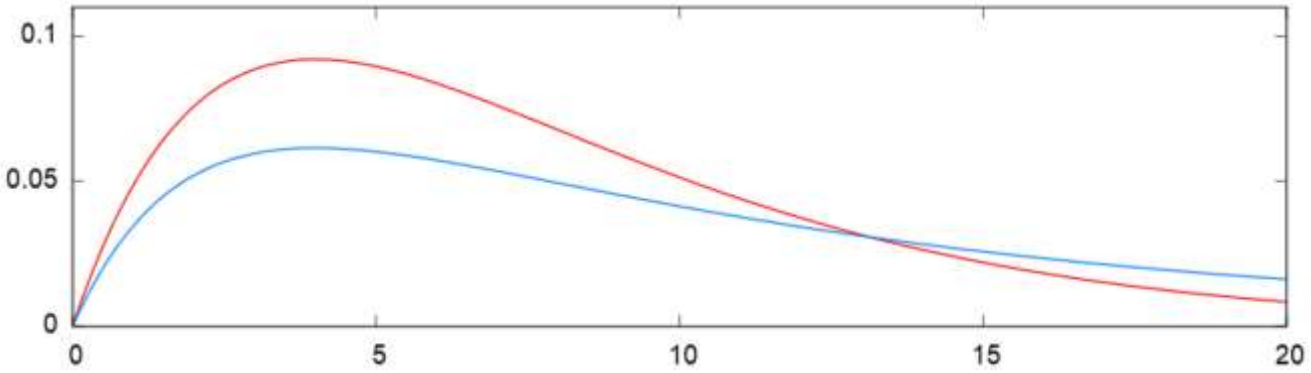
BayesWave

- Why BayesWave?
  - Poorly defined models
  - Noise and glitches obscure signal (Berger, 2018)
- BayesWave algorithm
  - Isolates unmodelled signals
  - Characterizes accompanying noise



BayesWave

- Classification:
  - Gaussian Noise
  - Gaussian Noise with glitch
  - Gaussian Noise with signal
- Signal-to-noise ratio (SNR)



- Bayesian inference
  - Signal and glitch priors
  - Most likely value: SNR*
  - Posterior distribution

Glitch prior distribution (red) and signal prior distribution (blue) (Cornish, 2015)

Research Goal

Find which parameter combination results in best classification

Run BayesWave…

With multiple parameter combinations

- Glitch prior peak: 2, 4, 6, 8
- Amplitude prior peak: 2, 4, 6

On two data sets

- LIGO noise only
- LIGO noise injected with binary black hole (bbh) signals

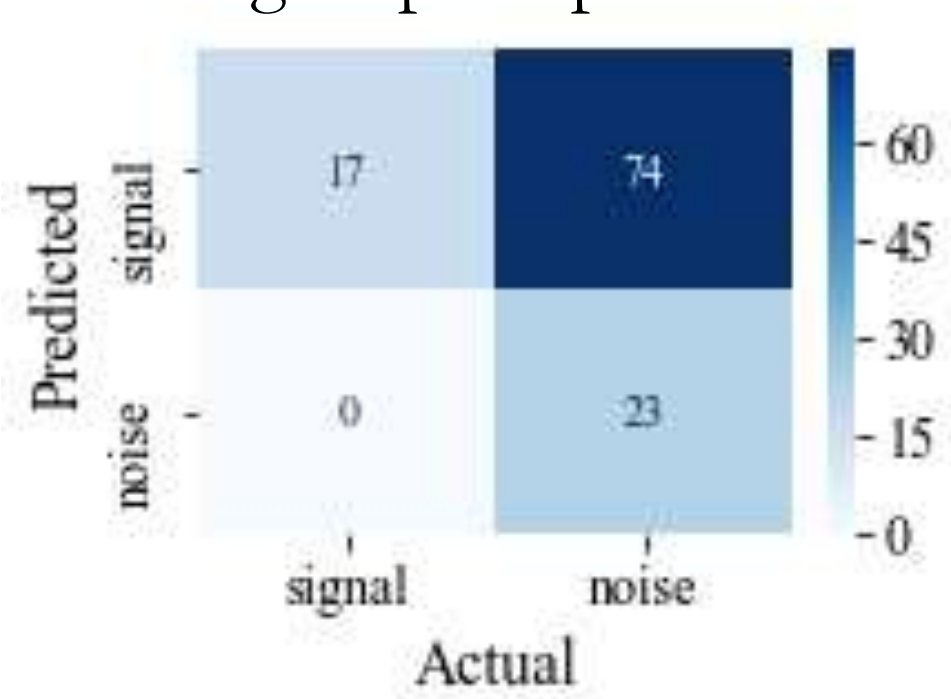
Results

Glitch/Signal Prior Peak	Old BW	New BW
2, 2	.33	.28
2, 4	.29	.25
2, 6	.28	.29
2, 8	.29	.29
4, 2	NA	.26
4, 4	NA	.23
4, 6	.27	NA
4, 8	.24	NA
6, 2	.26	NA
6, 4	.37	NA
6, 6	.38	NA
6, 8	.37	NA

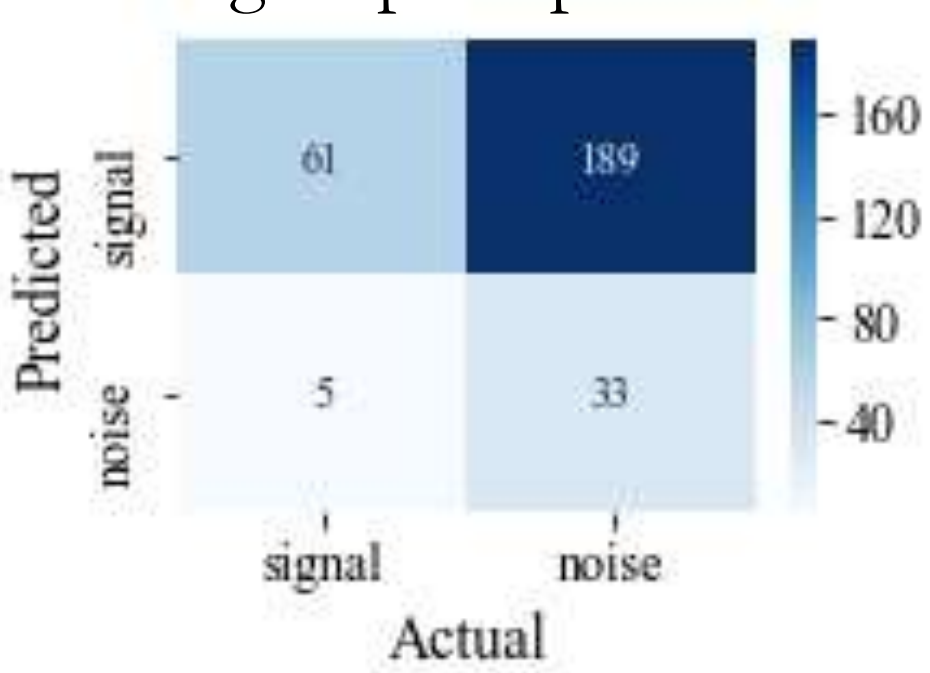
$$F1 = 2 * \frac{Precision * Recall}{Precision + Recall}$$

Results

Glitch prior peak: 6
Signal prior peak: 6



Glitch prior peak: 2
Signal prior peak: 6



Conclusion

- Best results:
  - Signal prior peak: 6
  - Glitch prior peak: 6
  - Results in F1 score of 0.38

Acknowledgements

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