

Comparing Narrow Spectral Artifact Line Finders to Enable Continuous Wave Searches in LIGO

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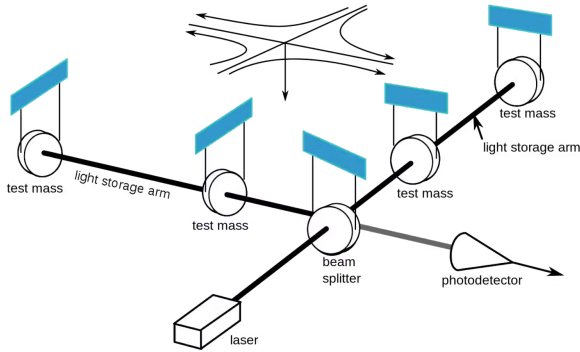
June 21, 2024

W

BOTHELL

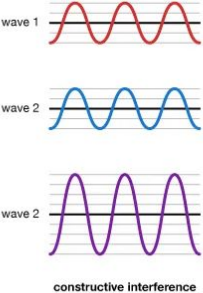


Background

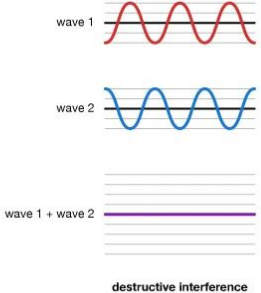


Source: LIGO
<https://www.ligo.caltech.edu/page/what-is-interferometer>

Wave interference

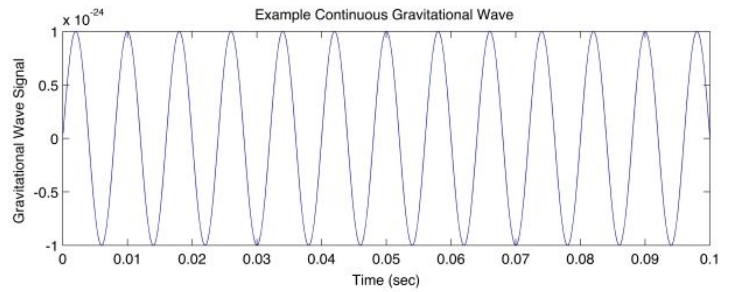
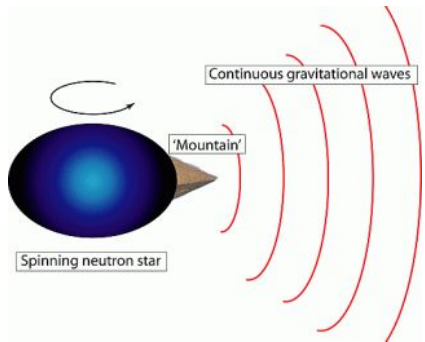


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Source: Encyclopedia Britannica
<https://kids.britannica.com/students/assembly/view/53869>

Background



Source:
<https://physics.anu.edu.au/quantum/cgp/research/data/theory/neutronstars.php>

Source: <https://www.ligo.org/science/GW-Continuous.php>

Terminology

1. Fscan
2. Normalized Data
3. Time Averaged Data

1. Fscan is a tool for identifying and characterizing noise in LIGO data . Fscan is run on normalized data at various levels of aggregation, such as daily, weekly, or monthly. Fscan can be used on the gravitational wave channel as well as auxiliary channels from other instrumentation at the detector site.
2. Normalized data are data that are processed to make them easier to analyze. In the case of LIGO data, the normalization manipulates the data such that the power spectral density curve is flattened, data anomalies are smoothed, and noise lines are easier to identify and characterize. Improving the Fscan line finder could enable accurate line-finding on non-normalized data such that researchers at LIGO would not need to switch between normalized and non-normalized views, and make it easier and quicker for LIGO data quality shift workers to spot changes in lines.

1. Time-averaging is a way to process and analyze data, to reduce short-term fluctuations and make true signals more apparent. For example, daily data can be aggregated into weekly or monthly weighted averages. Time-averaging can improve data quality but can also mask shorter-term phenomena of interest.

Purpose

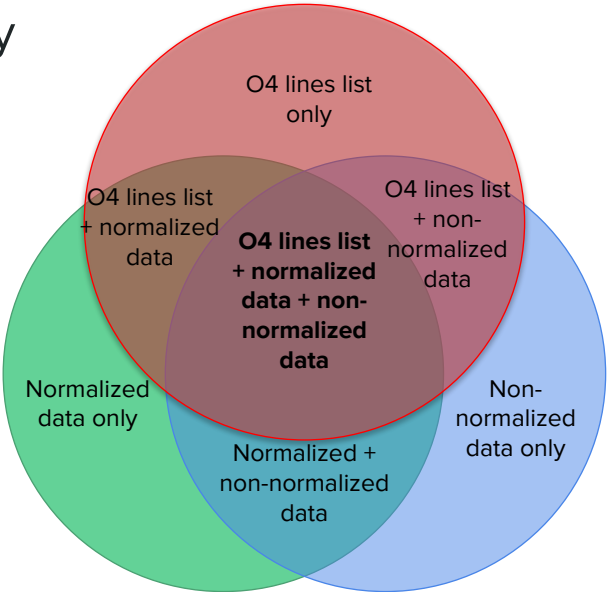
Attempt to show that line finder is effective to find lines in normalized and non-normalized data, such that normalization process is unnecessary.

If successful, LIGO researchers would not need to switch between normalized and non-normalized views. This would make it easier and quicker for LIGO data quality shift workers to spot changes in noise behaviors.

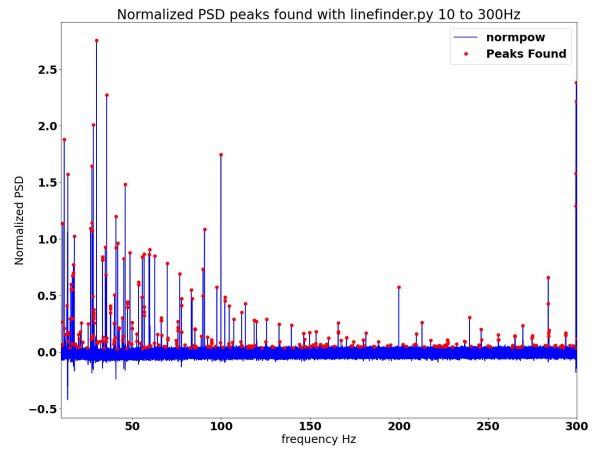
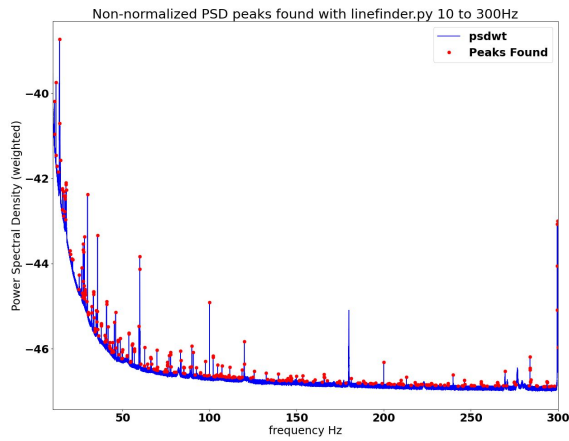
Methodology

1. Run Fscan line finder on normalized and non-normalized monthly data.
2. Adjust thresholds to find similar number of peaks across normalized and non-normalized data.
3. Check to see how well peaks match across the normalized data, non-normalized data, and O4 lines list.

Methodology



Results - December 2023



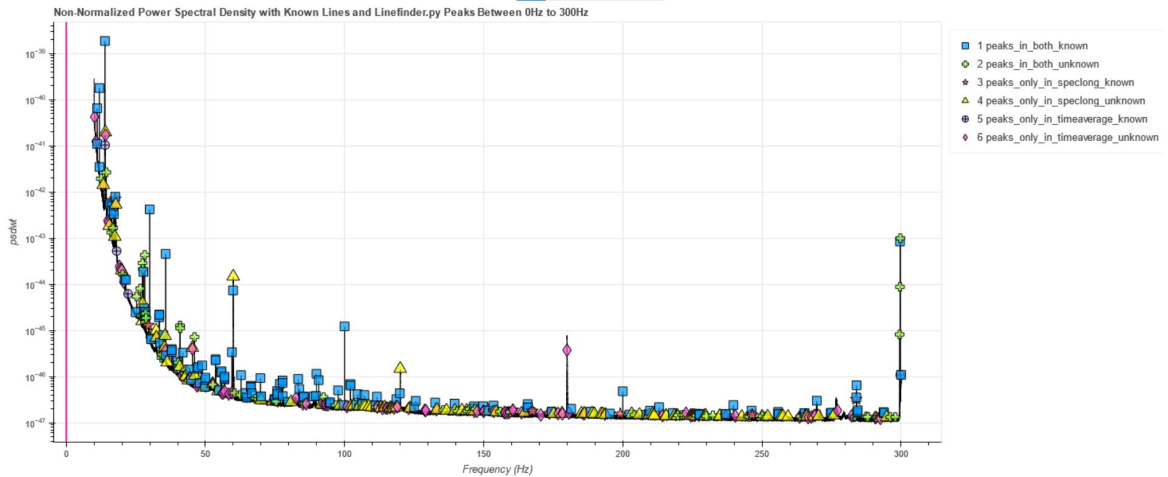
December 2023

1525 matching peaks

678 other peaks in non-normalized data

914 other peaks in normalized data

Results - December 2023



https://ldas-jobs.ligo-wa.caltech.edu/~carol.miu/custom_plots_12_23/

December 2023

601 peaks_in_both_known

924 peaks_in_both_unknown

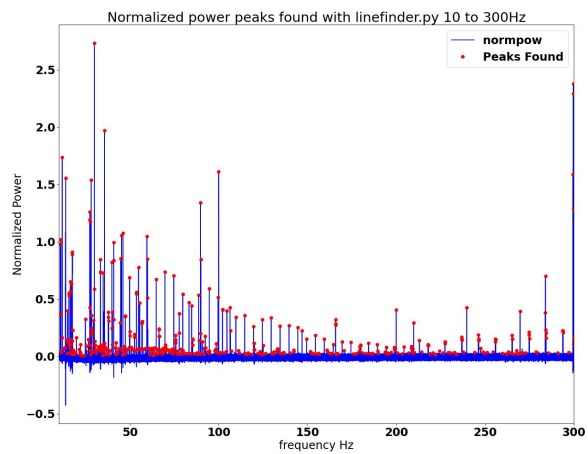
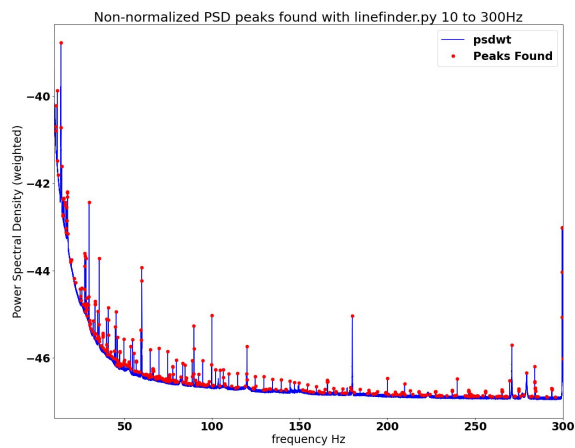
46 peaks_only_in_speclong_known

632 peaks_only_in_speclong_unknown

71 peaks_only_in_timeaverage_known - closer inspection frequencies 1 bin off from peaks in speclong

843 peaks_only_in_timeaverage_unknown

Results - November 2023



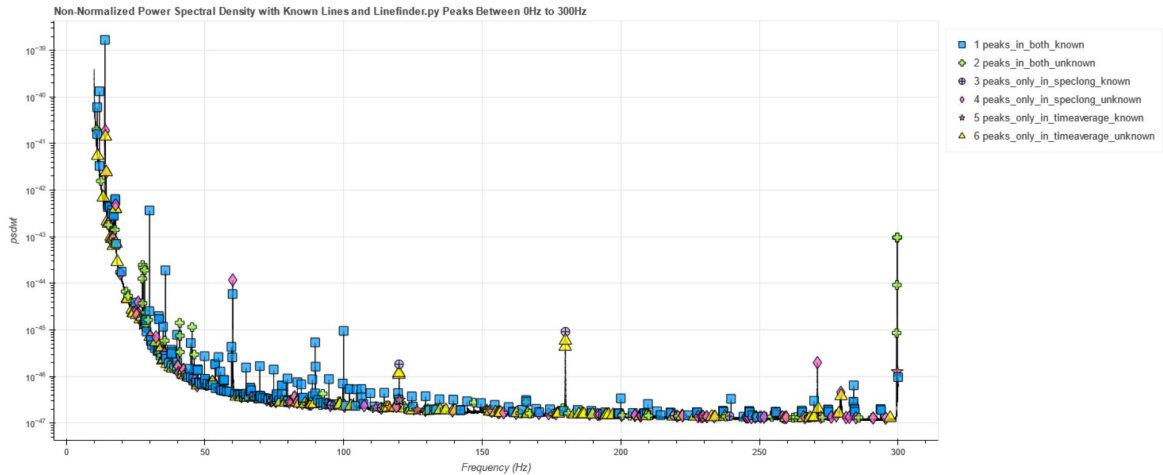
November 2023

1320 matching peaks

621 other peaks in non-normalized data

704 other peaks in normalized data

Results - November 2023



https://ldas-jobs.ligo-wa.caltech.edu/~carol.miu/custom_plots_11_23/

November 2023

757 peaks_in_both_known

563 peaks_in_both_unknown

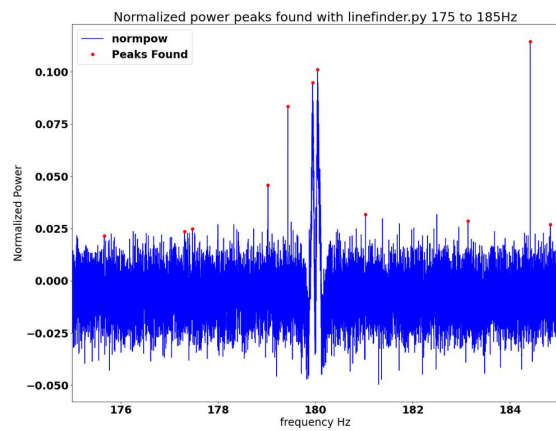
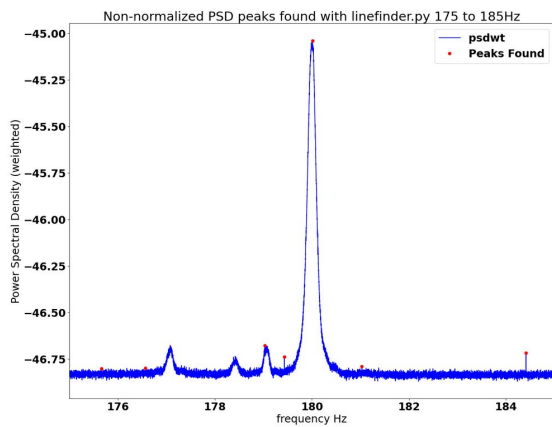
67 peaks_only_in_speclong_known

554 peaks_only_in_speclong_unknown

107 peaks_only_in_timeaverage_known - closer inspection frequencies 1 bin off from peaks in speclong

597 peaks_only_in_timeaverage_unknown

Results



Example of peak found in non-normalized data that is not a peak in the normalized data; 180Hz harmonic of 60Hz line from electrical power system.

Discussion

- Most peaks are found by the line finder in both the normalized and non-normalized data
- In many cases, a peak in the non-normalized data is smoothed away in the normalized data
- The number of peaks in the normalized data and the O4 lines list but not in the non-normalized data is relatively small, 71 in December 2023 and 107 in November 2023

Conclusion and Future Work

- The Fscan line finder is as effective at finding lines in non-normalized monthly data as in the normalized monthly data.
- Test and calibrate the Fscan line finder on daily data and compare to O4 lines list.

Acknowledgments

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Q&A

Thank You!