"**Instrumentation noise** in space-based **gravitational wave** detectors will likely be **non-stationary**."

Investigating the stationarity of sensing noise in LISA Pathfinder data

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I. Introduction

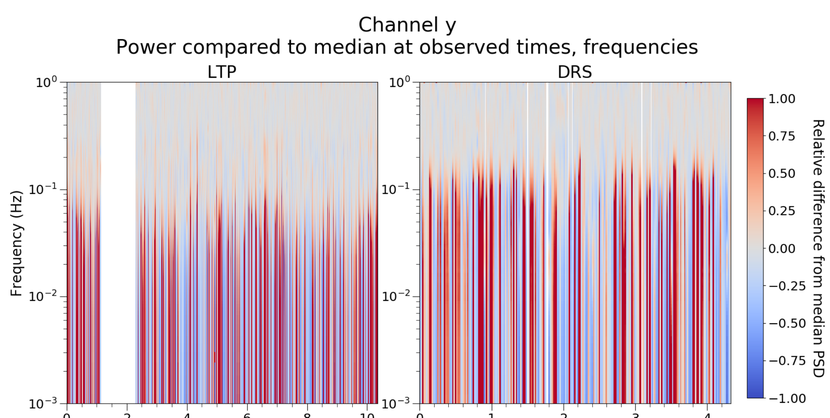
- LISA Pathfinder (LPF) was an ESA-led technology demonstration mission for space-based gravitational wave (GW) detectors
- **Two micro-propulsion systems were tested**: cold-gas thrusters (LTP) provided by ESA, and colloidal thrusters (DRS) provided by NASA
- Robust **statistical characterization of instrument noise** is critical for GW detection [1]
- To date, GW signal processing methods have assumed stationary noise (see [1] and references therein)
- **Sensing noise in LPF and LISA data is expected to be non-stationary** over long timescales

II. Methods

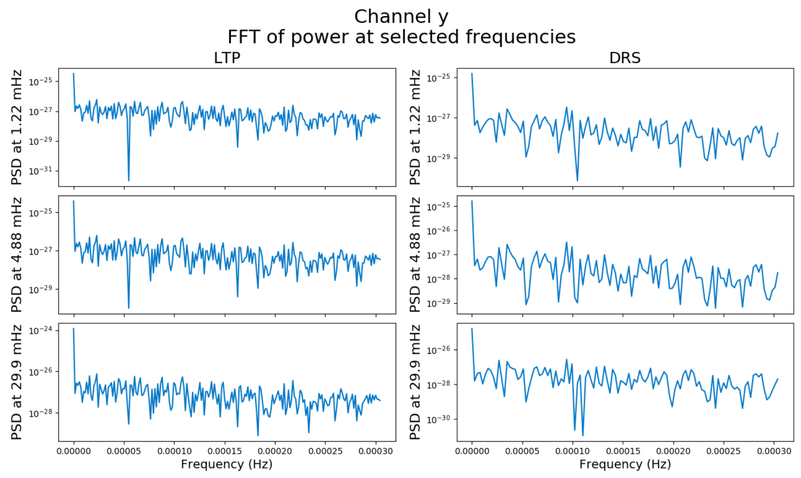
- Data obtained and processed for a study of micrometeoroid impacts on LPF [2]
- Power spectral density (PSD) and spectral line parameters were sampled from a Markov chain Monte Carlo (MCMC) process [1,2]
- Median values and credible intervals for the PSD were obtained from 100 MCMC samples at each observed time
- Power at particular frequencies was plotted over time to gain a qualitative understanding of time-dependent variance
- A one-dimensional discrete Fourier Transform (FFT) was performed to investigate periodic oscillations in the PSD at fixed frequencies

III. Results

- Spectrograms of LTP and DRS runs, compared to median PSDs across each run:



- Fourier transforms at selected frequencies:

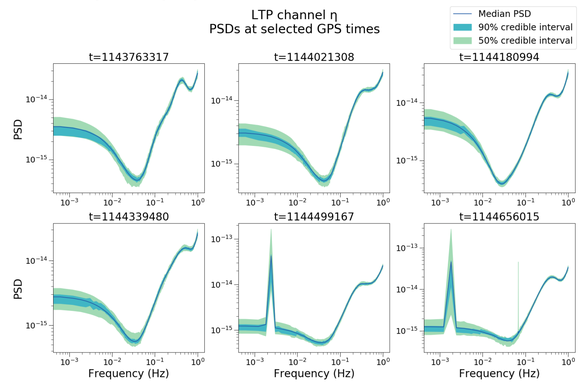


IV. Conclusions

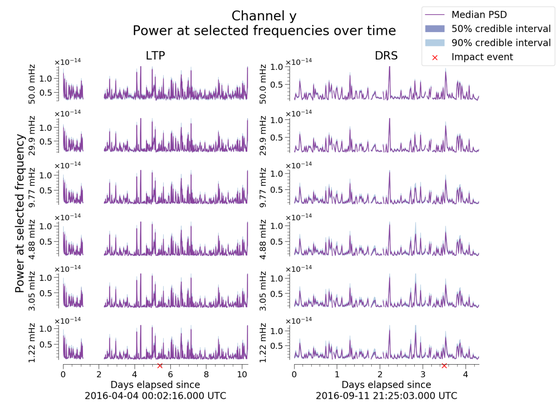
1. LPF instrumentation noise is non-stationary over short timescales (<1 day)
2. LPF noise exhibits broadband non-stationarity

Supporting Figures

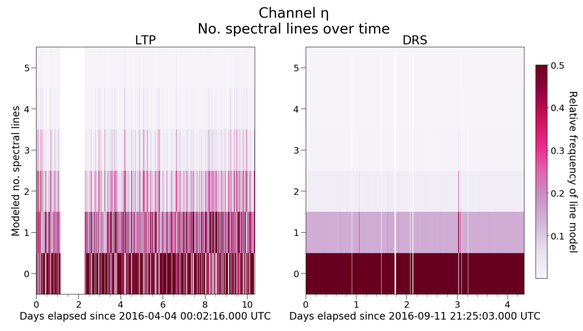
- Selected PSDs from an LTP run. The last two plots contain a prominent low-frequency spectral line:



- Power at selected frequencies over time:



- Spectral lines are more common in LTP data, but aren't present at all times:



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Scan to access the full code:

github.com/lod2000/lisa-pf-noise

References

[1] Littenberg and Cornish 2015, Phys. Rev. D 91, no. 8, 084034

[2] Thorpe et al. 2019, ArXiv:1905.02765 [Astro-Ph]