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ET-D Sensitivity Functions

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1 Scope of this Document

This document describes Matlab functions which can be used to recreate an estimate of the ET-D sensitivity of the Einstein GW Telescope for arbitrary frequency vectors in the range from 1 Hz to 10 kHz. A detailed description of the Interferometer configuration assumed for the ET-D sensitivity can be found in [1]. Please note that the ET-D curve (as well as the ET-C) curve is based on a 2-band xylophone detector [2], consisting on a low-frequency and a high-frequency detector, which together make up the total (broadband ET-D) sensitivity.

The original data vectors for the ET-D detectors can be download from the ET-sensitivity webpage [3], while the Matlab functions described in this document are available from [4].

2 Description of ET-D fit functions

ET-D fit functions allow to create an ET-D sensitivity estimate for any frequency or frequency vector in the range from 1 Hz to 10 kHz. Though there might be more elegant approaches, our fit functions are set up to split the total frequency range into small pieces and to make use of either power functions or polynomials to recreate the ET-D sensitivity over the frequency range of each piece.[1]

There are three Matlab functions available:

- **ET_D_HF_fit.m**: Fit function for the sensitivity of an ET-D high-frequency interferometer.
- **ET_D_LF_fit.m**: Fit function for the sensitivity of an ET-D low-frequency interferometer
- **ET_D_fit.m**: Fit function for total ET-D sensitivity (assuming that the noise in the low and high frequency interferometers is completely uncorrelated).

Please note that all the functions return the amplitude spectral density of the ET-D strain sensitivity.[2] The upper subplot of Figure 1 shows the result of the ET-D fit functions.

3 Accuracy of the ET-D fit functions

The upper sub-plot of Figure 1 shows the ratio of the original ET-D data from [3] and the Matlab functions. Apart from the frequencies of the violin modes (which have been removed for both, the low-frequency and the

[1] Please note that there might be small discontinuities at the transitions between two frequency ranges represented by different mathematical functions.

[2] Also it should be mentioned that the ET-D sensitivity is calculated for an arm length of 10 km and an opening angle of 90 degree. Information on how to convert the ET-D sensitivity into the resulting sensitivity of a full ET triangular observatory consisting of three detectors featuring opening angles of 60 degree, please see the last section in [1].

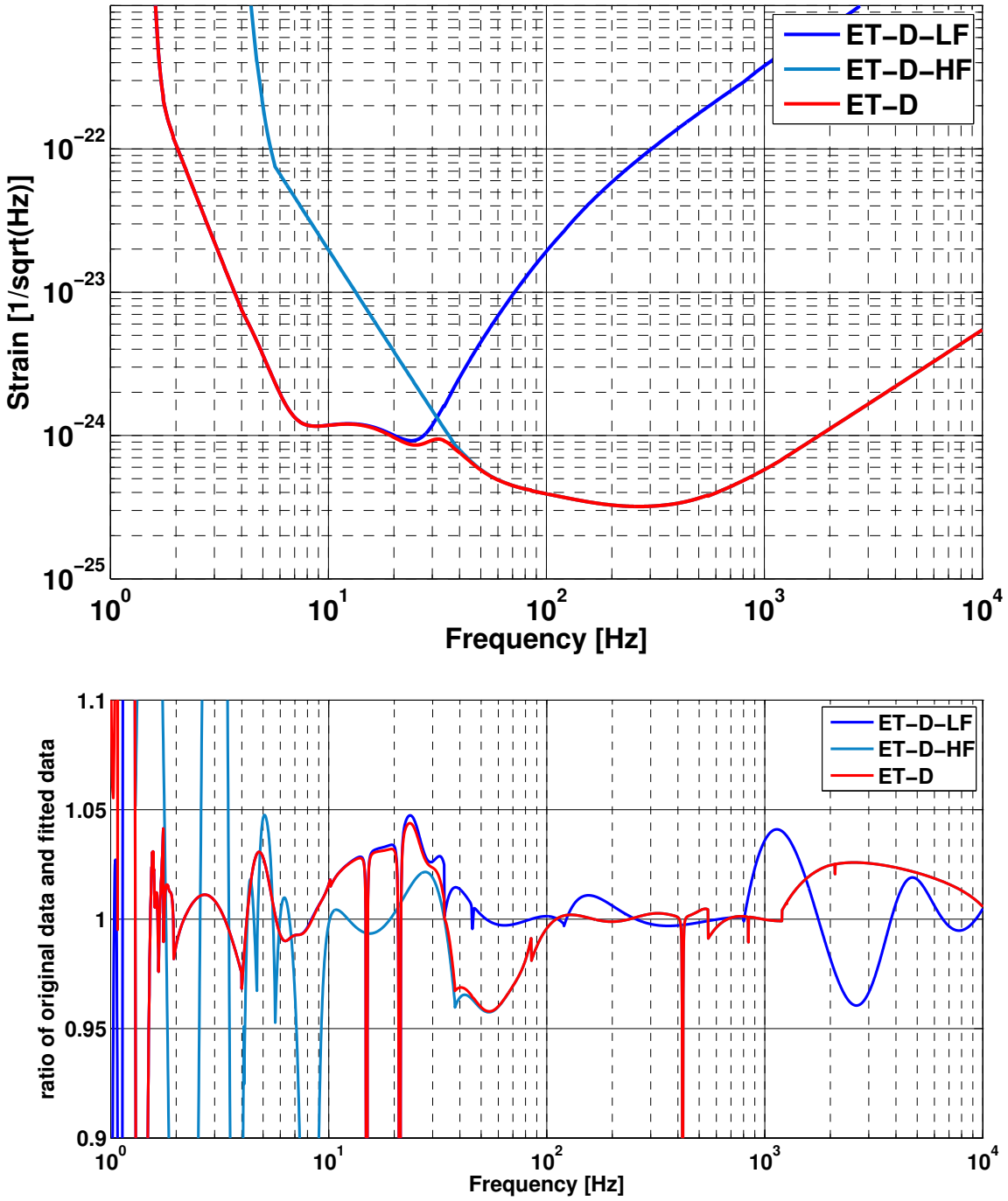

Figure 1: Upper subplot: Amplitude spectral density of the ET-D sensitivities from the Matlab functions described in this document. Lower subplot: Ratio of the original ET-D data from [3] and the Matlab functions available at [4]. The fit functions represent the total ET-D sensitivity to within 5 % for all frequencies between 1.5 Hz and 10 kHz.

high-frequency, interferometers), ET_D_LF_fit.m and ET_D_fit.m are accurate to within 5 % for all frequencies above 1.5 Hz, while ET_D_HF_fit.m is accurate to within 5 % for all frequencies above 10 Hz.

Detailed plots comparing the strain sensitivities of the low and high-frequency interferometers can be found in the appendix, Figure 2. The same comparison for the total ET-D sensitivity is shown in Figure 3.

A Comparison plots of ET-D-data and fit functions

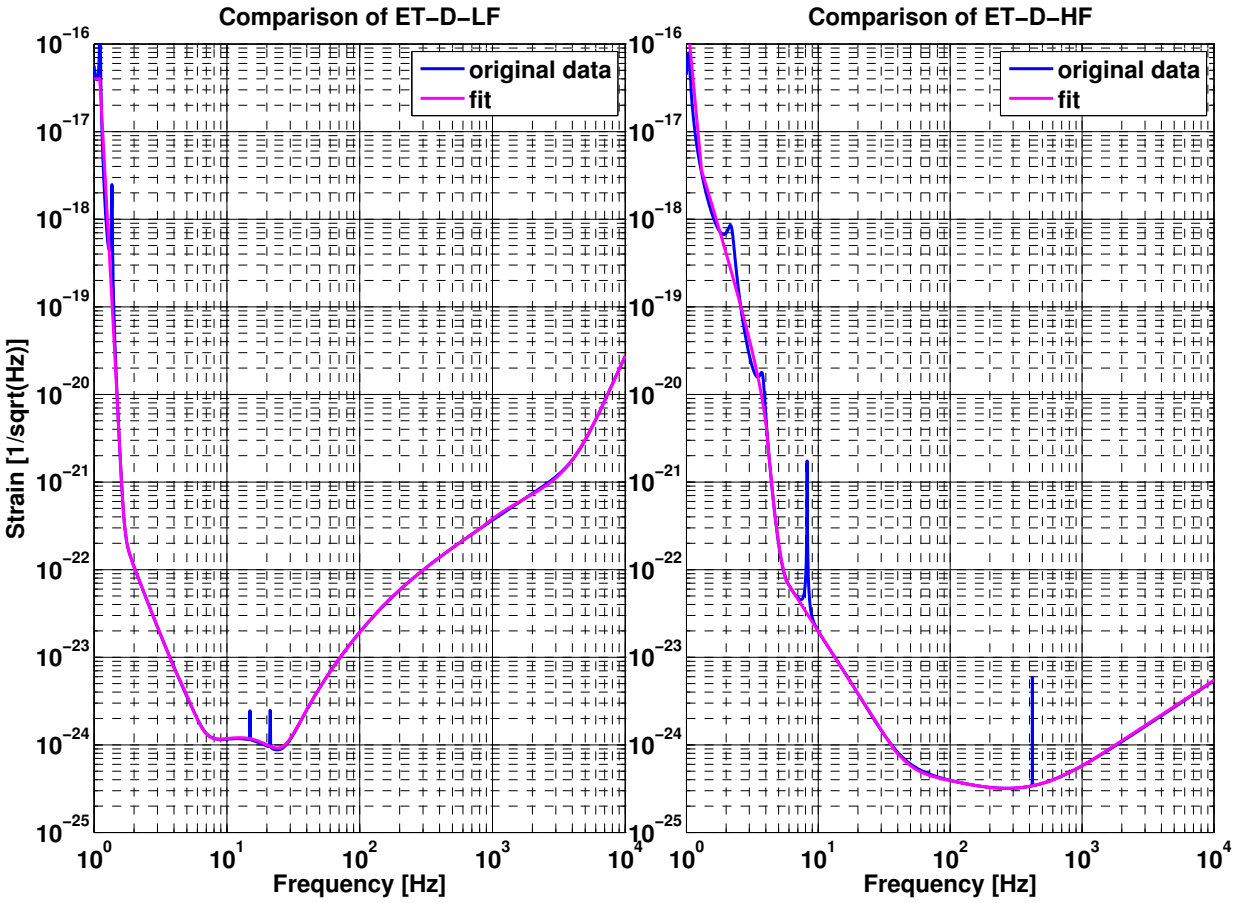

Figure 2: Comparison between the original ET-D-HF and ET-D-LF data [3] and fit functions described in this document [4].

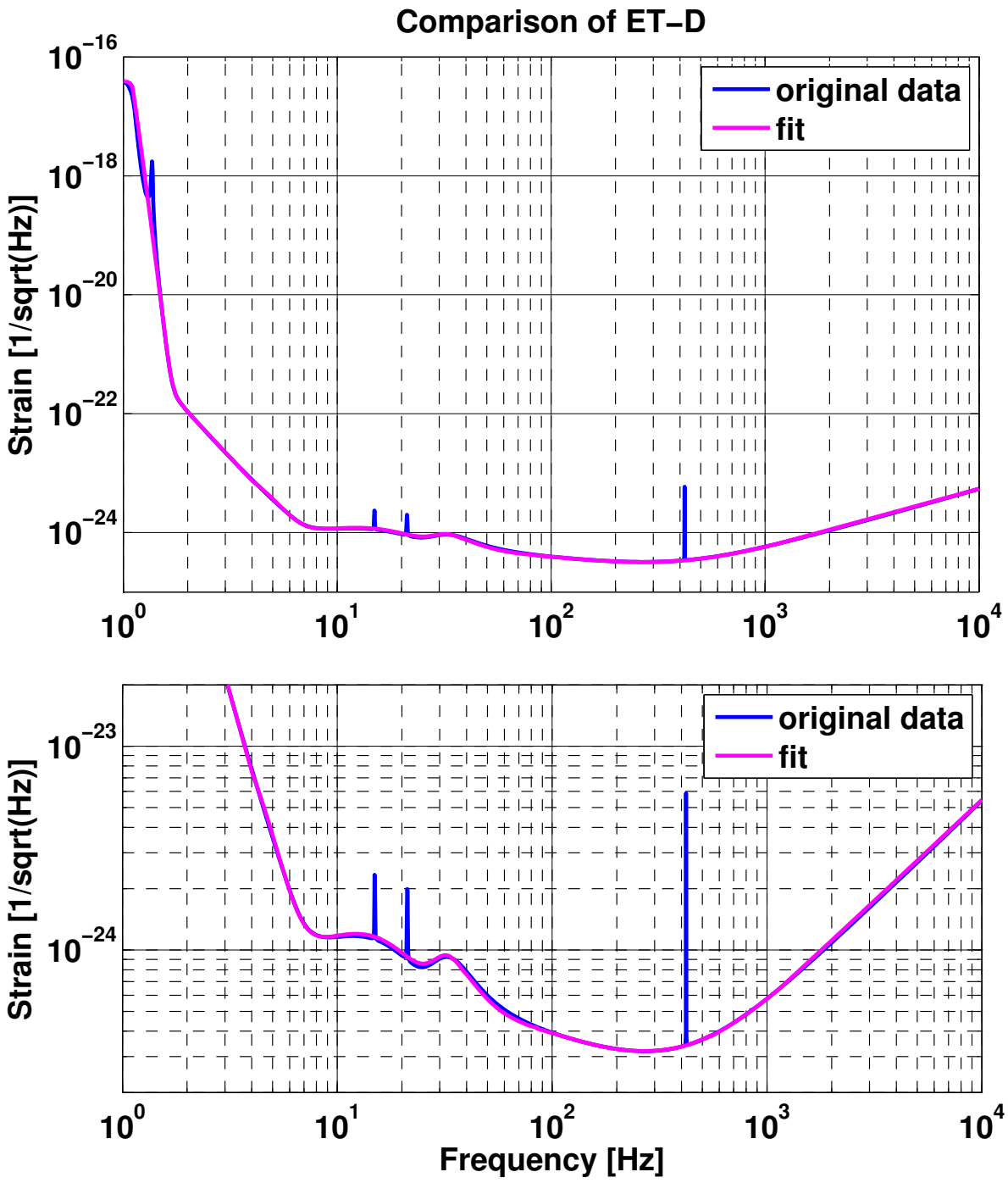

Figure 3: Comparison between the original ET-D data [3] and fit functions described in this document [4]. The upper plot shows the full vertical range, while the lower plot is a zoomed in version.

References

[1] S. Hild *et al*: "Sensitivity Studies for Third-Generation Gravitational Wave Observatories", arXiv:1012.0908v1 [gr-qc], submitted to CQG. 1

[2] S. Hild, S. Chelkowski, A. Freise, J. Franc, N. Morgado, R. Flaminio and R. DeSalvo: "A Xylophone Configuration for a third Generation Gravitational Wave Detector" *CQG* **vol. 27**, pp015003 (2010). 1

[3] ET sensitivity webpage: `http://www.et-gw.eu/etsensitivities` 1, 2, 3, 4

[4] The ET-D sensitivity functions described in this document can be downloaded from: `http://www.physics.gla.ac.uk/ shild/ET_D_functions.zip` 1, 2, 3, 4