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- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Technical Note **LIGO-T1600123-v1** 2016/07/29

2^{nd} Report - SURF Project 2016

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Abstract

The aim of this paper is to present the results of the parametric study introduced in the first SURF Project Report [1]. All the work and simulations were carried out from 07/07/2016 to 07/29/2016.
Many simulations were carried out varying a single parameter to study the effects on simulation results. The values for the fixed parameters came out from previous analysis [2]. The final parameter set value was chosen fitting the simulation results on the experimental values.
The final goal will be the direct application of the study in micro/nano scale to LIGO's concern. We want to input the developed micro-mechanical simulation results for the crackling noise form into the scaling model and predict for the crackling noise propagated to the blade tip under prescribed loading.

1 Probability Distribution for Threshold Value - Shape and Width Varying

The Elastic Coupling Coefficients were fixed to:

- $C = 400.00$
- $D = 5.00\,E\,-6$

The choice seems reasonable because both values come from the non-updating threshold stress code [2] which fits the experimental data very well. Furthermore, we expected C would have been of the same order of magnitude of the nominal Yielding Point. D order of magnitude comes from previous check of the old code.
All the distributions used are centered in 1.0, definition for the Yielding point in the simulations ($400MPa$). Fixed the Elastic Coupling Coefficient and the distrbution shape width was varied. Expectancy was for a great sensibility for the micro-plasticity regime starting point to this parameter.

1.1 Gaussian Distribution - Standard Deviation Varying

In $Fig.(1)$ the results for increasing standard deviations are plotted and compared.

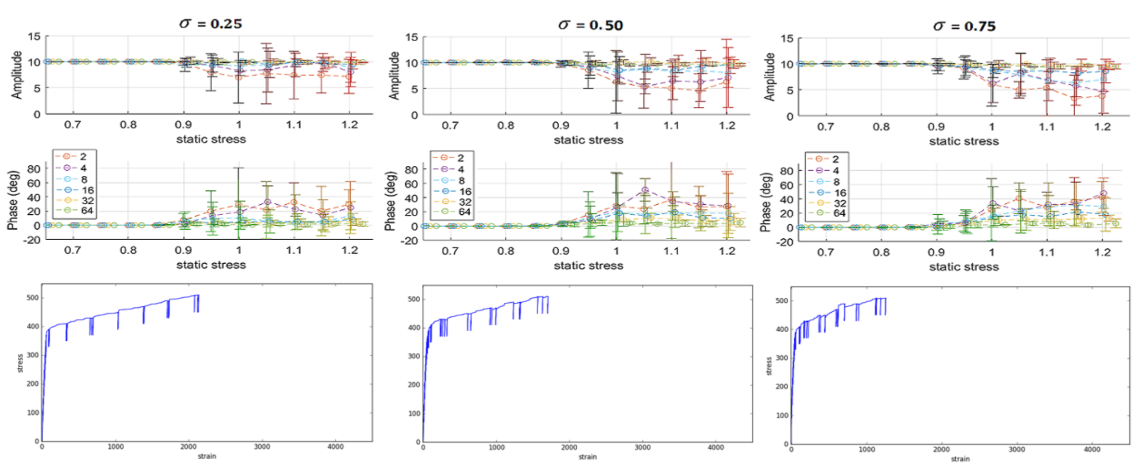

Figure 1: Gaussian Distribution - Amplitude and Phase VS Stress (Up) - Stress VS Strain (Down)

In spite of all expectations, the micro-plasticity regime starting point seems not to depend on the width of the Standard Deviation. The average modulus Amplitude is inversely proportional to the increasing of the standard deviation. Width increasing corresponds to the decrease of the average modulus Amplitude.

1.2 Flat Distribution - Width Varying

In $Fig.(2)$ the results for increasing width for flat distribution are plotted and compared.

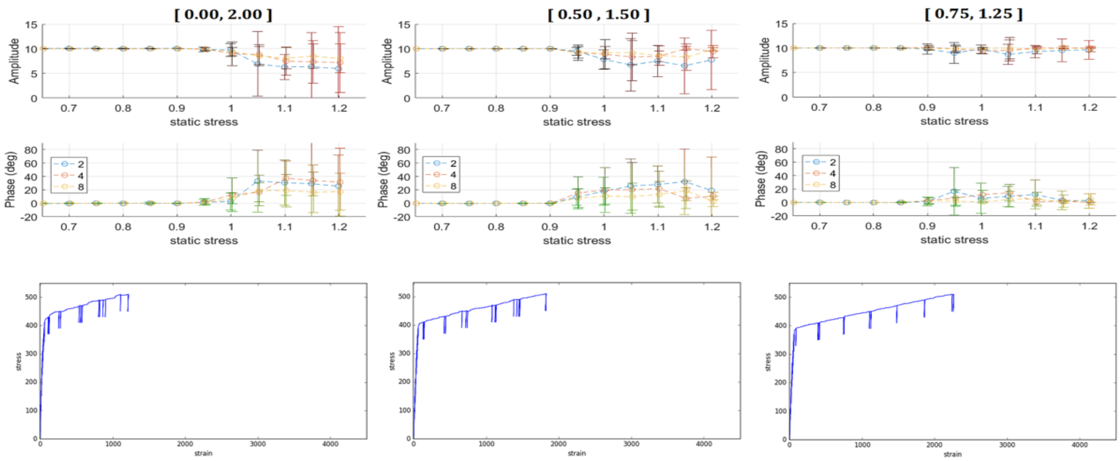

Figure 2: Flat Distribution - Amplitude and Phase VS Stress (Up) - Stress VS Strain (Down)

The micro-plasticity starting point is not fixed, as in the Gaussian distribution, but it depends on the width of the distribution. As for the Gaussian distribution, the average modulus Amplitude is inversely proportional to the increasing of the distribution range. Width increasing corresponds to the decrease of the average modulus Amplitude.

2 Elastic Coupling Coefficient - Varying

Threshold distribution and, alternately, one of the Elastic Coupling Coefficient were fixed to:

- Gaussian Distribution
- $D = 1.00\,E\,-6 \Longrightarrow C$ varying
- $C = 400.00 \Longrightarrow D$ varying

The choice of a Gaussian distribution seems reasonable because it was the one used for the non-updating threshold stress code, it gave a better data shape and, intuitively speaking, has more physical sense.

2.1 C constant, Internal Stress Prefactor - Varying

In $Fig.(3)$ the results for increasing C are plotted and compared.

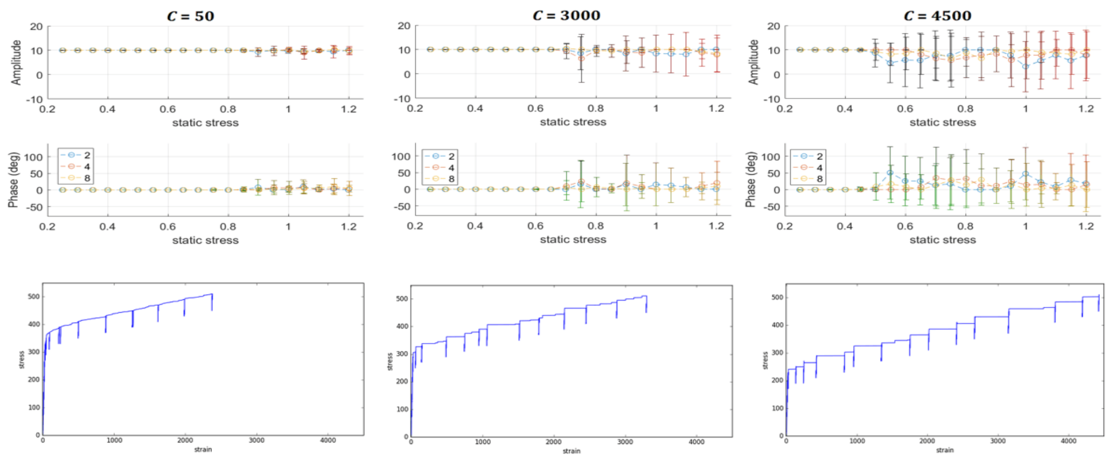

Figure 3: C Varying - Amplitude and Phase VS Stress (Up) - Stress VS Strain (Down)

The micro-plasticity starting points inversely depends on the increasing of C. Constant increasing corresponds to a negative shifting for the micro-plasticity regimes starting point, and viceversa, up to small C, where the regime is predominantly elastic. The average modulus amplitude is sensitive to C varitions.

2.2 D constant, Viscoplastic Rate Coefficient for the Micro-Plasticity Channel - Varying

In $Fig.(4)$ the results for increasing D are plotted and compared.

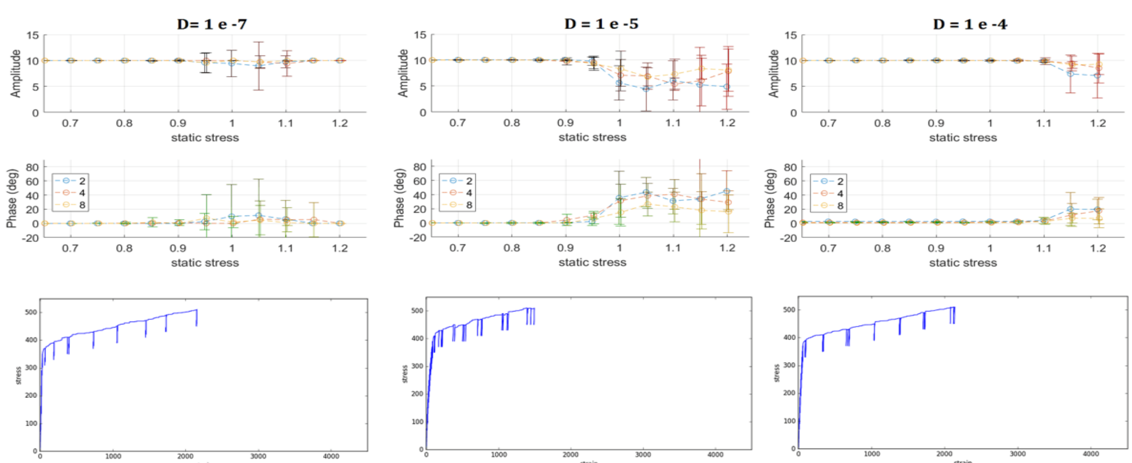

Figure 4: D Varying - Amplitude and Phase VS Stress (Up) - Stress VS Strain (Down)

The micro-plasticity starting point proportionally depends on the increasing of D. Constant increasing corresponds to a positive shifting for the micro-plasticity regimes starting point, and viceversa, up to small D, where the regime is predominantly elastic. D increasing corresponds to the decrease for the average modulus Amplitude.

3 Best Fitting

It was used a Gaussian distribution for the above mentioned reasons ($Sect.(1)$) as well as because it came out to be an accetable compromise between good values for the average modulus Amplitude and physical sense.
To shift negativetly the micro-plasticity starting point C was fixed to 2750. To avoid the average modulus amplitude increasing, due to C increasing, D was fixed to $1.00\ E\ -5$.

- Gaussian Distribution - $\sigma = 0.50$
- $C = 400.00$
- $D = 1.00\ E\ -5$

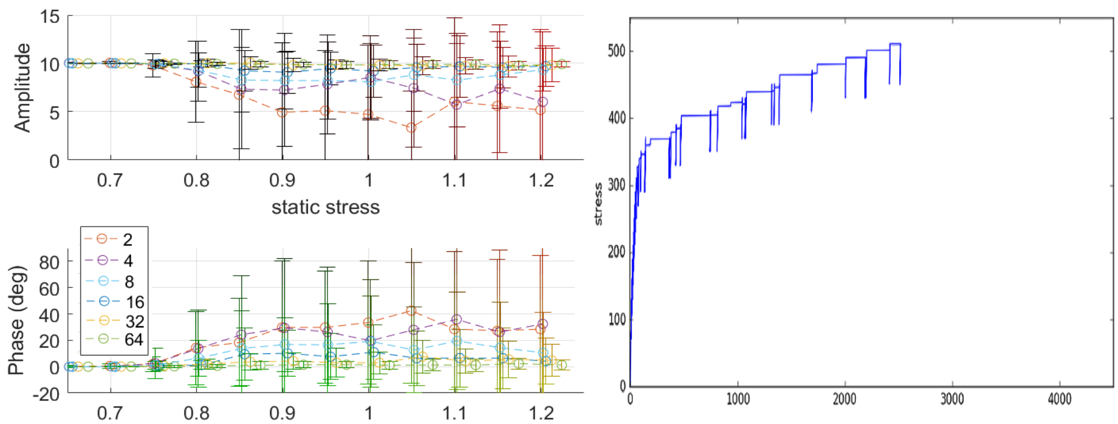

Figure 5: Amplitude and Phase VS Stress (Left) - Stress VS Strain (Right)

4 Future Work Planning

- Check physical units of the elastic coupling coefficient to validate the results and choose the correct configuration;
- After finishing the parametric study for the simulation and obtaining results that are close to the experimental observation, we want to implement the crackling-noise-experiment like loading condition and carry out different frequency and amplitude driving tests at constant nominal elastic stress, for the demodulation studies of the Crackling Noise;

- In order to directly apply the study in micro/nano scale to LIGO's concern, we want to input the developed micro-mechanical simulation results for the crackling noise form into the scaling model [3], and predict for the crackling noise progagated to the blade tip under prescribed loading.

References

[1] R.Maggiore, "SURF Project 2016 - 1^{st} Report", LIGO-T1600123 (2016)

[2] X.Ni, "Micromechanical Investigation on Crackling Noise, Crackle Meet @Pasadena" (2016)

[3] G.Vajente, "Crackling Noise: Scaling Model", LIGO-T1600246-v2 (2016)