

## Introduction

Electromagnetic Levitators (EML) position and heat samples of metal through the application of voltages. In property derivation, the heater voltage also acts as a stimulant, causing the metallic droplets to oscillate through Faraday excitation [1]. The frequency of these free oscillations can be used to derive surface tension using the following equation, where  $\nu$  is free frequency, and  $p_1$  and  $p_2$  are correction factors [1].

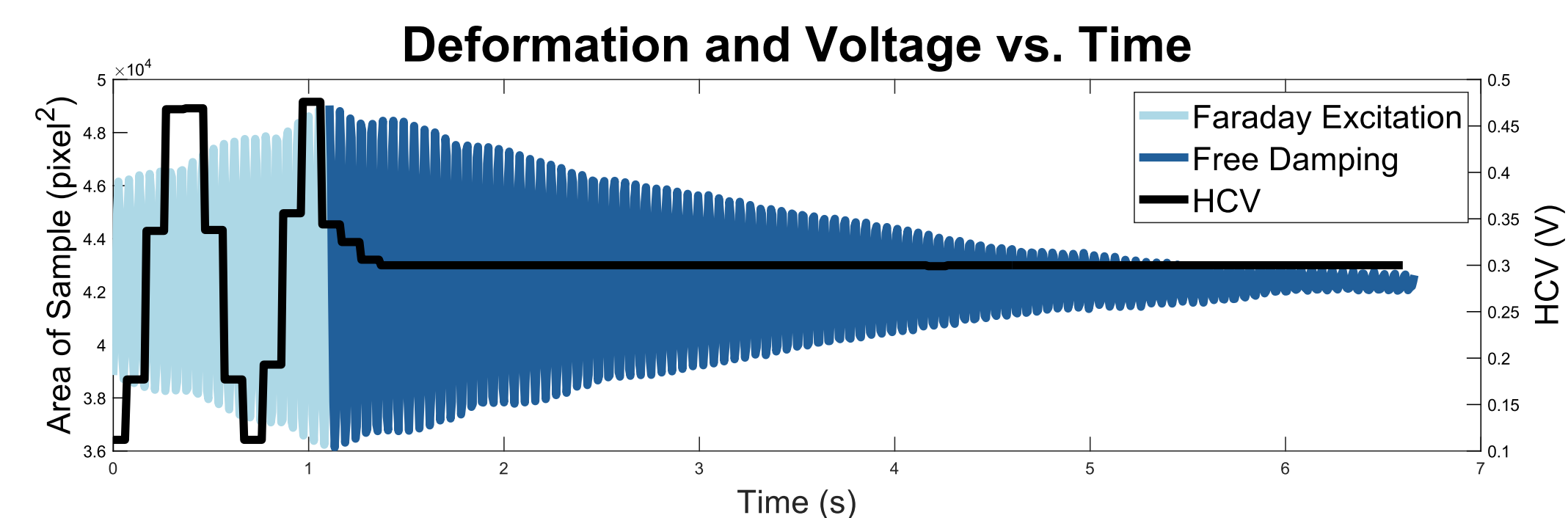
$$\sigma = \frac{3}{8} \pi m \nu^2 (p_1 \delta + p_2 \delta^2)^{-2} \quad (1)$$

Knowledge of a metal's surface tension is vital for creating models of manufacturing processes that involve melts, such as laser powder bed fusion (LPBF).

## Methods – Faraday Forcing

Testing was conducted at four separate median heater control voltages (HCV): 0.3, 0.6, 0.8, and 1.0 V. Overlapping sections of the droplet oscillation were curve-fit to the following damped sine wave equation:

$$y = A \cdot e^{-\frac{t}{\tau}} \cdot \sin(2\pi\nu t + \phi) + D \quad (2)$$

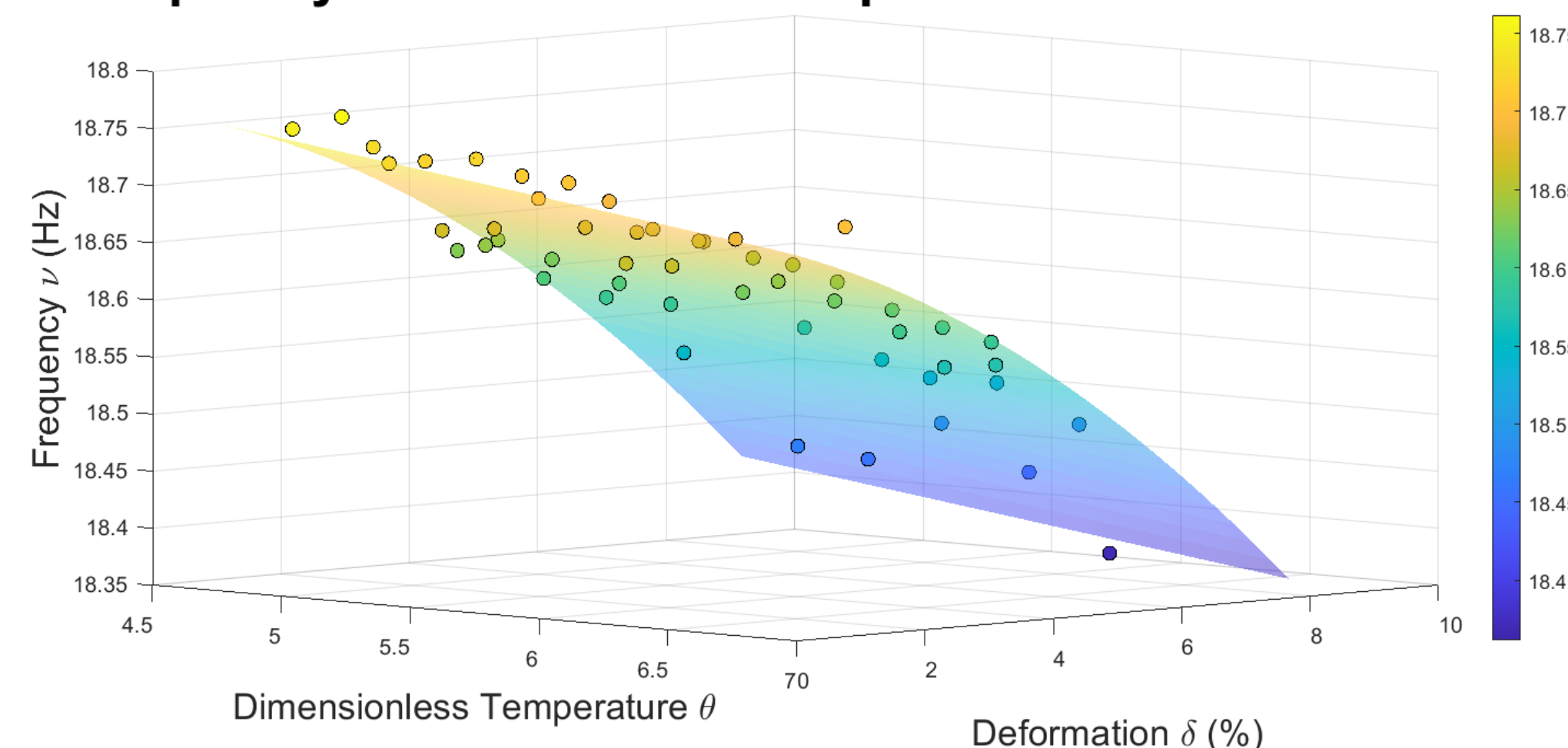


$\nu$  was plotted against deformation amplitude,  $\delta$ , and dimensionless temperature  $\theta = \frac{T - T_{liq}}{T_{liq}}$ , and curve fit to find deformation and temperature dependence [1].

## Results

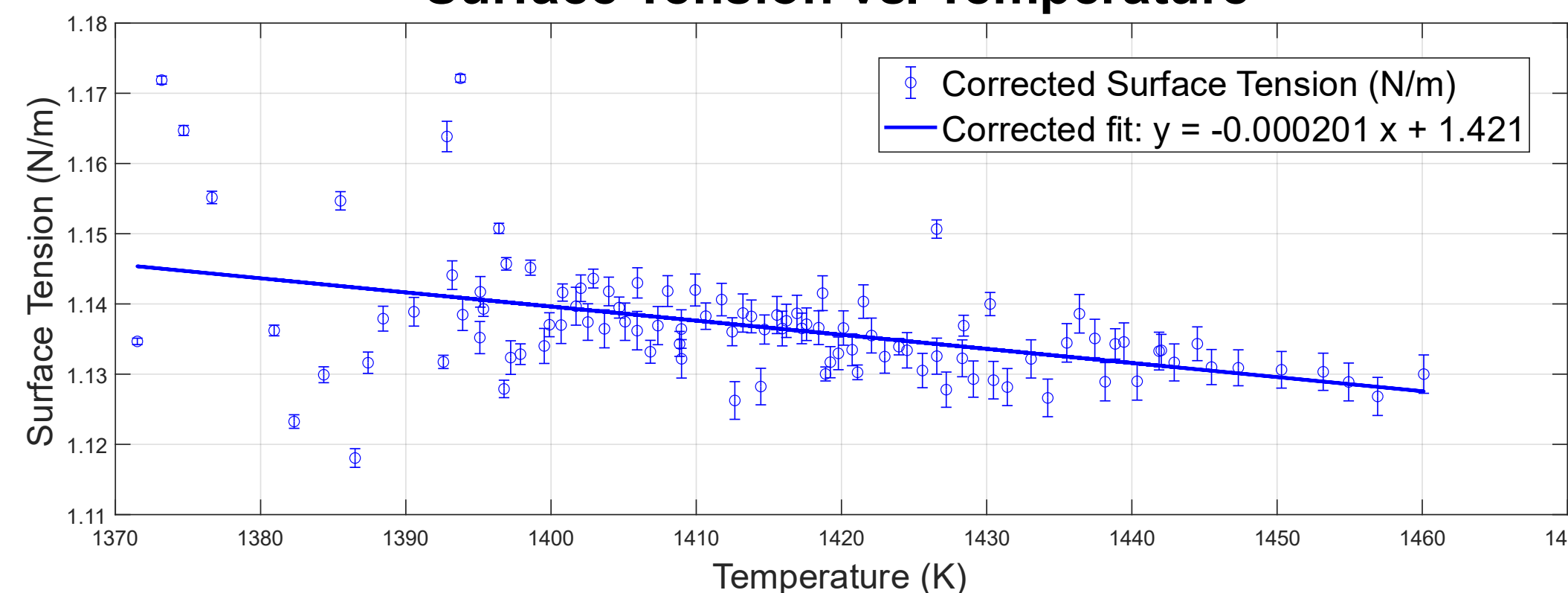
Curve fitting of frequency values against dimensionless temperature and deformation showed a more significant dependence on deformation.

Frequency as Function of Temperature and Deformation



These derived correction values were taken and used in equation (1), yielding the linear surface tension data shown below ( $y = mx + b$ ).

Surface Tension vs. Temperature

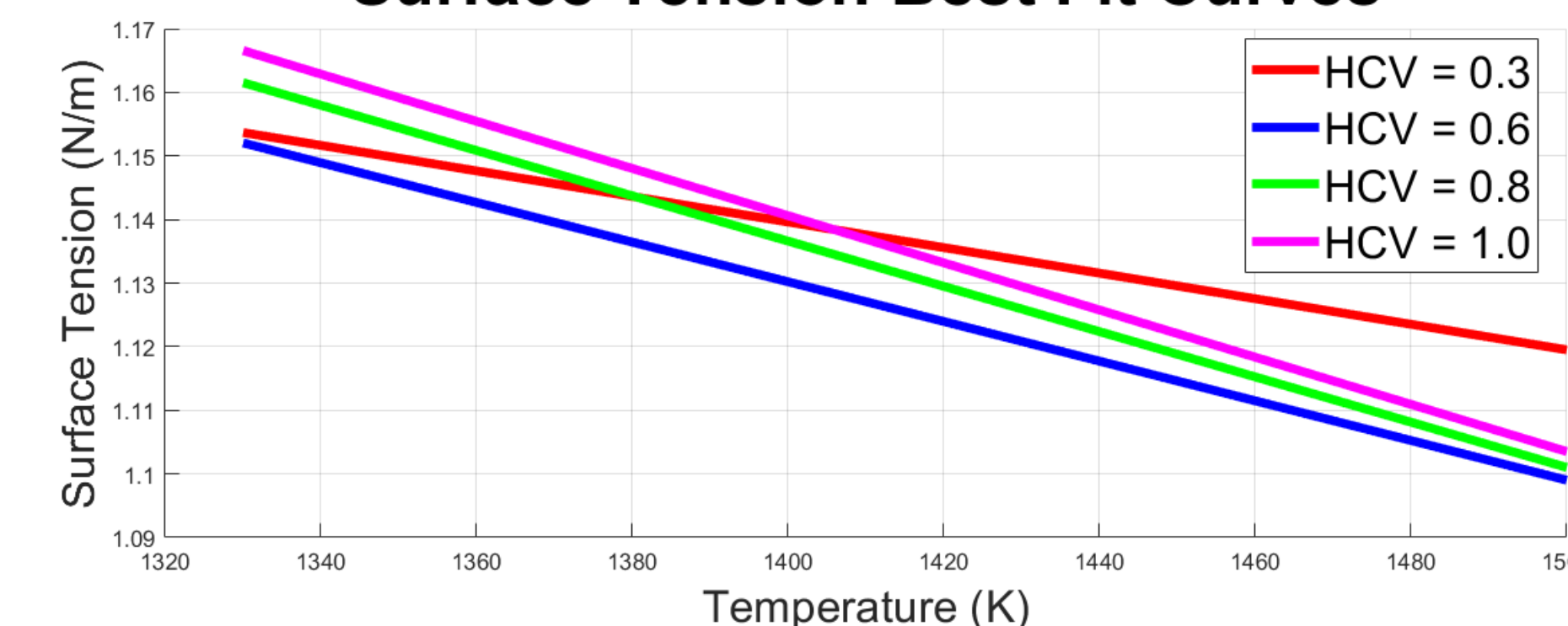


| HCV | m (N/mK)  | b (N/m) |
|-----|-----------|---------|
| 0.3 | -0.000201 | 1.421   |
| 0.6 | -0.000312 | 1.567   |
| 0.8 | -0.000356 | 1.635   |
| 1.0 | -0.000371 | 1.660   |

## Discussion

An increase in heater control voltage corresponds to a stronger temperature dependence in the surface tension measurement.

Surface Tension Best Fit Curves



Further statistical analysis needs to be conducted to determine whether the results are truly different. Additionally, for the 0.6, 0.8, and 1.0 HCV runs, there only existed one test for each voltage, leading to a small amount of data to analyze. To increase fidelity, more tests should be run, isolating these HCVs.

## Acknowledgements

I would like to thank Professor Douglas Matson for his guidance and expertise during this research process and for providing the opportunity to collaborate with reputable agencies such as NASA and DLR. NASA has provided funding through Grant 80NSSC24K1119.

## References

[1] X. Xiao, R. W. Hyers, R. K. Wunderlich, H.-J. Fecht, and D. M. Matson, "Deformation induced frequency shifts of oscillating droplets during molten metal surface tension measurement," *Appl. Phys. Lett.*, vol. 113, no. 1, p. 011903, 2018, doi: 10.1063/1.5039336.