Measuring Superfluid Helium Drop Evaporation Rates from Surface Mode Oscillations

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Harris Labs

Yale

Summer Symposium 2025

Wright Laboratory

Harris Lab Objectives

1. High-finesse optical cavities ⟶ **Quantum optics**
2. Fluid dynamics (vortices and turbulence) ⟶ **Condensed matter**
3. Precision test of standard model ⟶ **Particle physics**

Image credit: Google

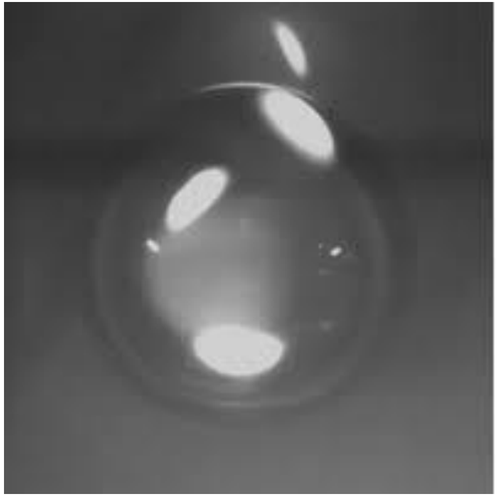
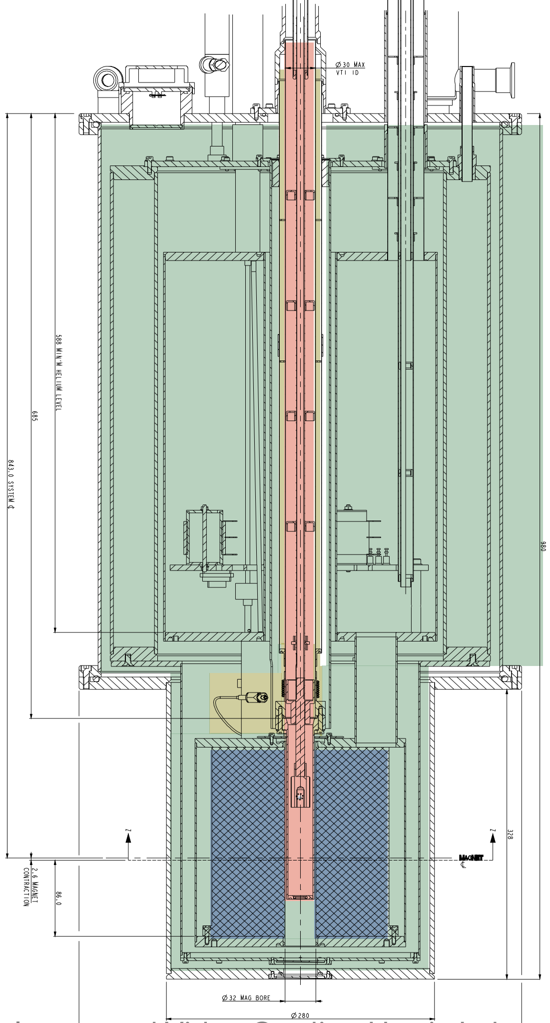


Image credit: PRL 130-Superfluid Helium Drops Levitated in High Vacuum

Cryostat



Magnet and Sample Space with Drop

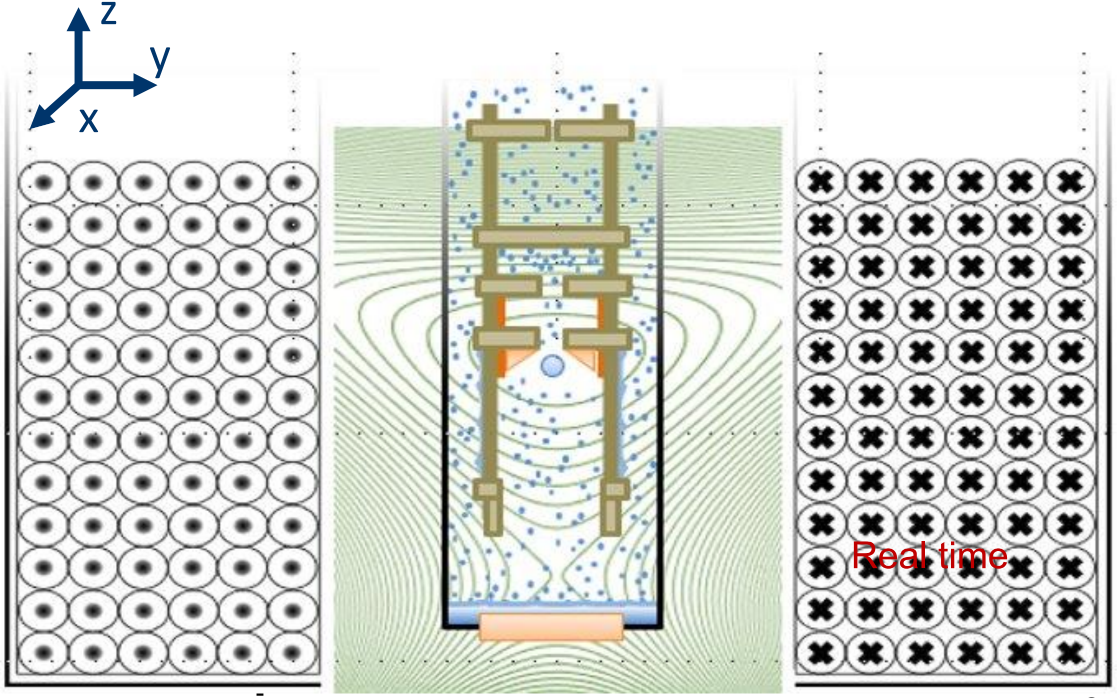
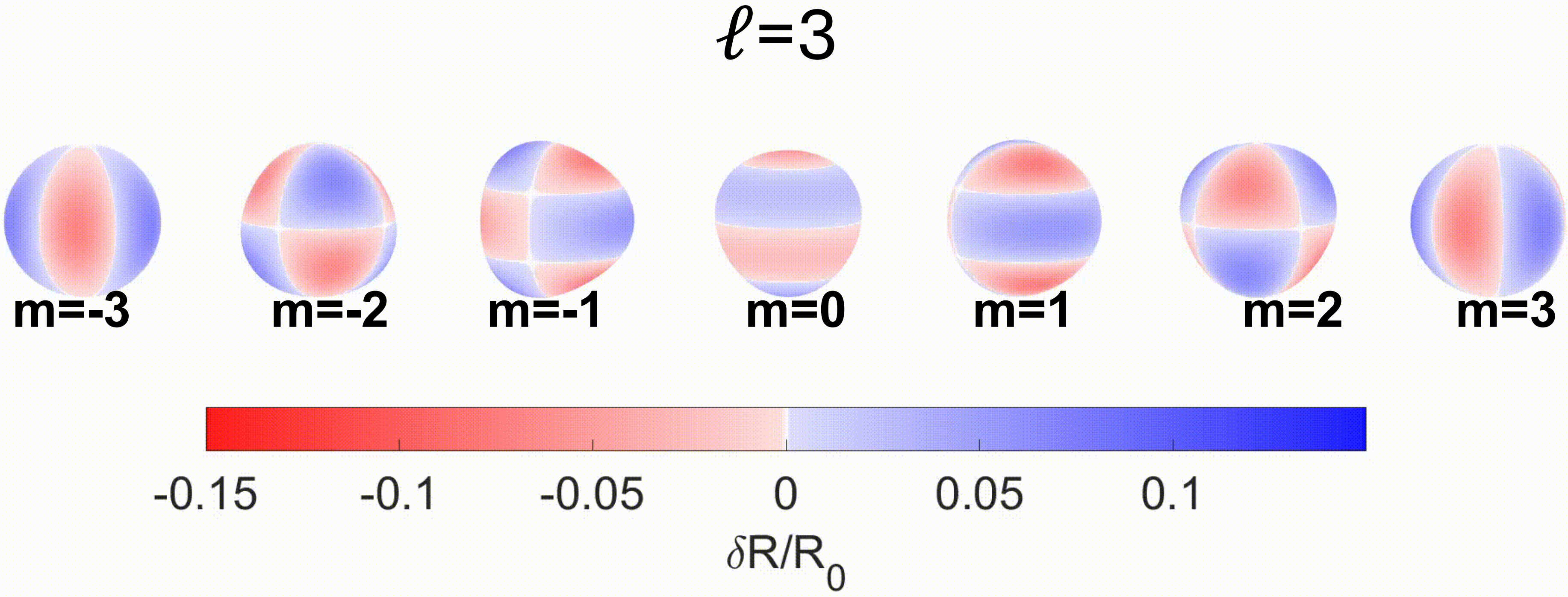


Image and Video Credits: Harris Labs

Surface Oscillations

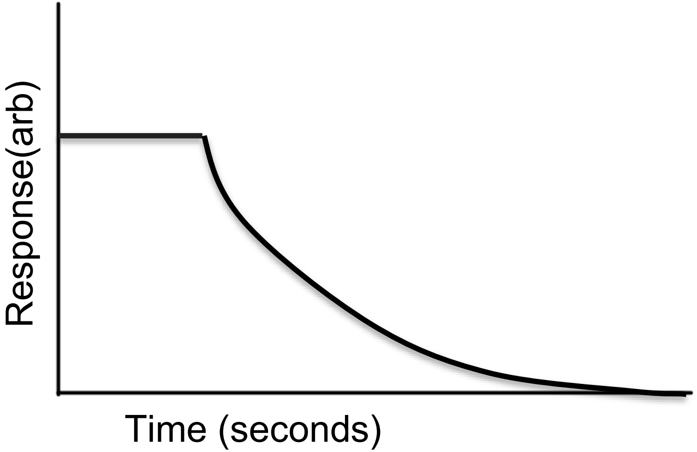


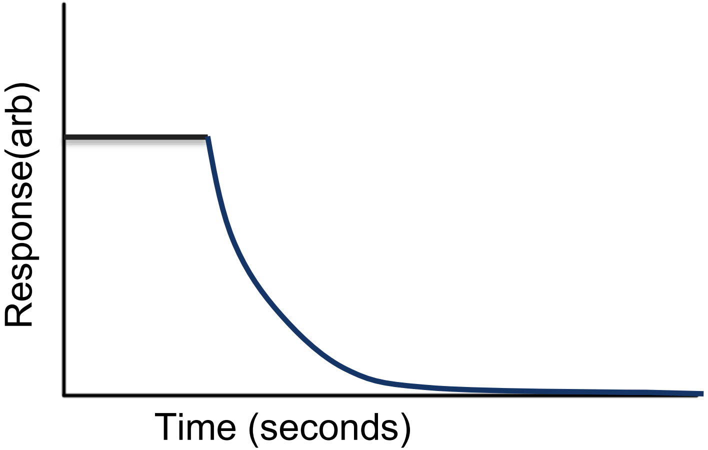
Animation Credit: Harris Labs, Igor Brandão

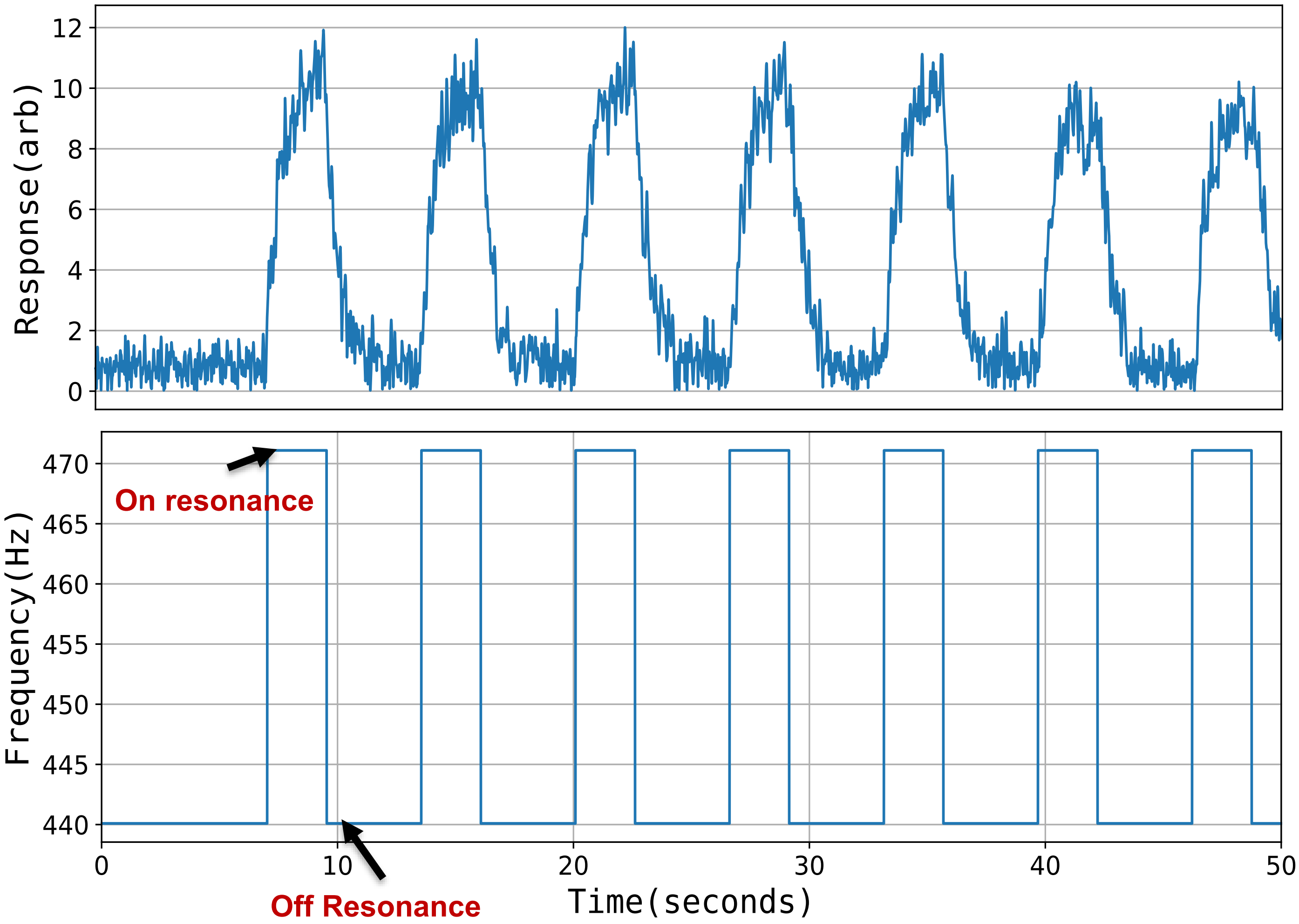
Musical Ringdowns

Image credit: Google

Image credit: Premier Percussions



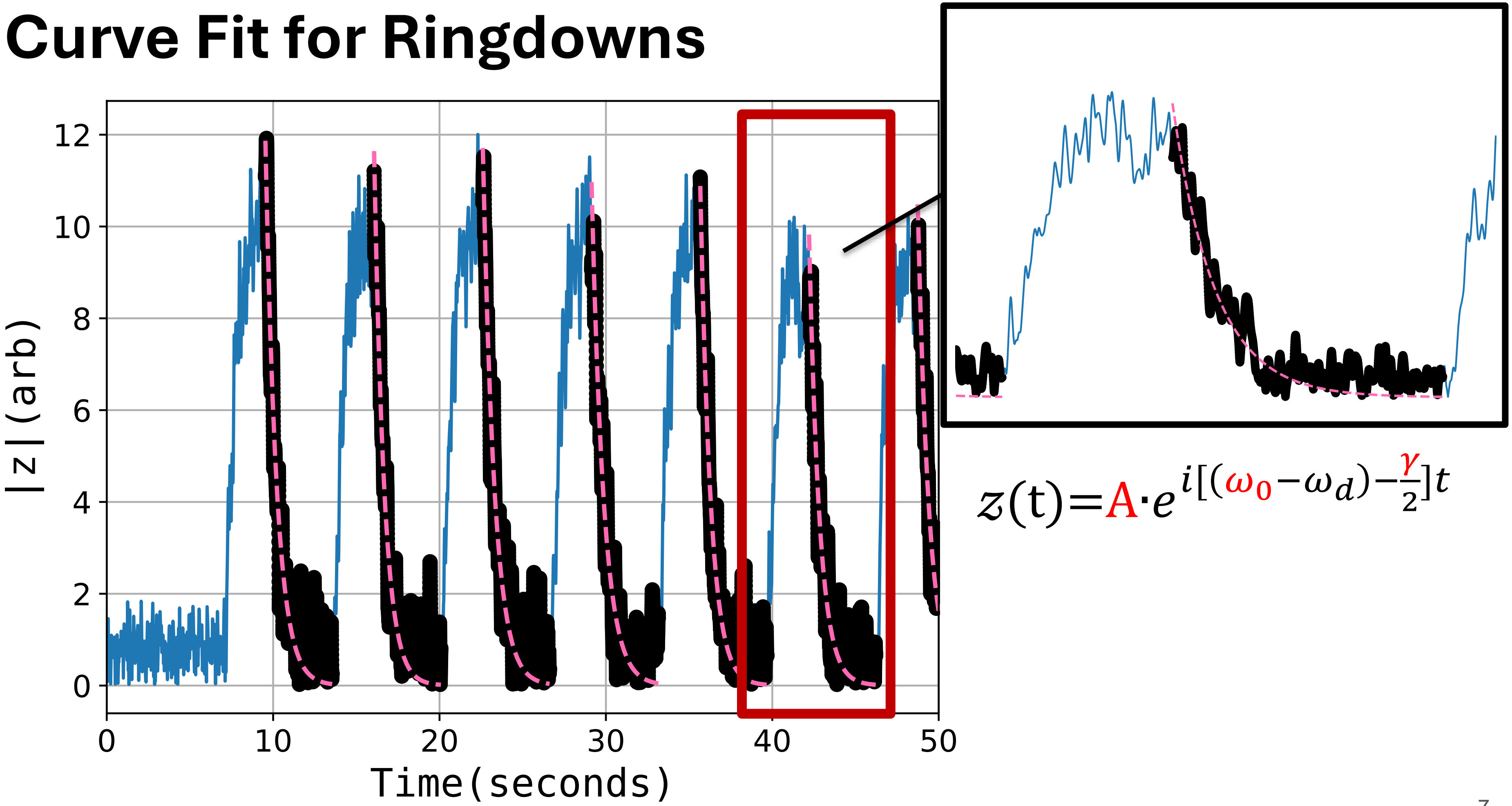




Amplitude vs. Time

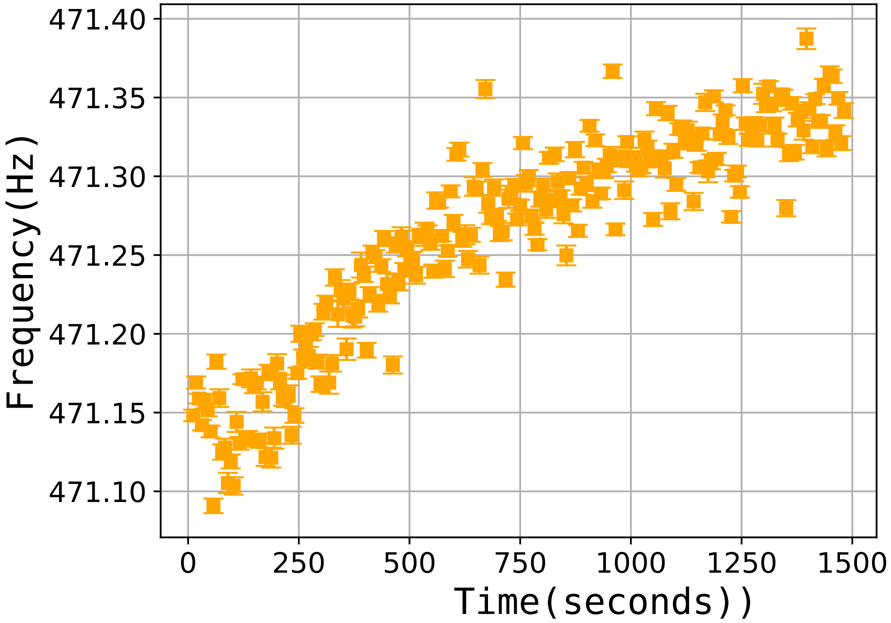
Driving Frequency

Curve Fit for Ringdowns



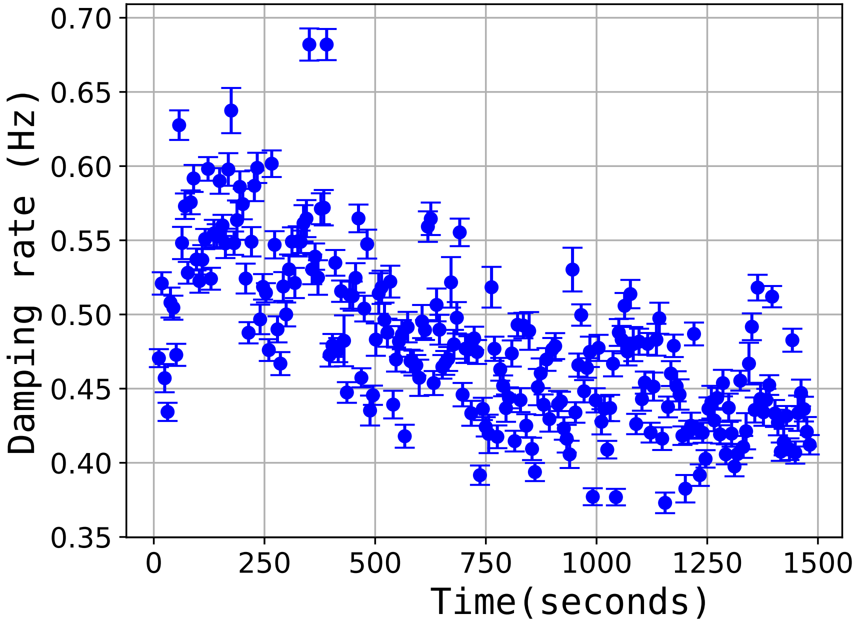
$$z(t) = A \cdot e^{i[(\omega_0 - \omega_d) - \frac{\gamma}{2}]t}$$

Best Fit Values for Frequency



$$z(\mathrm{t}) = \mathrm{A} \cdot e^{i[(\omega_0 - \omega_d) - \frac{\gamma}{2}]t}$$

Best Fit Values for Damping



$$z(\mathrm{t}) = \mathrm{A} \cdot e^{i[(\omega_0 - \omega_d) - \frac{\gamma}{2}]t}$$

$$\omega^2 = \frac{k}{m}$$

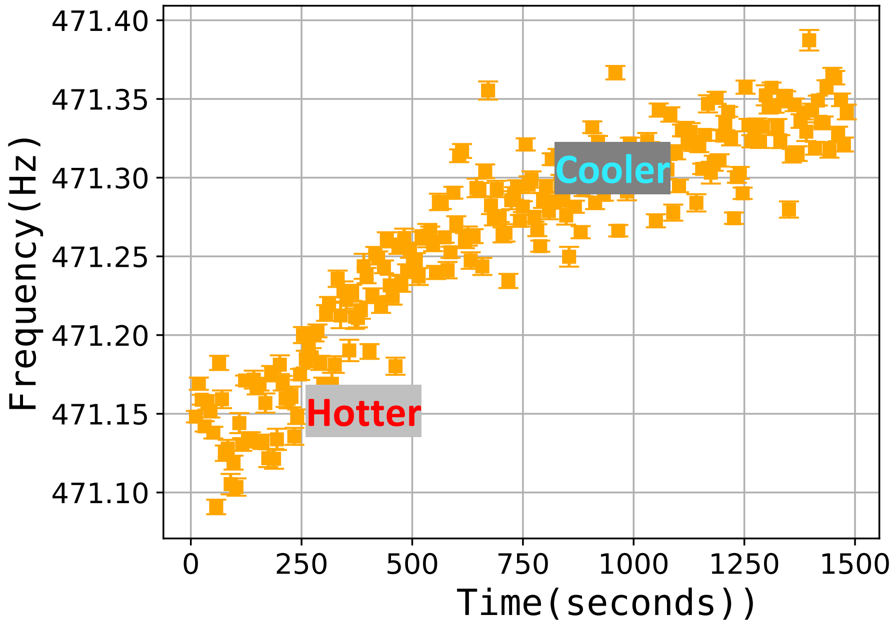
$$\Downarrow$$

$${\omega_\ell}^2 = \frac{\sigma}{\rho {R_0}^3}\ell(\ell-1)(\ell+2)$$

$$\Downarrow$$

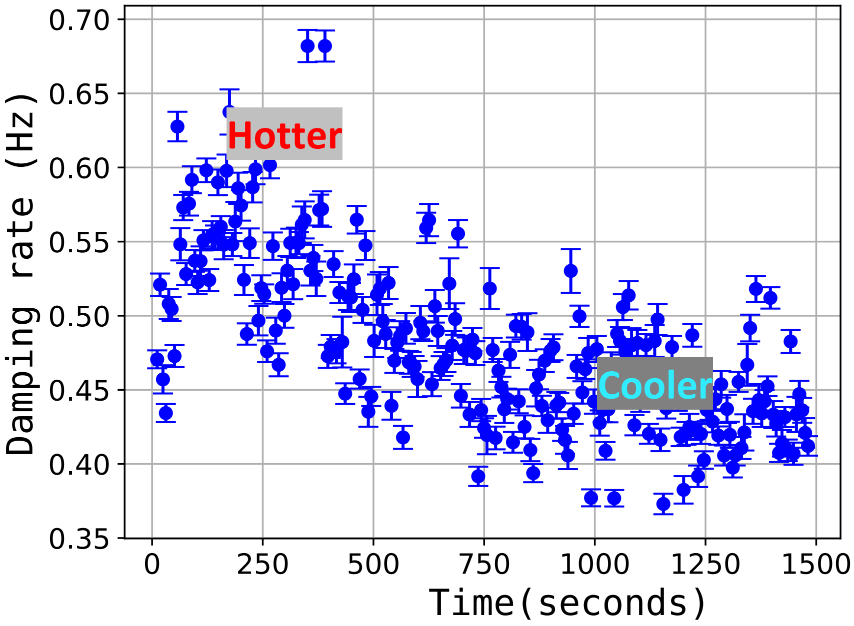
$$\frac{1}{\omega^2} \propto R_0^3$$

Best Fit Values for Frequency

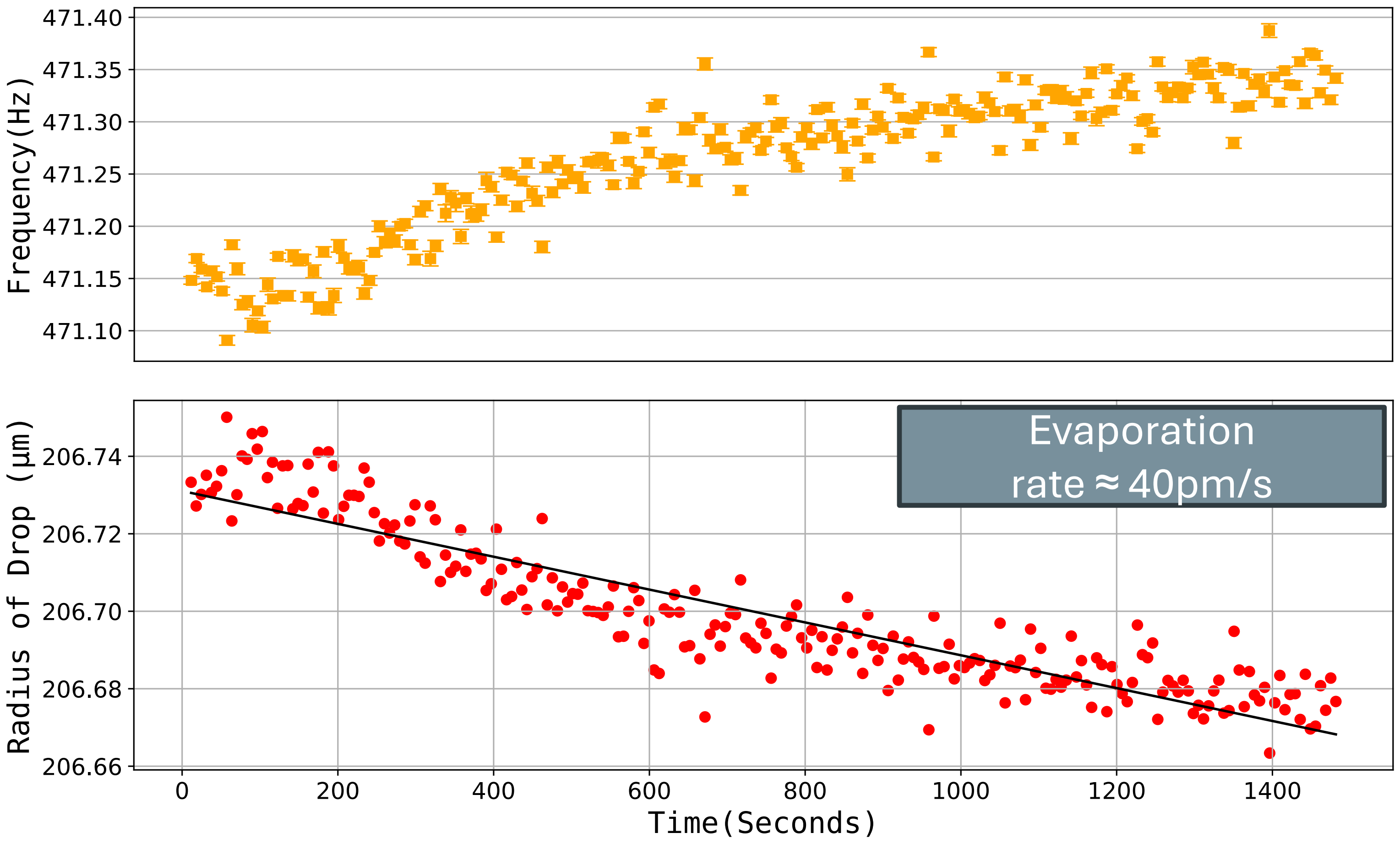


$$\frac{1}{\omega^2} \propto R_0^3$$

Best Fit Values for Damping



Damping Rate ∝ Temperature ^{4}



$$\frac{1}{\omega^2} \propto R_0^3$$

Evaporation Rate of Helium Drop

Acknowledgements

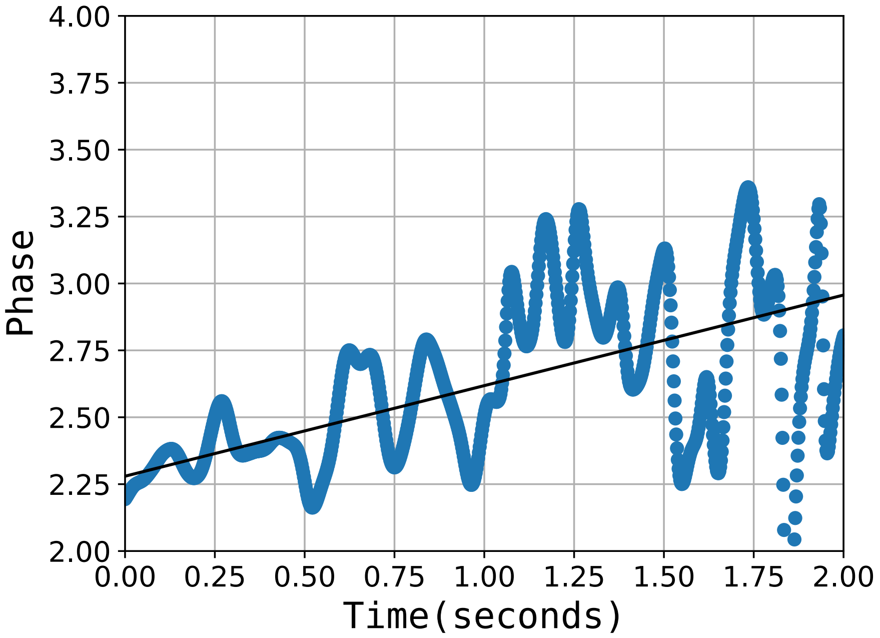
Igor Brandão

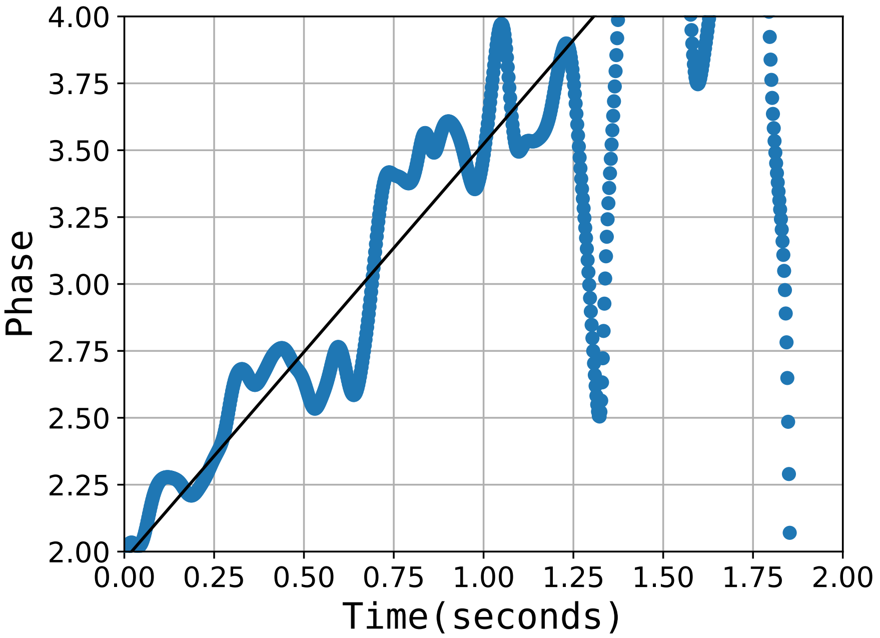
Theophilus Human

Jack Harris

Harris Labs

Phase vs. Time





$$z(\mathrm{t}) = A \cdot e^{i[(\omega_0 - \omega_d) - \frac{\gamma}{2}]t}$$