Modeling the Sympathetic Resonance of a Loaded Chain

Jaromir Luiken, Kellen Overvig, Tin Nguyen, Dr. Andy Rundquist
Department of Physics, Hamline University, Saint Paul, MN 55104

Introduction

Our research was focused on understanding the properties of the helicoseir, or gyrating hanging chain. Despite the seemingly simple properties of rotating a hanging chain to achieve different standing modes, in practice, the exact nature of the modes is still a topic of debate among physicists today. The specific properties we focused on understanding and modeling, involved the tendency for the chain to "pull back" on the motor to fight influences to change states.

Abstract

Our goal was to improve upon the attempts of our peers at Hamline University over the past two years to create a realistic computer model of the helicoseir. Our theory was that the issues of the previous codes that failed to completely match reality, were mostly sourced around issues with the computer modeled motor. We built our code with the purpose to include fluctuations in how the motor performed under stress when spinning the beads. From there we could use this model to predict what the beads in the program would do, and planned to further investigate the helicoseir.

Procedure

With the adjustments to the motor in our code, we ran simulations to compare with the helicoseir being demonstrated in the lab. Our more realistic motor now had a non-constant internal torque with resistance, which caused our code to produce graphics resembling the motor we were using in the lab.

The rest of the code was constructed using functions in *Mathematica* based on the classical model of different forces acting on each of the individual beads. Fig. 3. This allowed us to reproduce behaviors which much more closely resemble those observed in the lab.

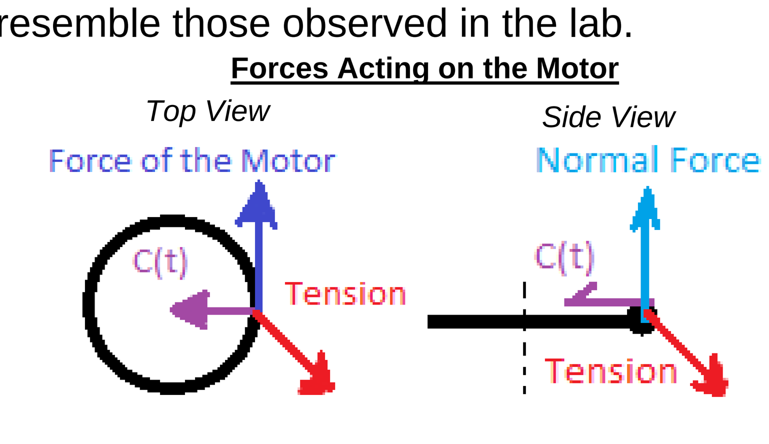


Fig.1 Shown here are the fundamental forces acting on the motor we used to develop the code in *Mathematica*. Our function is represented here as C(t).

Fig.2 This is a Graphic showing *Mathematica* accurately tracking the positions of the beads along side a stable mode 2.

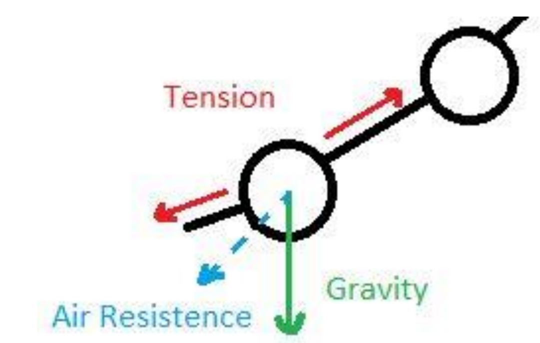
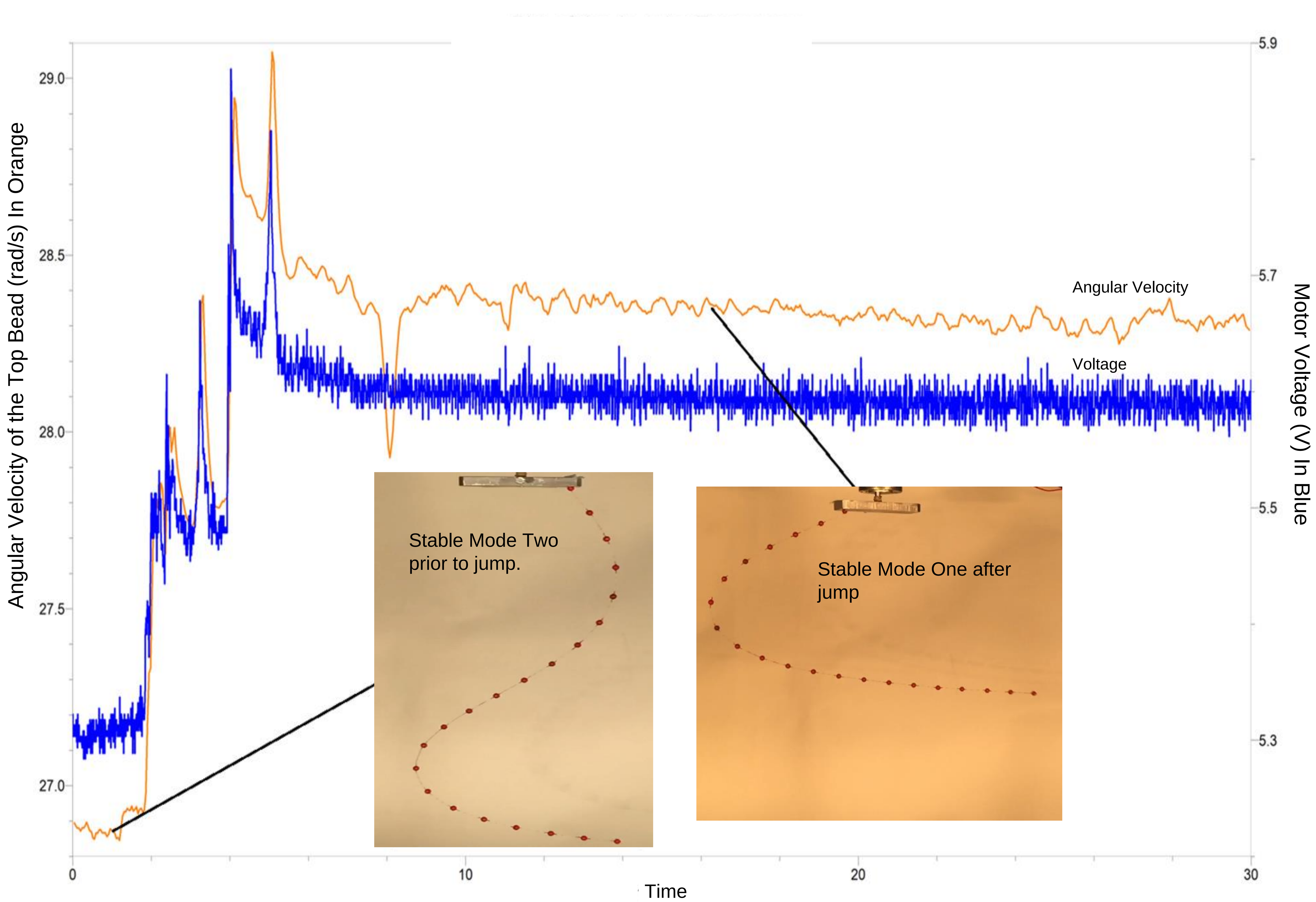


Fig.3 Shown here are the fundamental forces acting on a example bead.

The key in our success with modeling these semi-stable modes, was allowing *Mathematica* to solve for a function which represented the "pull-back" on the motor these beads were exerting. This functions is shown in the free-body diagram in Fig.1. as C(t).

Plot of the Angular Frequency



Graph Interpretation

As shown, the pull of the beads causes the angular frequency to be slowed after the systems initial efforts to maintain a higher velocity are overcome. Despite the increase in voltage seen in the graph, the system fights the influences to increase the angular frequency and settles into a resonant state.

Seen in the Plot of Angular Frequency, it is evident where the motor is experiencing this pull back force. Starting from a stable mode two, the voltage is increased to the threshold which the system should jump to mode one. The system fights this change and violently pulls back on the motor spiking both the measured angular frequency and measured Motor Voltage. Finally, the system jumps to mode one after the period of chaos. **Without modeling the pullback, the simulation doesn't exhibit this behavior.**

Analysis and Results

Our analysis of this force being generated by the pullback of the beads on the system, was that the helicoseir is in fact a sympathetic system. By this we mean that the chain prefers to be in a stable state or in a chaotic one but once there, will fight outside influences to be directed into an alternative state. This phenomena is only clearly modeled when the pull back force is taken into account.

The states that the system could be achieve, resulted from different combinations of outside factors. For example, speeding up the motor slowly vs. quickly would result in different states based on what state the chain was in before a stimulus was provided.

Mathematica Modeled Graphics

Below are examples of modeled systems that *Mathematica* produced using the pull back function we included in the code as well as other alterations. These simulations much more accurately lined up with the demonstrations produced in the lab.

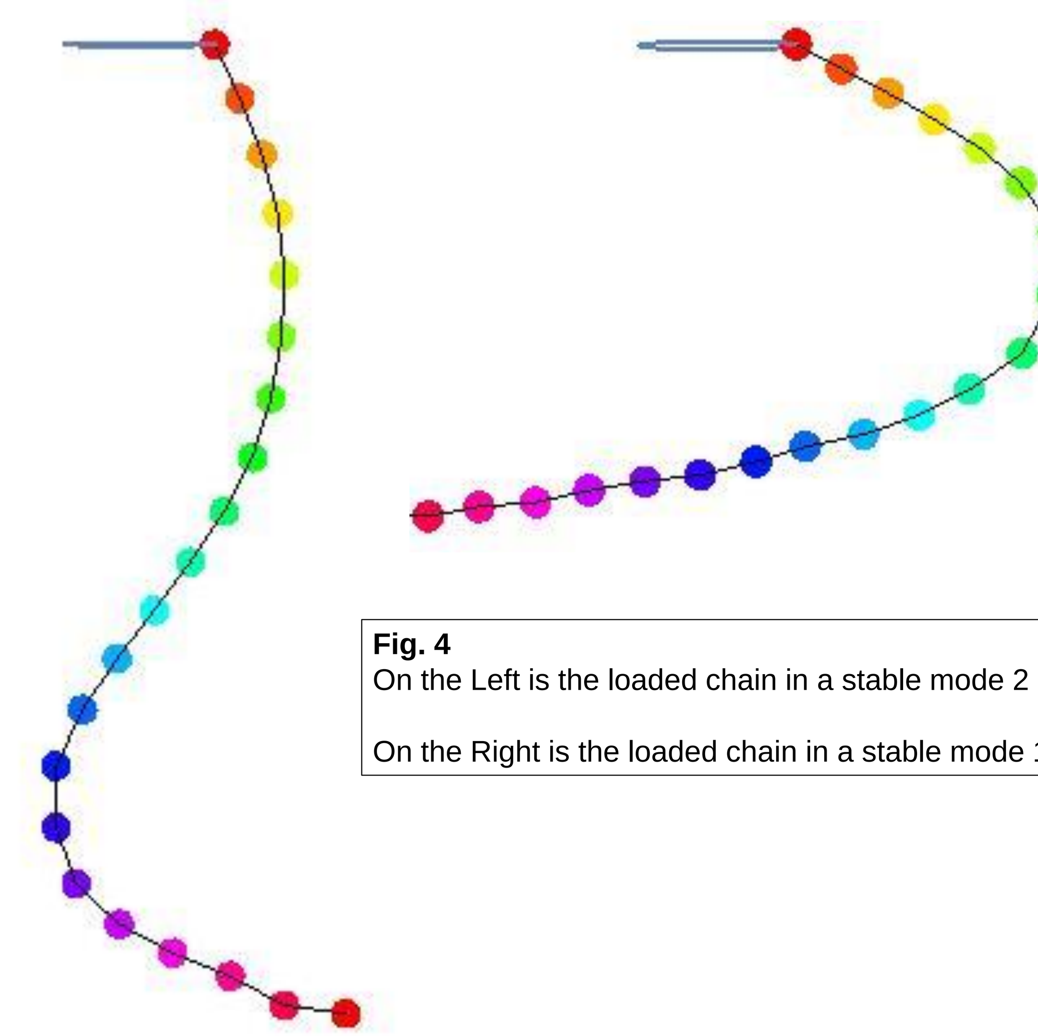


Fig. 4
On the Left is the loaded chain in a stable mode 2
On the Right is the loaded chain in a stable mode 1

Acknowledgements and References

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