Statistics and dynamics of vertically vibrated granular chains

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LUCAS PRATES

Abstract

This experiment ventured to study the statistics and dynamics of vertically vibrated granular chains and consisted of two phases. The first phase studied the opening times of a trefoil knot initially located in the center of the chain. The second phase studied the equilibrium radius of gyration of the chain after the dissipation of transient motion.

In the first phase, I collected 30-60 opening times for each chain length $40 \leq N \leq 140$, with intervals of 20 beads. The data results are in tables 1-12 (pg 7-20), but note that tables 1, 2, and 5 have been discarded due to an inconsistent shaker plate amplitude (pg 21). After ommiting the long tail end times, I found that the mean opening times for each chain length N were given by $\tau_{\text{avg}} \propto (N - N_0)^{\delta}$ with $\delta = 2.01 \pm 0.07$ with $\chi^2_{\text{red}} = 1.04$ and CDF = 38.4% (pg 25-28). I also plotted the empirical survival probability for each chain length data set (pg 23) and verified that they come from the same distribution using the Komogorov Smirnov test (pg 44).

For the second phase, I searched for a relationship between equilibrium radius of gyration and N. I recorded the motion of the vibrating ball chains for $40 \leq N \leq 140$ with a 20 bead interval and also for $N = 50, 55$ (pg 32-34 and 37-38) and computed the radius of gyration at each 2 second interval. For each trial, I plotted the radius of gyration for the last 60 seconds of motion, and plotted the distributions of these radii of gyration, but trials 2, 4, and 8 were discarded (pg 40-41). At equilibrium, the chains tended to form spirals. I found that there were 3 regimes of equilibrium motion (pg 42-43)

- $N < 60$: spirals were unable to form
- $60 < N < 80$: loose spiral formation
- $80 < N < 140$: area filling spiral formation

Due to the complex nature of the equilibrium radius of gyration vs N relationship, more data is required in order find a best fit curve for each regime.