Pulse propagation in heterogeneous granular media

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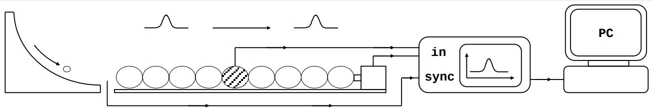
Experimental study of impulse propagation in 1D heterogeneous and unconstrained granular media.



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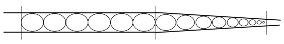
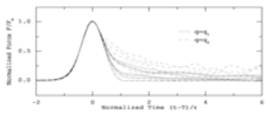
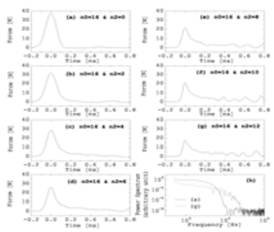
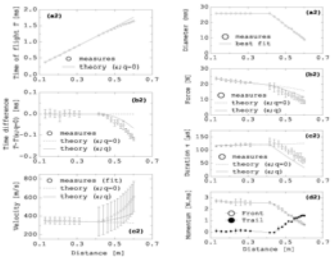


- We have studied here a granular chain whose bead diameters decrease exponentially (namely a tapered chain).
- The pulse is relatively similar to the one that would propagate in a monodisperse chain, and follow same scaling laws. We have shown that the front of the impulse adopts a self-similar form. However, a train of wave is formed behind the front wave as it propagates down the chain.
- In comparison to a monodisperse chain, an additional dispersion process breaks the spatial compactness of the solitary wave solution, and modifications of the nonlinearity of the medium tighten the front pulse. Thess processes broaden the pulse and transfer a part of the energy to higher frequencies of the spectrum. As a consequence, the maximal strain reaching the end of the chain is diminished.







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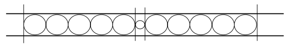
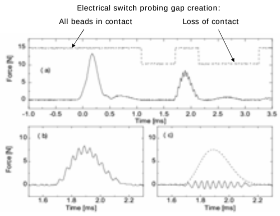
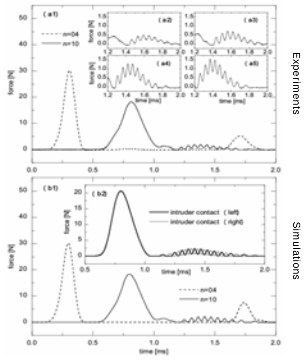
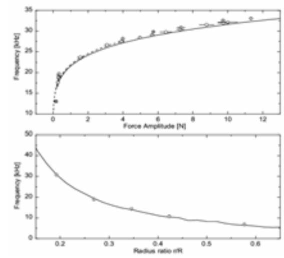


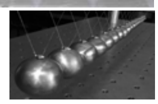
- This configuration corresponds to a monodisperse chain of beads containing a smaller intruder. The case of a lighter intruder (but same dimensions) has been previously addressed, through numerical simulations, by Hascoët and Herrmann. Similar systems, concerning wave propagation in atomic lattices with nonlinear potential interaction with single or more impurities have also been widely studied in solid-state physics (e.g. see Li *et al*).
- When a solitary wave, or a pulse, reaches the intruder, we observe a spatial localization of a part of the incident energy: the intruder starts to oscillates, and this oscillations remains localized at the intruder position.
- In parallel to experiments, we have developed a numerical simulation code, showing a precise agreement. Finally, a dimensional analysis allow us to correlates the oscillation frequency to the characteristic of the chain and of the incident wave.
- We demonstrates that the localization of the energy is strongly related to the opening of a gap between the intruder and its nearest neighbors.



$$f_m \approx \frac{\sqrt{3}}{2\pi}\frac{\kappa^{1/3}F_m^{1/6}}{m^{1/2}} \propto \left(\frac{r}{R}\right)^{-4/3}\left(1+\frac{r}{R}\right)^{-1/6} F_m^{1/6}$$







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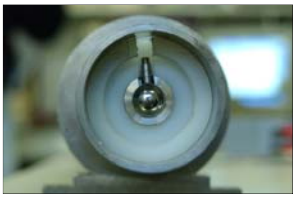
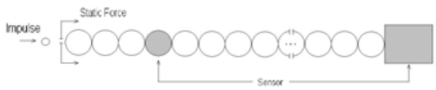
Future Work ...

Chain system under static load, controlled by an imposed constant force applied on the first bead of the chain. The effect on the propagation of compression waves is observed.



Front view of the bead sensor placed inside the ring holder.



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