Stability of cylindrical magnets chains

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An arrangement of several spherical or cylindrical magnets presents different stable configurations. One of them is the straight chain, whose dynamics is studied in the present work. This structure behaves similarly to a beam, but here the rigidity is exclusively due to magnetic forces. Using calculations or numerical computations of the magnetic energy interaction between elements of the chain, we look for equilibrium configurations of the chain and analyse their stability. Using Lagrange's formalism we also develop dynamical models of these systems. Influence of external gravity or magnetic fields on the stability is also analysed [1, 2]. As an example, figure 1 shows the a stable chain of 10 elements clamped vertically and an unstable chain of 11 elements, buckling under its own weight.

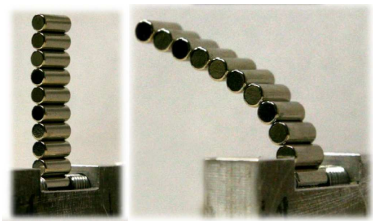

Figure 1: Buckling of a chain of magnets under its own weigth

A particular attention is also paid to the shape and aspect ratios of the elements. They have been shown to influence the stability of the chain. In figure 2, the energy of a three cylinders chain is represented. The cylinders of height H and radius R are only allowed to roll (no sliding), so that the system is parameterized by two angles. The figure displays a change in the stability of straight chain equilibium ($\varphi_1 = 0$ and $\varphi_2 = 0$) when the aspect ratio $\lambda = R/H$ of the cylinders is varied between 0 and 1.

Ongoing work is focused on the nonlinear dynamics of these systems and their potential use for nonlinear vibration control.

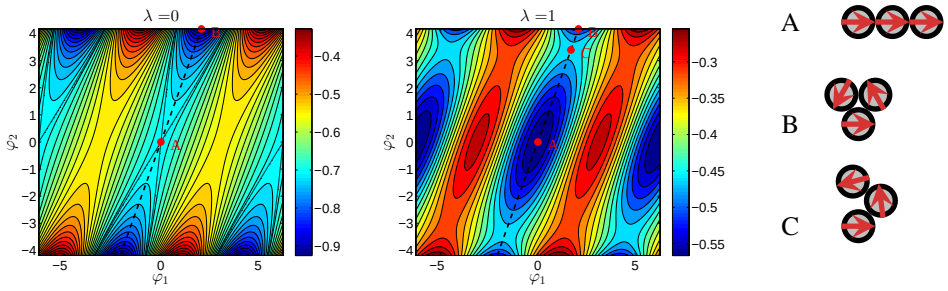

Figure 2: Contour map of the magnetic energy of a three cylinders chain whose first element is clamped, for two cases of the aspect ratio λ. The problem is parametrized by the orientations φ_1 and φ_2 of the second and third cylinders. Equilibium configurations identified by red dots on the maps are sketched on the right.

References

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[2] Schönke, J., & Fried, E. (2017). Stability of vertical magnetic chains. In Proc. R. Soc. A (Vol. 473, No. 2198, p. 20160703).