Canceling the elastic Poynting effect with geometry

Valentina Balbi
(vbalbi@universityofgalway.ie)

School of Mathematical and Statistical Sciences,
University of Galway,
Galway, Ireland

The Poynting effect is a paragon of nonlinear soft matter mechanics. It is the tendency (found in all incompressible, isotropic, hyperelastic solids) exhibited by a soft block to expand vertically when sheared horizontally. It can be observed whenever the length of the cuboid is at least four times its thickness. In this study, we show that the Poynting effect can be easily reversed and the cuboid can shrink vertically, simply by reducing this aspect ratio. In principle, this discovery means that for a given solid, say one used as a seismic wave absorber under a building, an optimal ratio exists where vertical displacements and vibrations can be completely eliminated. In this talk, I will first recall the classical theoretical treatment of the positive Poynting effect, and then show experimentally how it can be reversed. With the help of finite-element simulations, I will demonstrate how the effect can be suppressed. Our results indicate that cubes always provide a reverse Poynting effect, irrespective of their material properties (in the third-order theory of weakly nonlinear elasticity).

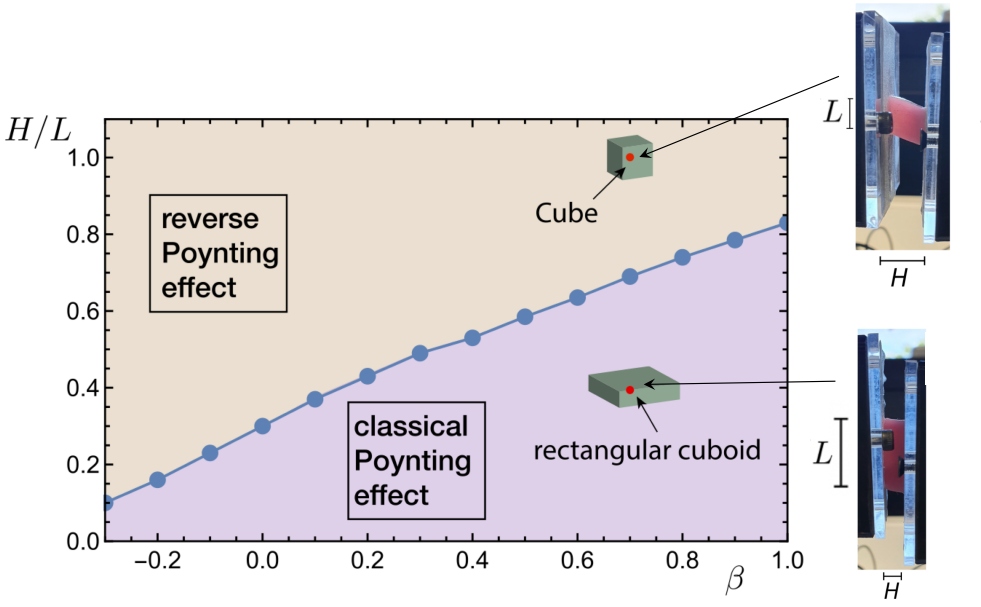

Figure 1: Diagram showing how geometry can reverse the Poynting effect in rectangular cuboids with a Mooney-Rivlin material behaviour. Here H and L are the height and length of the cuboid, respectively. β is linked to the Mooney Rivlin parameters $C_1 = \mu(1-\beta)/2$ and $C_2 = \mu(1+\beta)/2$ and can span between $[-1, 1]$.

References

[1] Destrade M, Du Y, Blackwell J, Colgan N, & Balbi V. (2023). Canceling the elastic Poynting effect with geometry. Physical Review E, 107(5), L053001.