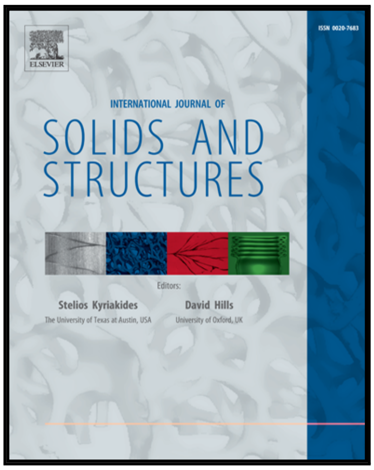
Accepted Manuscript



Magnetic field induced deformation and buckling of slender bodies

R.P. Singh, P.R. Onck

PII: S0020-7683(18)30084-2
DOI: 10.1016/j.ijsolstr.2018.02.029
Reference: SAS 9917

To appear in: *International Journal of Solids and Structures*

Received date: 21 July 2017
Revised date: 5 February 2018
Accepted date: 19 February 2018

Please cite this article as: R.P. Singh, P.R. Onck, Magnetic field induced deformation and buckling of slender bodies, *International Journal of Solids and Structures* (2018), doi: 10.1016/j.ijsolstr.2018.02.029

Magnetic field induced deformation and buckling of slender bodies

R.P. Singh, P.R. Onck*

Micromechanics of Materials, Zernike Institute for Advanced Materials, University of Groningen, 9747 AG Groningen, The Netherlands

Abstract

Magneto-responsive slender bodies are used in a range of promising applications, such as artificial cilia, magnetic fiber networks and cellular actuators. To accurately describe the magneto-elastic deformations, both the demagnetization field as well as the resulting magnetic loads on the body should be properly accounted for. The calculation of the demagnetization field for a general sample shape is very challenging, which has hampered the experimental characterization of the intrinsic magnetic and magnetoelastic properties. Here, a methodology is developed to accurately calculate the demagnetization field for slender bodies, i.e., for long beams having a rectangular or circular cross-section. We propose two different expressions for the magnetic load on slender bodies. To validate the two expressions, we solve the magnetic buckling problem for cantilever beams using an analytical approach for small deflections. We compare the critical buckling fields with an energy approach and with experimental results from three different studies. The load and energy methods were found to be similar and to correspond very well with the experimental data. To also validate our slender body approach (i.e., demagnetization field calculation and magnetic load expression) for large deflections, we analytically solve for the large (postbuckling) rotational deformation of slender beams. To do so, we formulated a weak form of the governing equations using a variational approach, which can be readily solved using

*Corresponding author
Email address: `p.r.onckrug.nl` (P.R. Onck)