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Numerical investigation on the vibration of inflated space structure

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Summary

A space inflatable structure typically consists of one or more tubular elements that are made of membrane materials, such as polyimide films or woven fabric materials. When not pressurized, these highly flexible booms can be folded up or rolled up and stowed in a very small volume for launch. In space, the booms are pressurized and deployed by cold gas to achieve design configuration of the structure. Due to its low storage volume, mass and cost inflatable structures technology can be used for future large space flight systems, such as solar arrays, telescope reflectors, sunshields, solar concentrators, and radar antennas. In order to investigate the dynamic behavior of these inflatable structures, the 3-D membrane finite element is employed in modeling the inflated cylindrical strut. The modal analysis shows that the phenomenon of wrinkling occurs at lower pressure, where as the beam-type deformations occur at higher pressure. It is also found that the natural frequency corresponding to the beam-type mode shape keeps constant when the internal pressure increases. Further theoretical investigation on the relationship between stiffness of global bending and the internal pressure for the inflatable thin-wall beam provides support to the numerical results. Two model types, the 3-D membrane element and beam element of the strut are then applied to the inflatable antennas structure separately, where it is found that the membrane model captures more of the dynamic subtleties of the system than the beam model, but that both types of model can provide similar global information on the bending behavior of the structure.