FY25 Strategic University Research Partnership (SURP)

Advancing Multifunctional and Deployable Space Structures through Topology-Optimized, Origami-Inspired Design

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Figure 1. Habitable Worlds Observatory (HWO) concept
Credit: NASA Goddard / Conceptual Image Labs.
Adapted from https://science.nasa.gov/astrophysics/programs/habitable-worlds-observatory/

Background

Deployable shrouds are critical elements of space telescope architectures; they must (1) shield against micrometeoroids, (2) ensure thermal stability of the telescope, (3) reduce stray light, (4) stow in a volume compatible with launch, and (5) deploy to the desired shape without any detriment to the telescope.

An approach would be to use tensioned membranes, akin to the James Webb Space Telescope (JWST) sunshield. However, JWST's development highlighted challenges with tensioned membranes: (1) Expensive ground testing, due to large size, high compliance, and high-touch labor, and (2) Difficulty with computational modeling, given the high structural compliance, which forces all development and testing to be done in hardware.

Approach

We desire solutions that (1) are stiff throughout deployment, (2) have deterministic stowed states, (3) can be gravity offloaded, and (4) have predictable deployment.

We consider nesting known origami patterns developed on cylindrical surfaces, e.g., Kresling, Yoshimura. Instead of membranes, we use thin shells made of fiber-reinforced composite materials to construct the deployable shrouds. Unlike tensioned membranes, these materials have inherent bending stiffness. We envision thin-shell collapsible spacers between the layers to enforce separation.

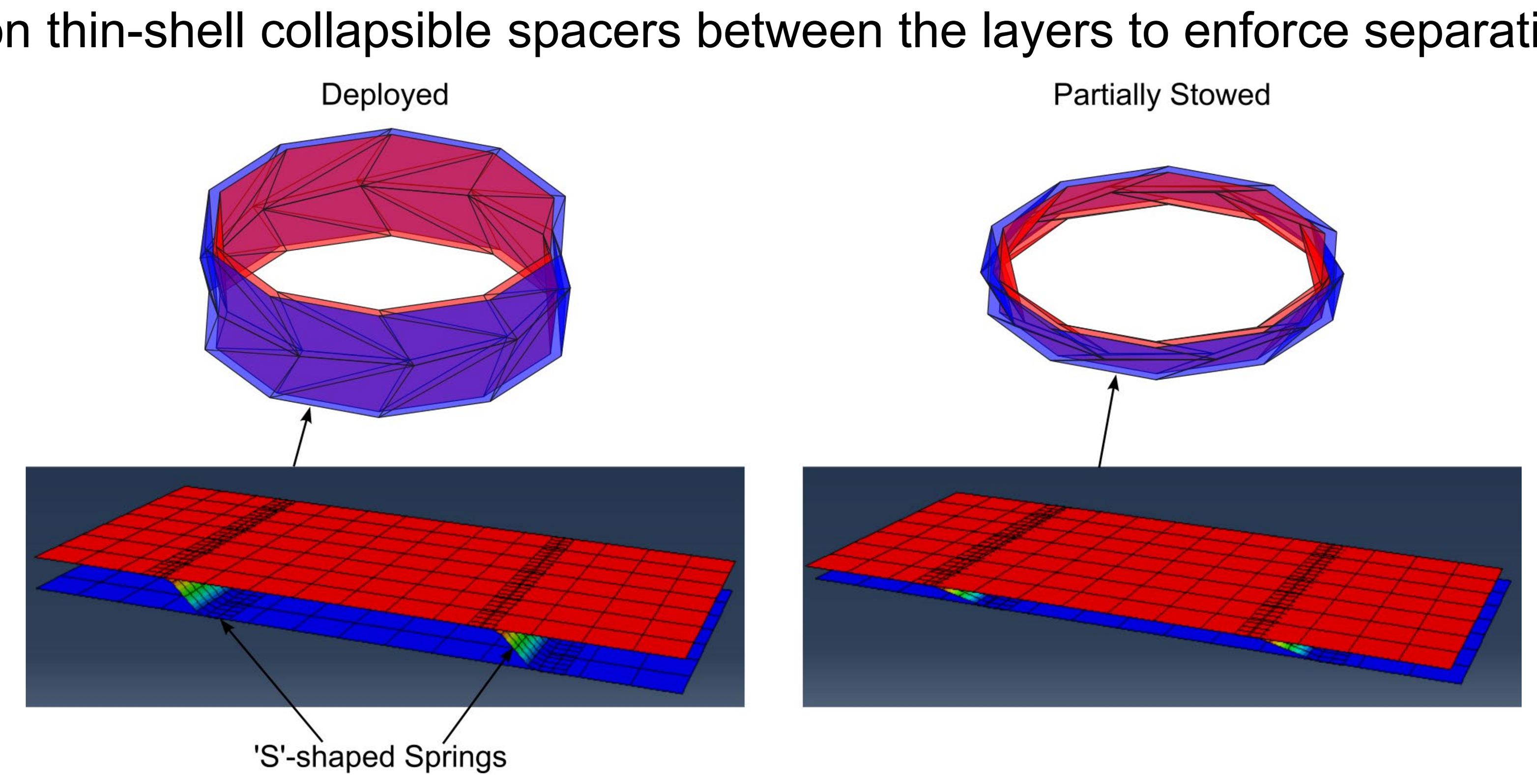

Figure 5. 'S'-shaped springs, made of thin fiber-reinforced composite material, attach the inner layer faces to the outer layer faces. These springs flatten elastically during stowage. The near-parallelism of the faces ensures that the springs are minimally strained. Finite-element simulations in Abaqus are shown.

Objectives:

1. Create an optimized design for the Habitable Worlds Observatory (HWO) micrometeoroid/thermal shroud/baffle using topology optimization and origami techniques, backed by rigorous numerical models & lab testing,
2. Develop methodologies and tools with wide applicability to deployable space structures.

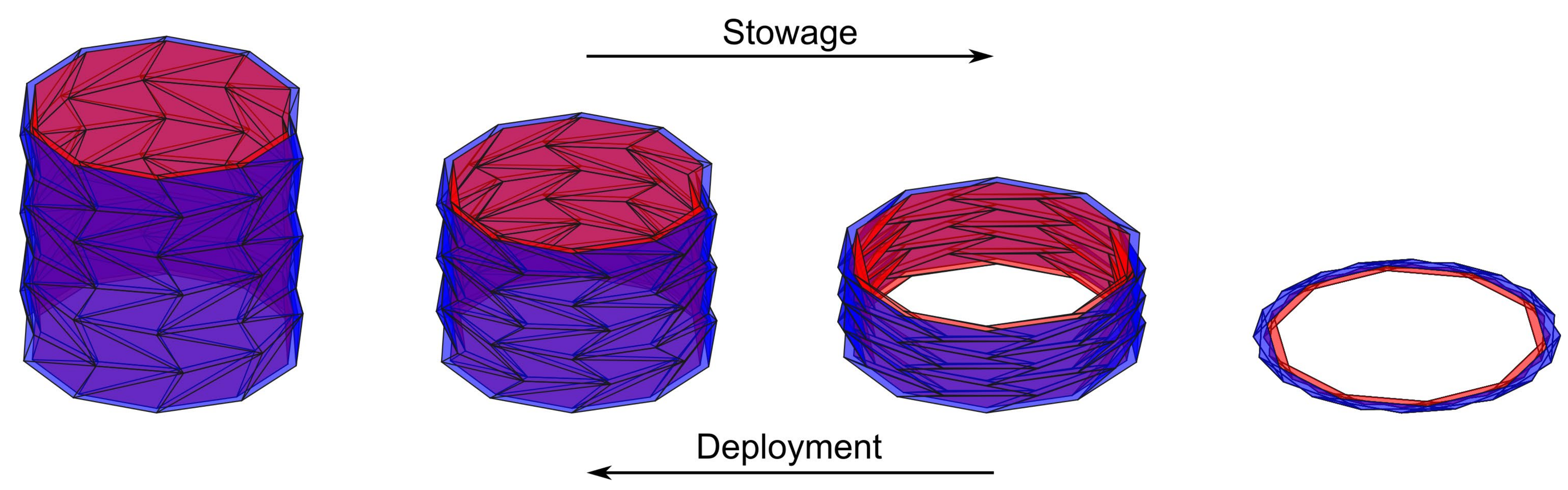

Figure 2. Concept of co-stowage of a two-layer thermal shroud using a nested Kresling origami tube. The inner layer (red) and outer layer (blue) co-fold into a flat configuration (right). The structure is light-tight throughout.

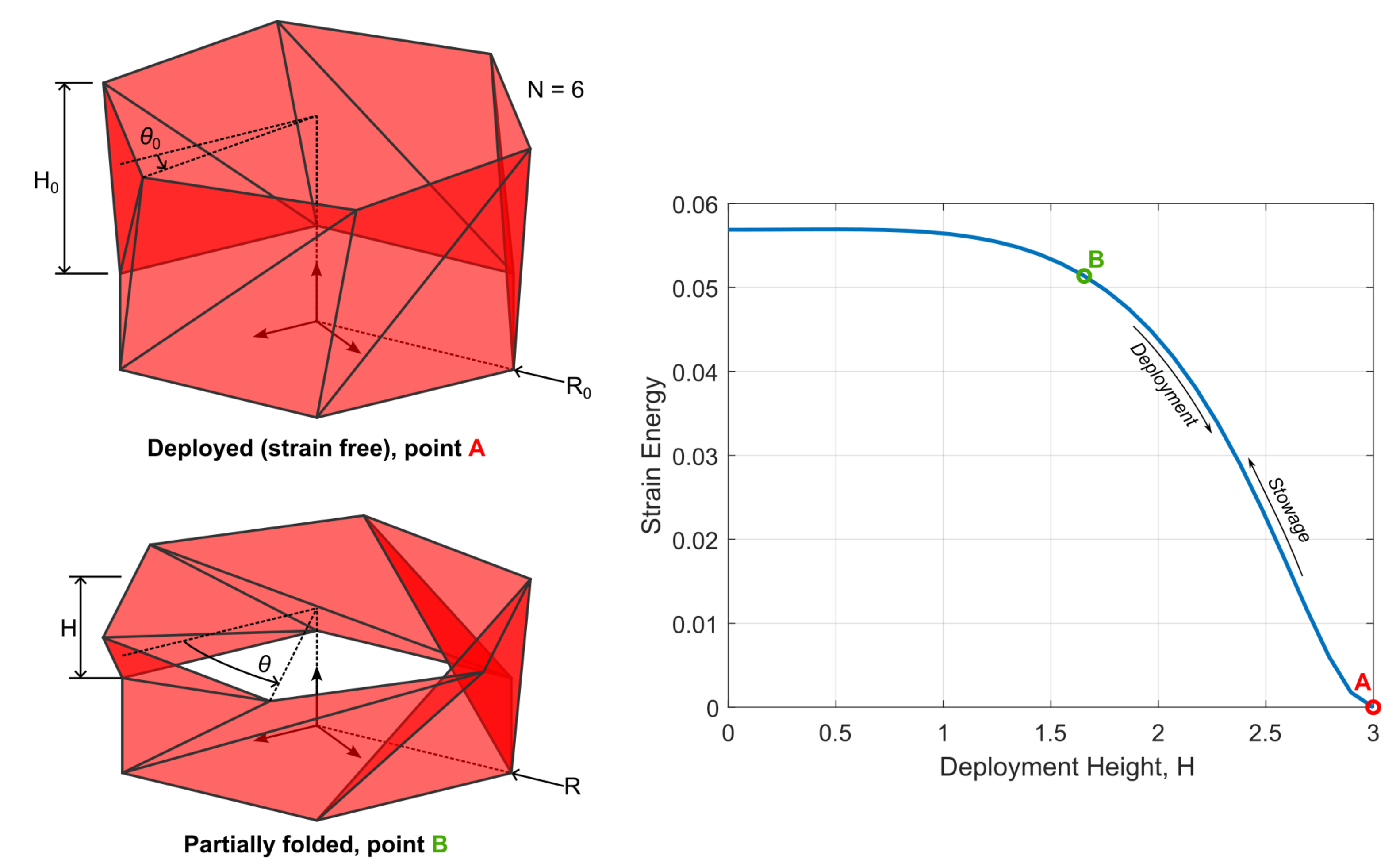

Figure 3. A single "storey" of a Kresling tube, defined by 4 parameters: number of polygon sides N, height H, radius R, and relative rotation θ. We simulate folding by enforcing a folded height H, & finding R and θ that minimize internal strain energy.

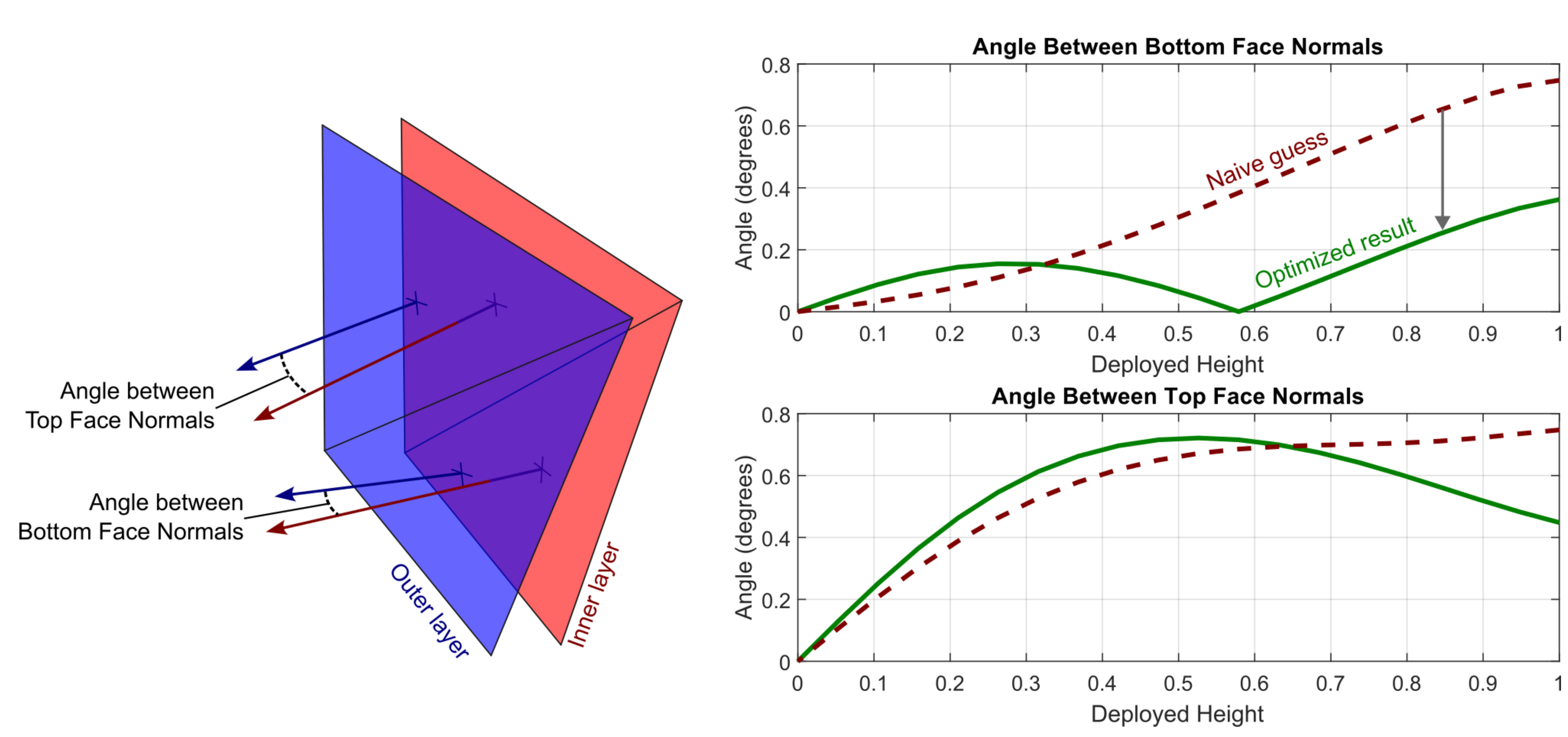

Figure 4. By varying geometrical parameters, we optimize inner and outer Kresling geometries such that the faces (both top and bottom) of the unit cells of the inner and outer Kresling pattern (left) remain close-to-parallel throughout.

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Publications:

Connie Liou, Manan Arya, Serena Ferraro, "Deployable Multilayer Origami-inspired Telescope Shrouds", submitted to *AIAA SciTech Forum, 2026,* Orlando, FL, January 2026.

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