Fourth European Workshop on Inflatable Space Structures
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Geometrical Mechanics for Inflatable Structures
(Geometric Structural Mechanics)

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Contents

- Geometry and tension
- Reducing tension
- Unidirectional tension
- Some new ideas

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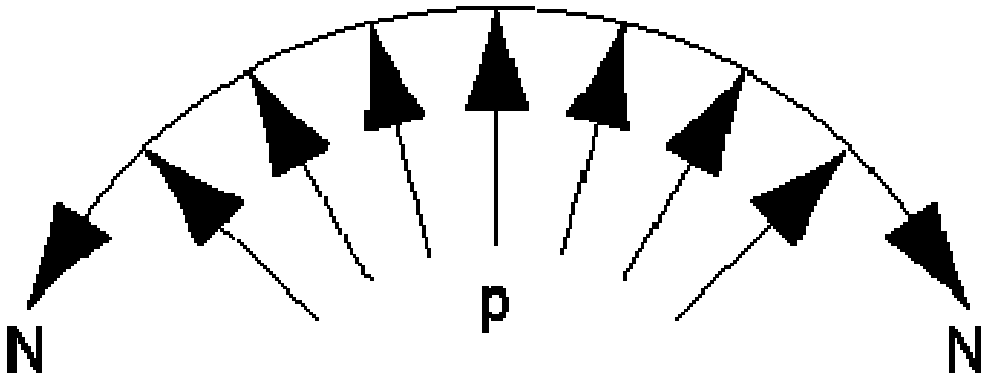
Equilibrium of Inflated Structures



$$N = pr$$

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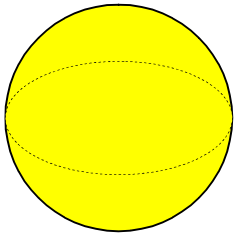
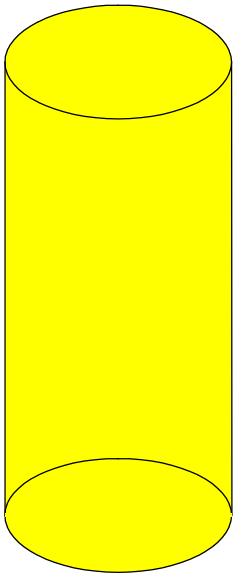
Sphere and Cylinder



$$\sigma_{sphere} = \frac{pr}{2t}$$

$$\sigma_{cyl,hoop} = \frac{pr}{t}$$

$$\sigma_{cyl,long} = \frac{pr}{2t}$$



maximum cylinder stress = 2 x maximum sphere stress

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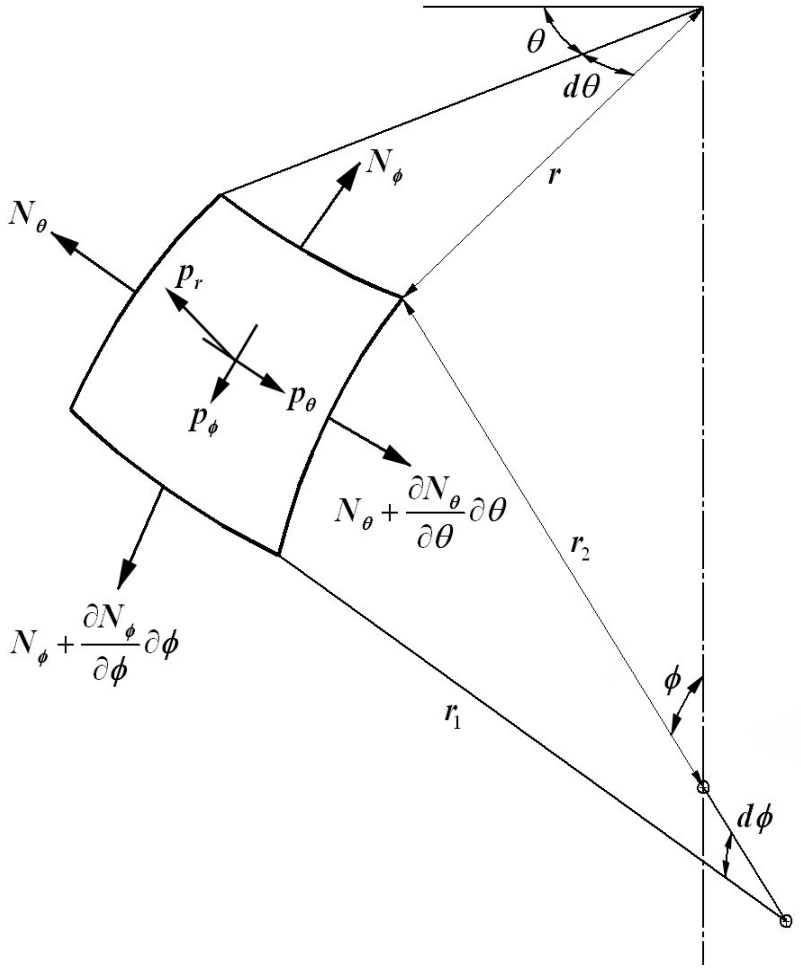
Generalised Membrane Surface



$$\frac{N_\phi}{r_1} + \frac{N_\theta}{r_2} = p$$

(see Flügge 1962 for detail)

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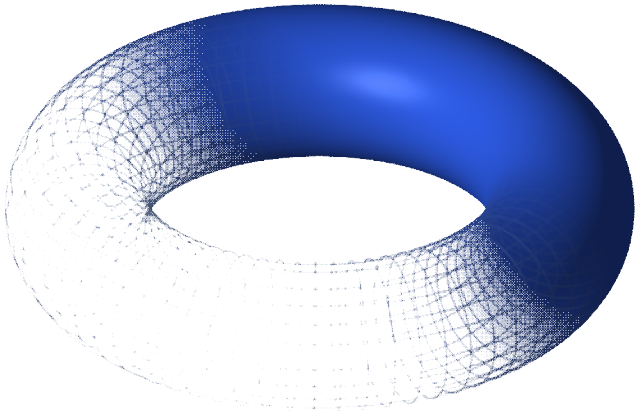
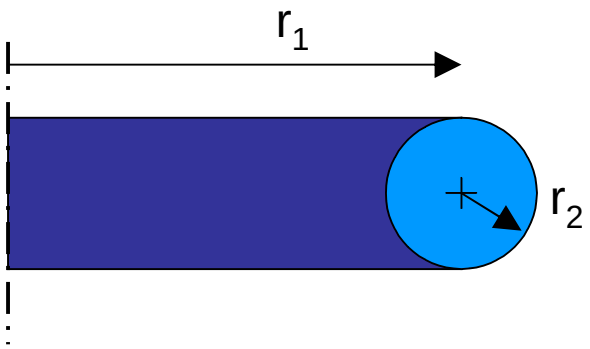
Stress in Inflated Torus





$$\sigma_{\max} = \frac{pr_2}{2t} \cdot \frac{2r_1 - r_2}{r_1 - r_2}$$

$$r_1 \to \infty \quad \therefore \quad \frac{2r_1 - r_2}{r_1 - r_2} \to 2$$

$$\sigma_{\max} \to \frac{pr_2}{t}$$

(see “Roark’s Formulas for Stress and Strain” for detail)

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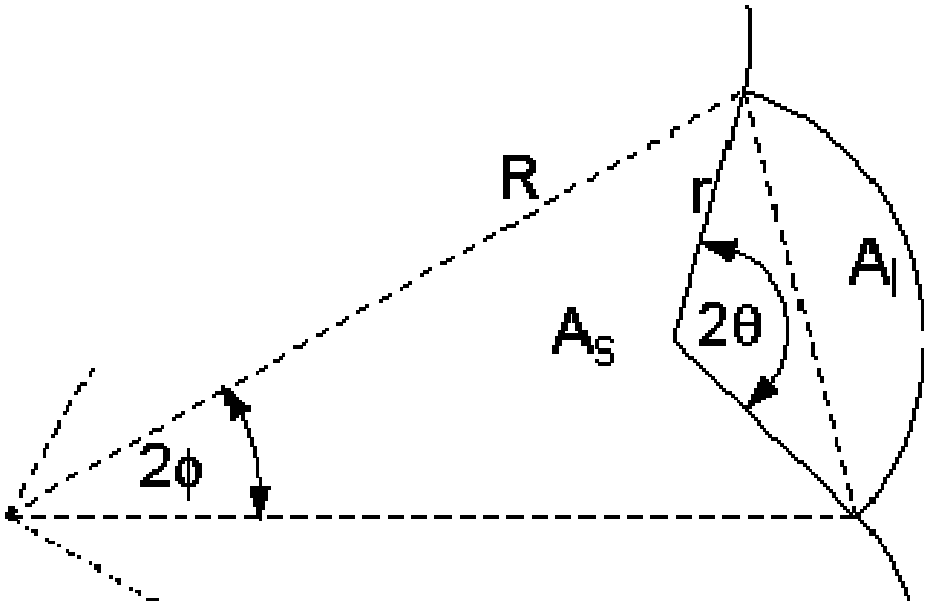
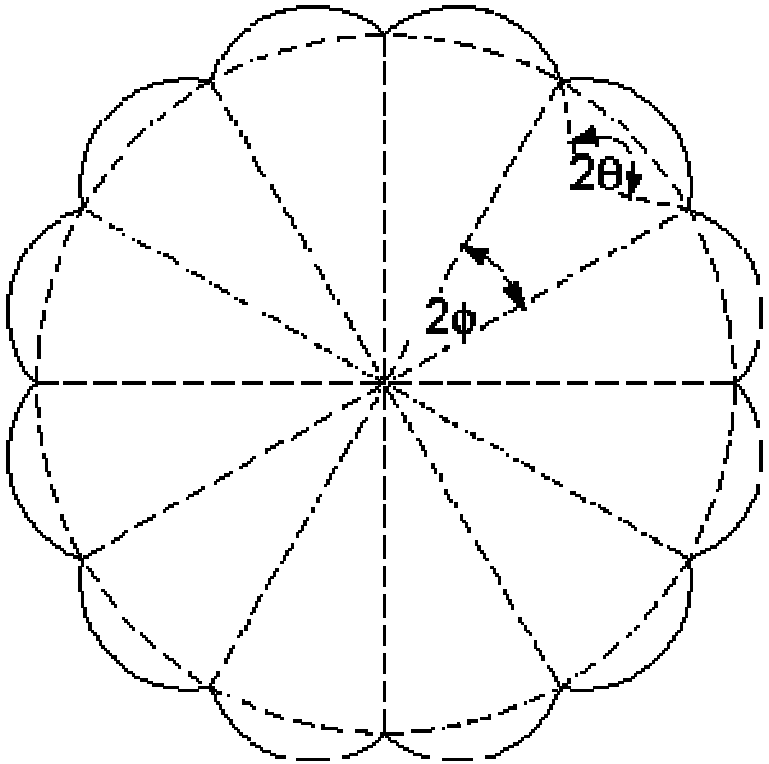
Lobed Structure

$$N = pr$$





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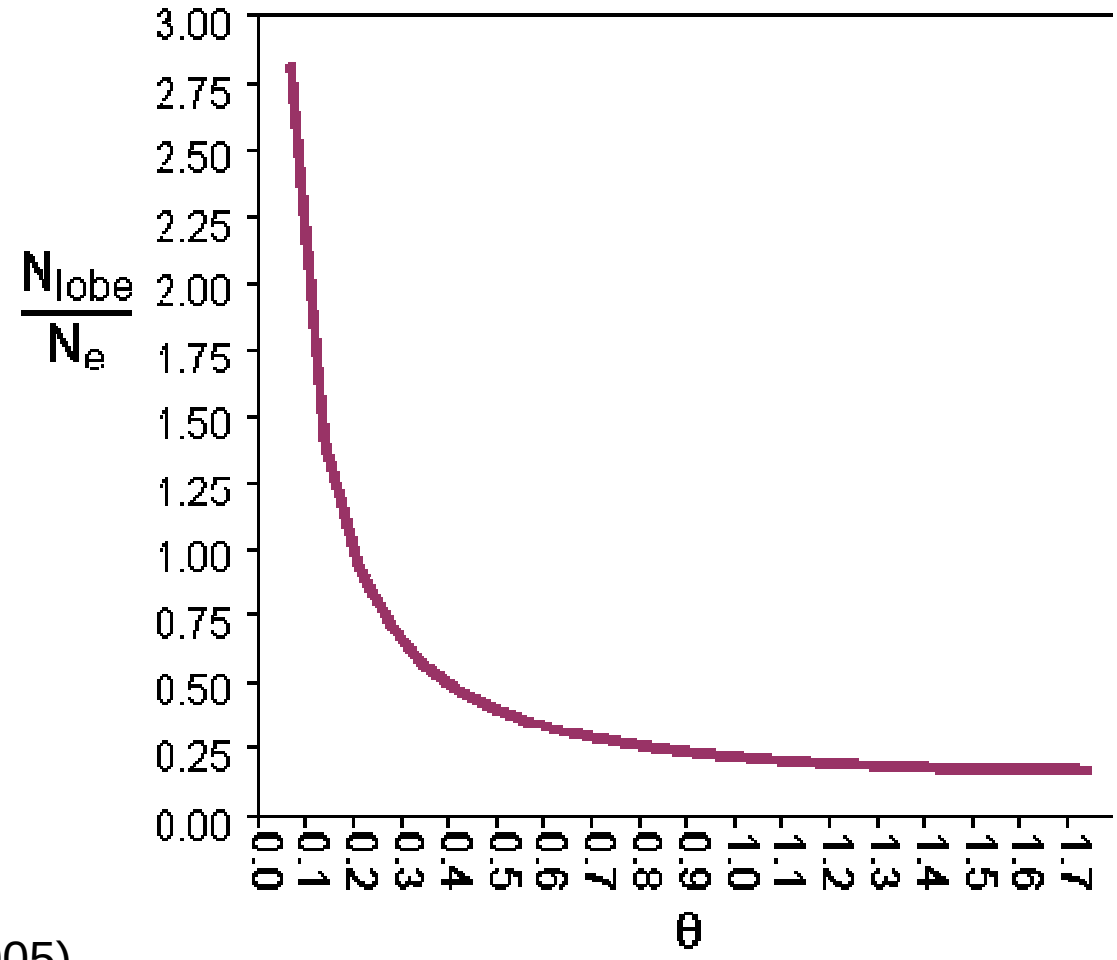
Lobed Structure

$$\frac{N_{lobe}}{N_e} = \frac{r}{R_e}$$



(see Lennon & Pellegrino 2005)

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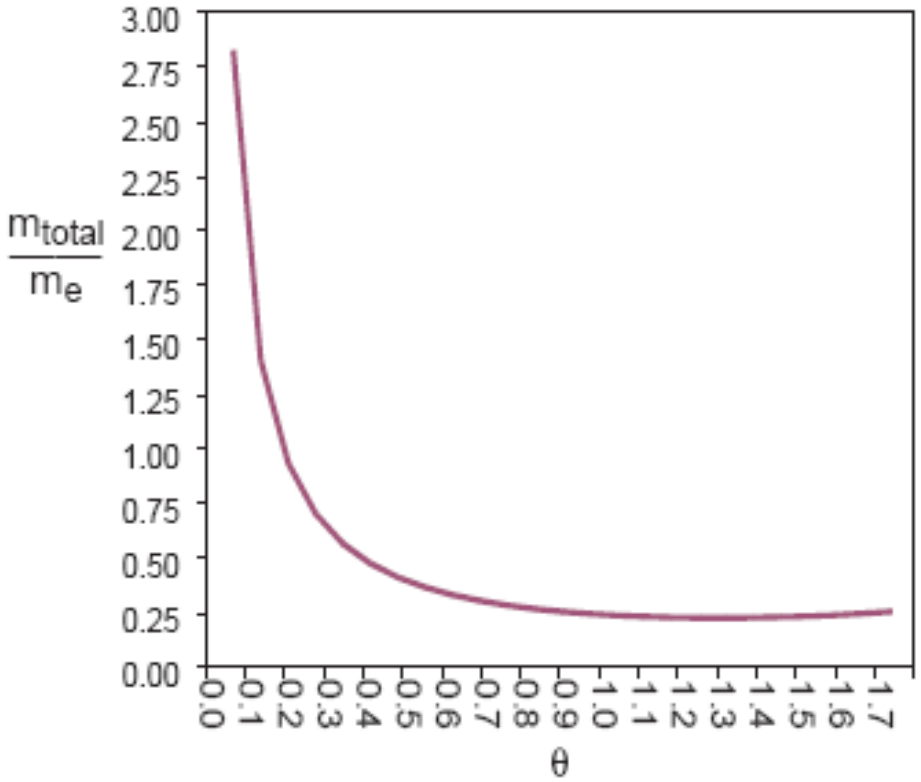
Lobed Structure

$$\frac{m_{total}}{m_e} = \left(\frac{n\theta}{\pi}\right)\left(\frac{R}{R_e^2}\right)\left(\frac{\sin\left(\pi/n\right)}{\sin\theta}\right)$$

mass reduction due to use of lobes to give equal stress to equivalent circle (for n=16)



(see Lennon & Pellegrino 2005)

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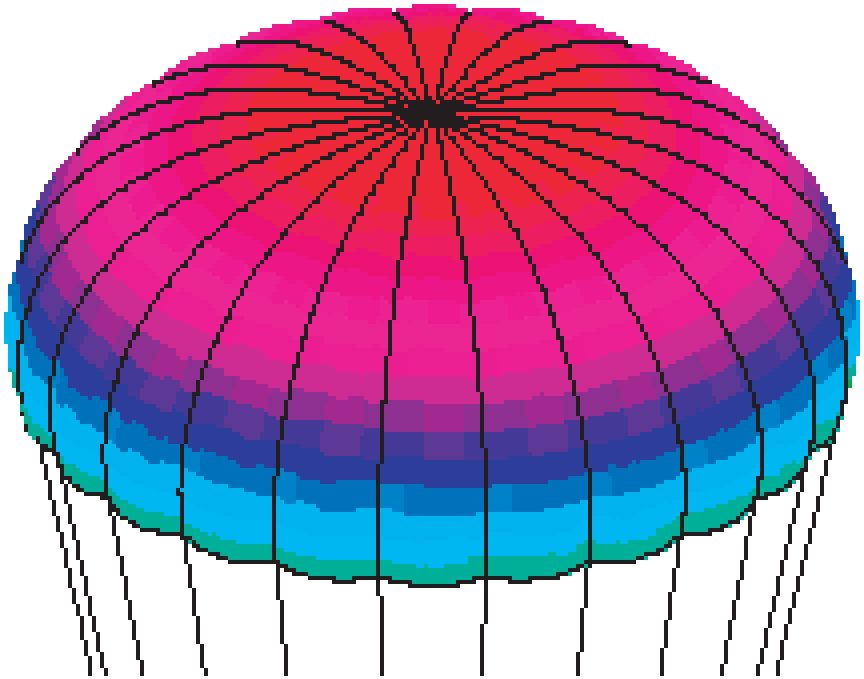
Unidirectional Tension



(see Taylor 1919 in Batchelor 1963)

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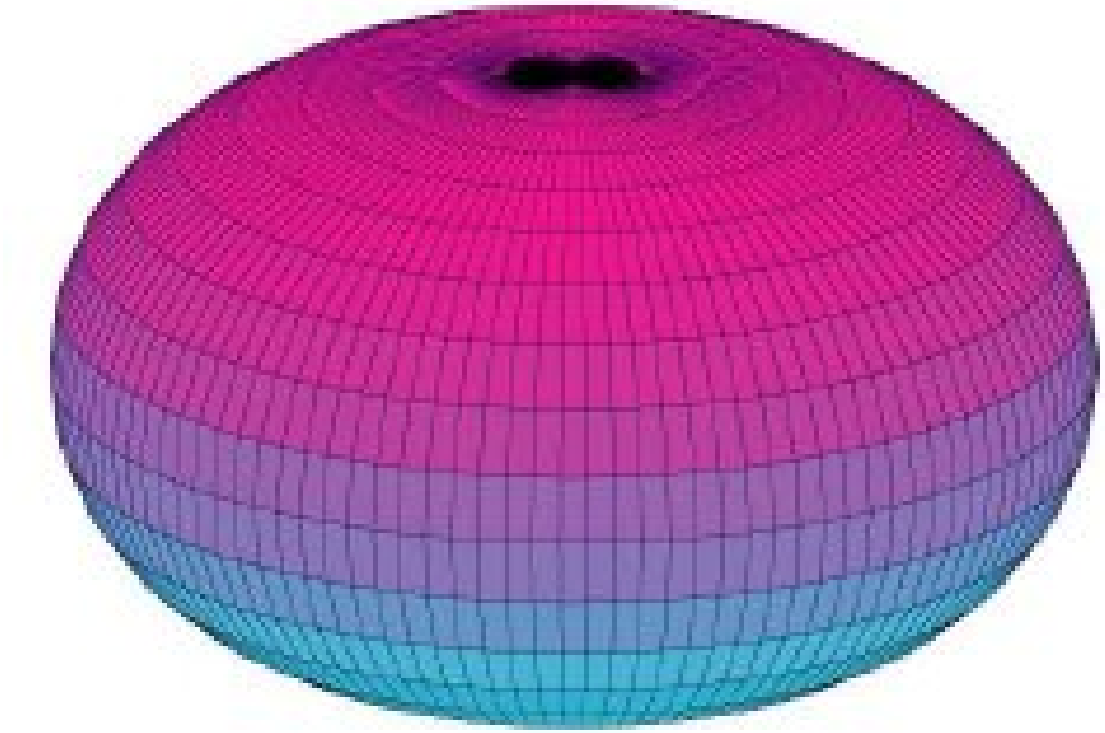
Unidirectional Tension



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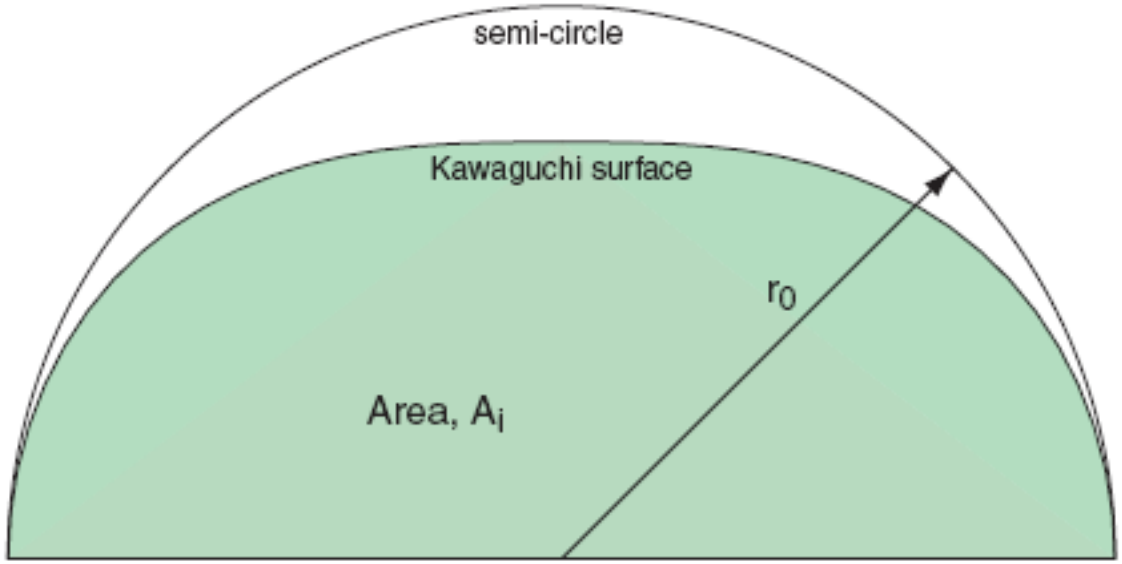
Shallowest Possible Dome



(see Kawaguchi 1977)

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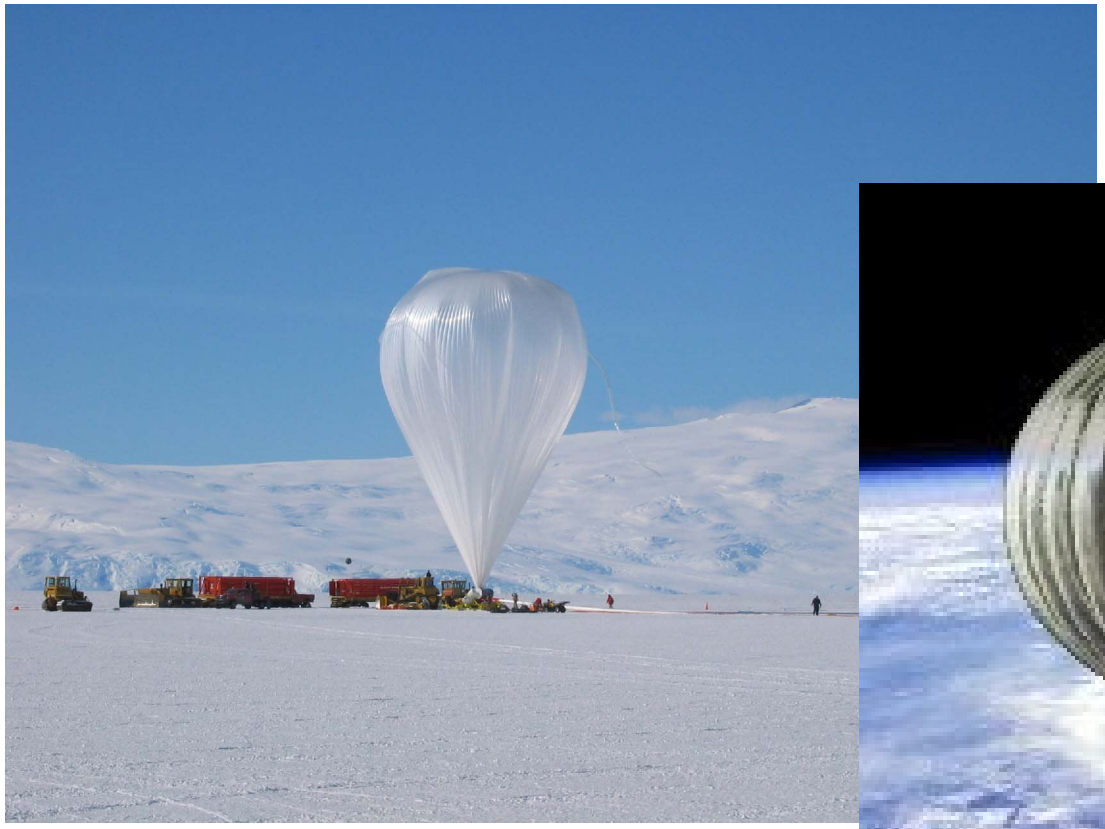
Scientific “Pumpkin” Balloons



(images from NASA)

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A Note on Folds and Wrinkles

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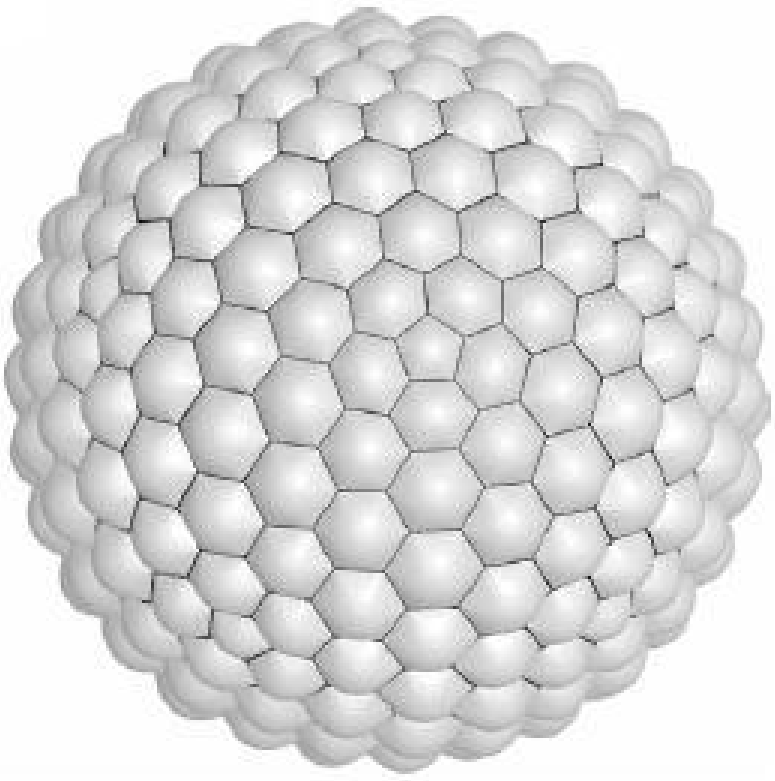
New Ideas



(see Pagitz 2007)

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Conclusions

- Geometry has a significant effect on tension
- Manipulation of geometry can reduce tension
- Need to remember difficulty of construction
- More work to be done on geometry

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