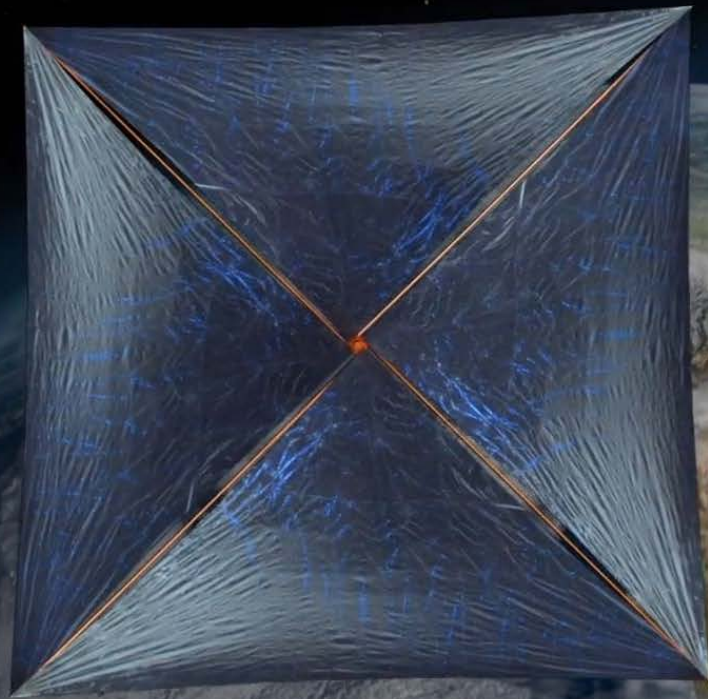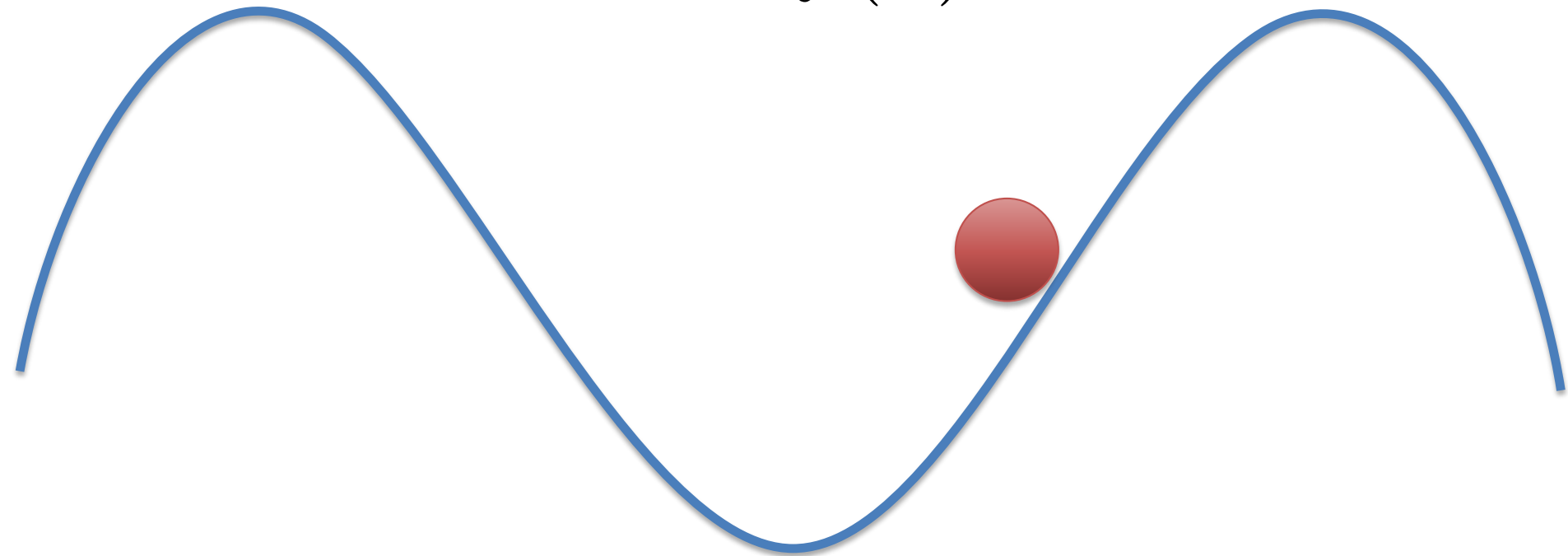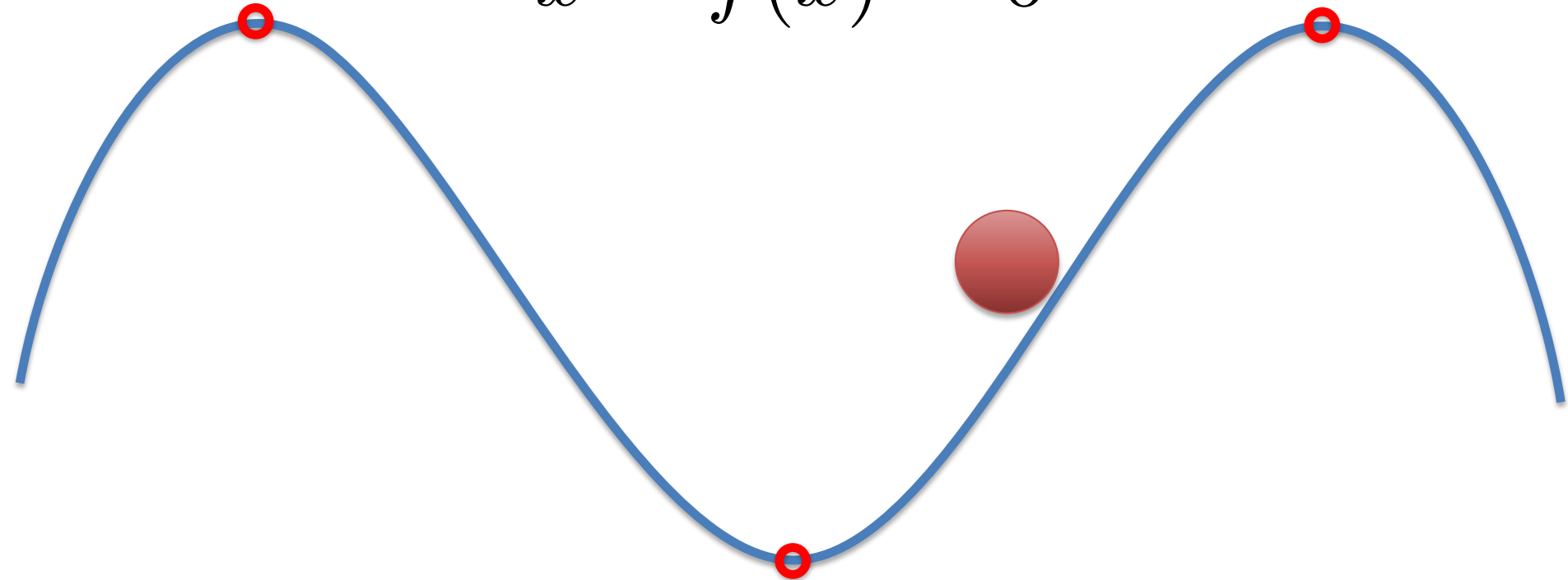# Sail Stability

What Is Stability?

$$\dot{x} = f(x)$$
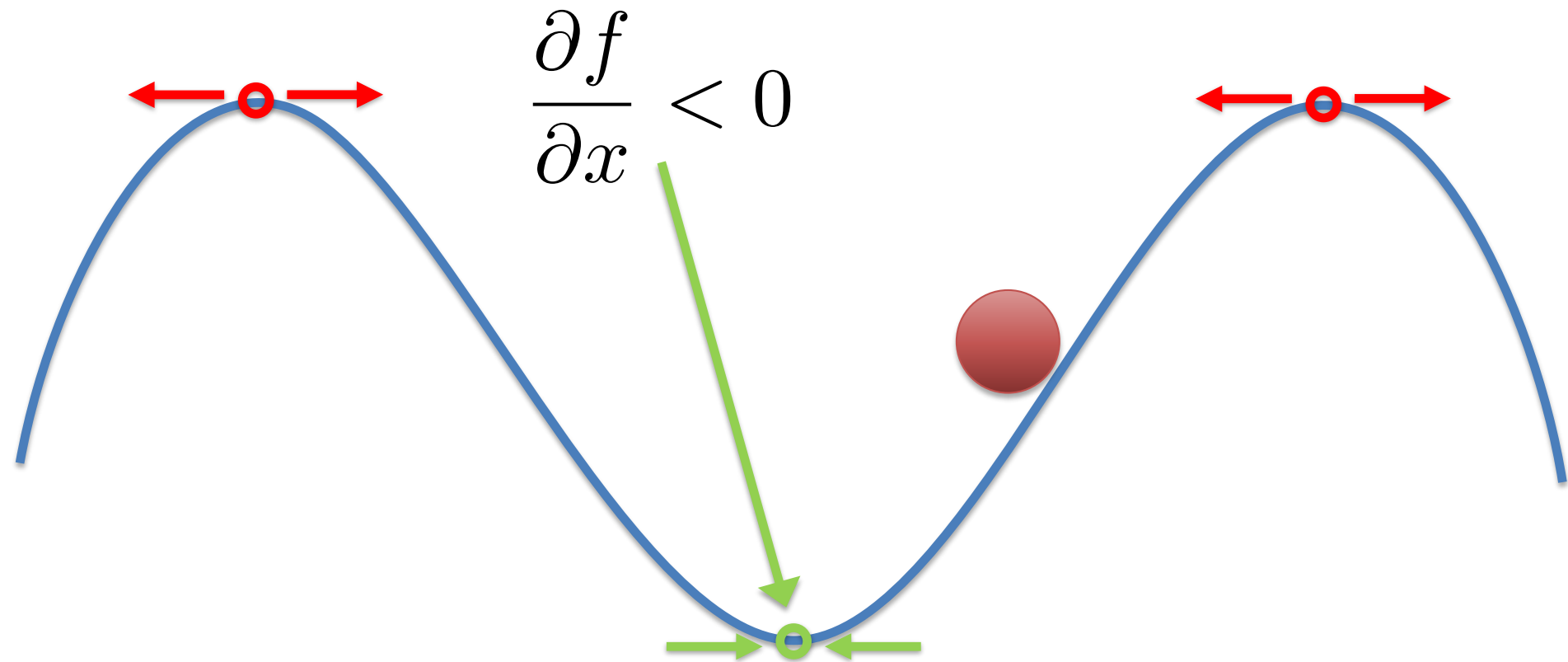
What Is Stability?
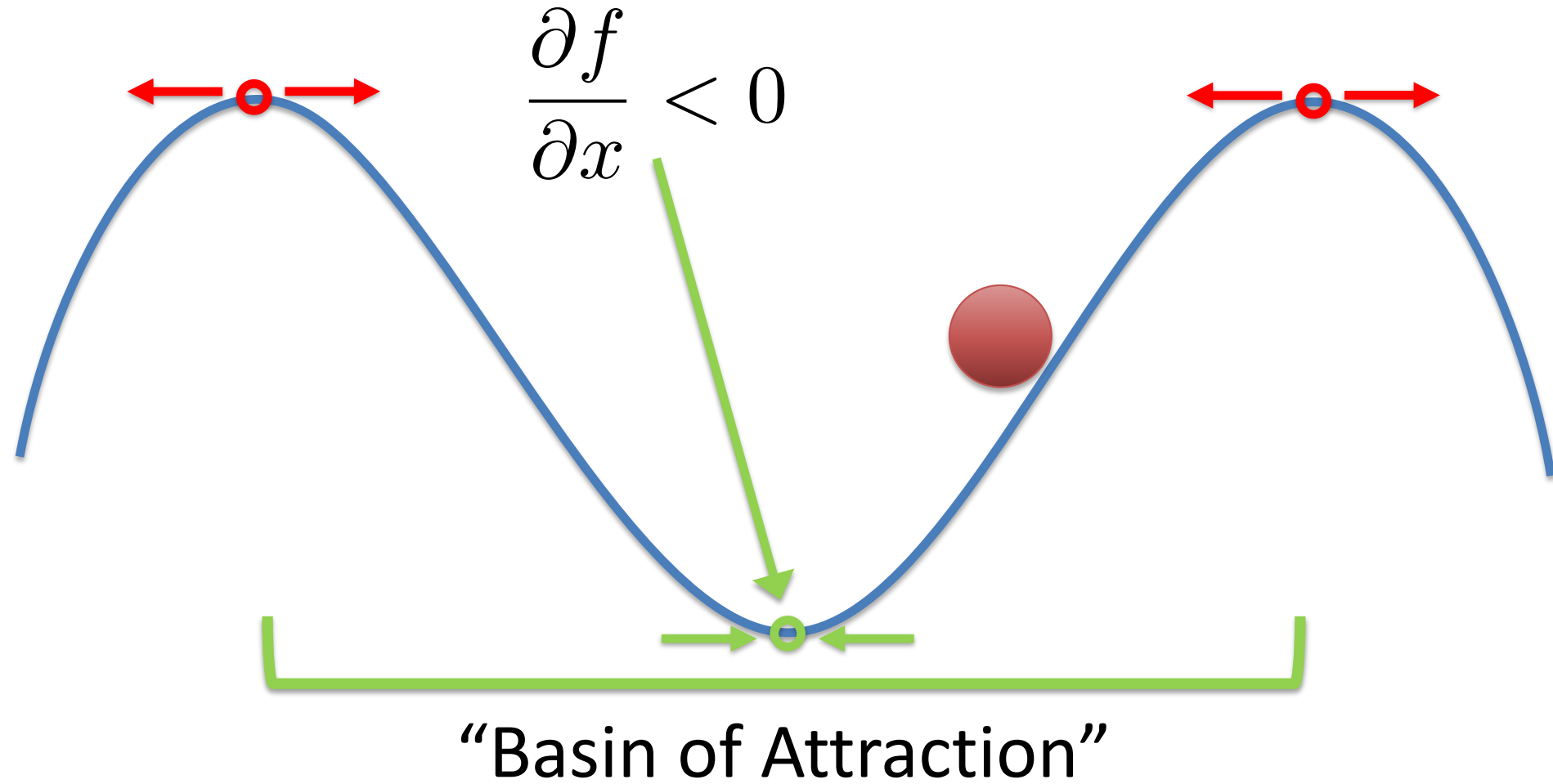
$$\dot{x} = f(x) = 0$$
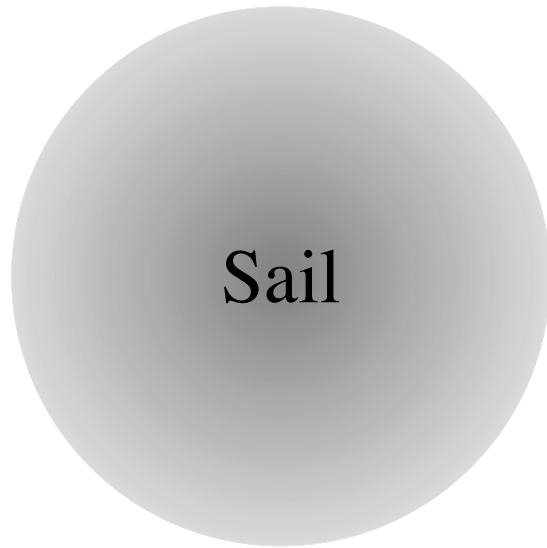
What Is Stability?

$$\frac{\partial f}{\partial x} < 0$$

What Is Stability?

$$\frac{\partial f}{\partial x} < 0$$

"Basin of Attraction"

Sail Dynamics

Sail

$$\boldsymbol{F} = \int_S 2\,\frac{P(\boldsymbol{x})\,\hat{\boldsymbol{b}}\cdot\hat{\boldsymbol{n}}(\boldsymbol{x})}{c}\,\hat{\boldsymbol{n}}(\boldsymbol{x})\,dS$$

$$\boldsymbol{\tau} = \int_S 2\,\frac{P(\boldsymbol{x})\,\hat{\boldsymbol{b}}\cdot\hat{\boldsymbol{n}}(\boldsymbol{x})}{c}\,\bigl(\boldsymbol{r}(\boldsymbol{x})\times\hat{\boldsymbol{n}}(\boldsymbol{x})\bigr)\,dS$$

"Beam Riding" Stability

$$\dot{\boldsymbol{x}} = f_\perp(\boldsymbol{x}^*) = 0 \qquad \mathrm{Re}\left\{ \mathrm{eig}\left(\frac{\partial f_\perp}{\partial \boldsymbol{x}}\bigg|_{\boldsymbol{x}^*} \right) \right\} < 0$$

Some Important Implications
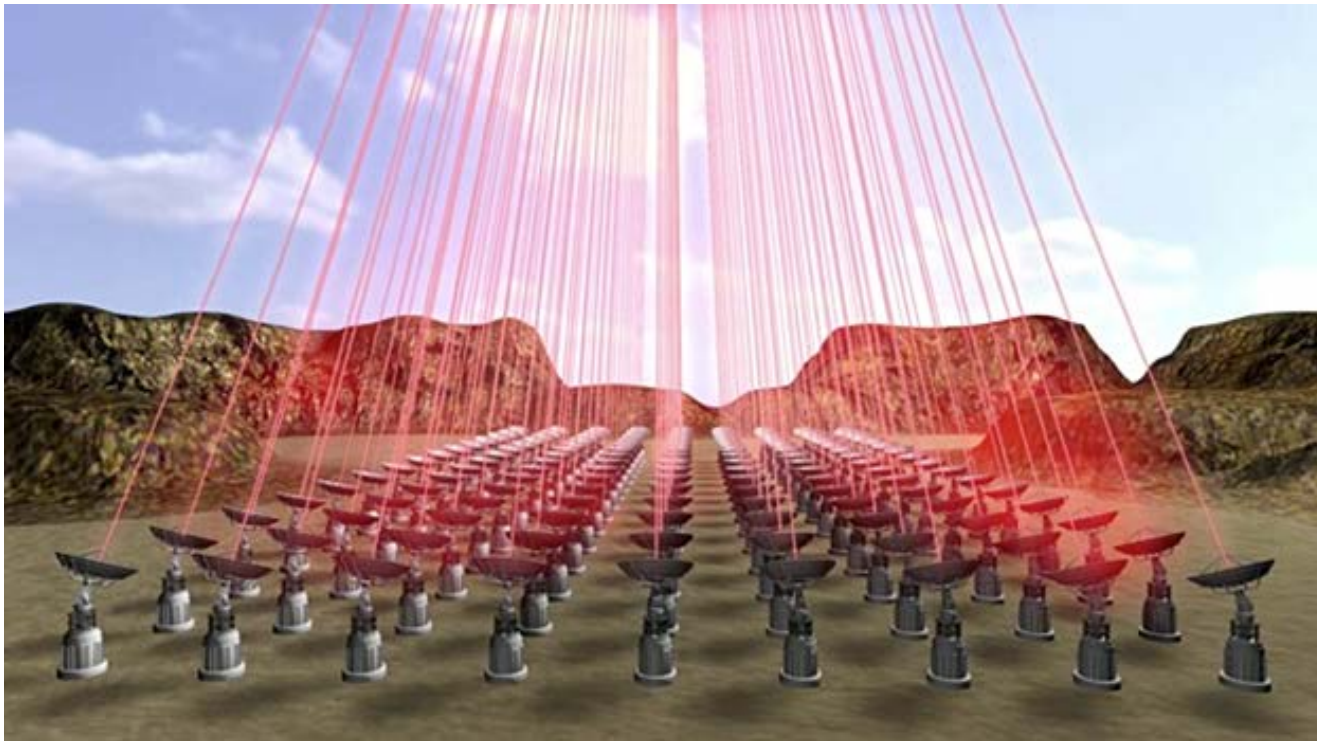
Sail Material:

- Incidence angle requirement

- Mechanical/structural requirements

Some Important Implications

Laser:

- Beam power profile

- Noise PSD requirements
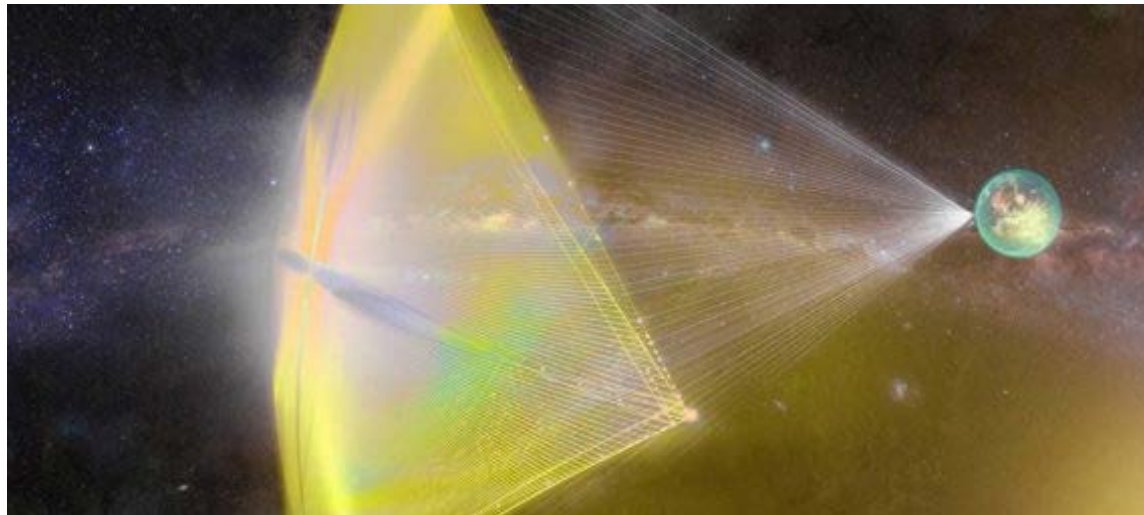
- Steering capabilities/requirements

Some Important Implications

Communications:

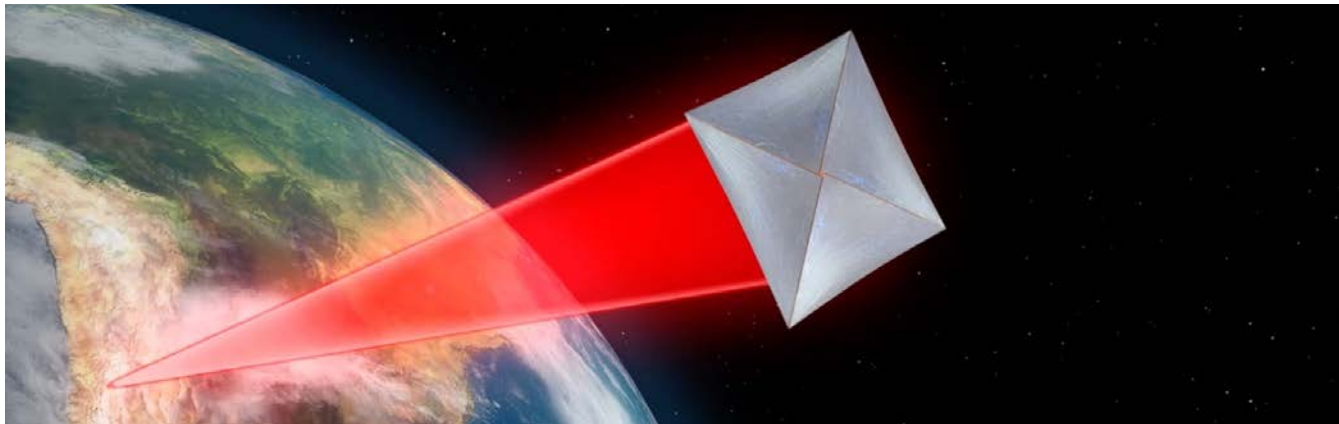- How do we store/deploy an antenna?

Payload:

- How much mass can be accommodated?

- How large can sensor apertures be?

- What will the thermal environment look like?

Things To Work On

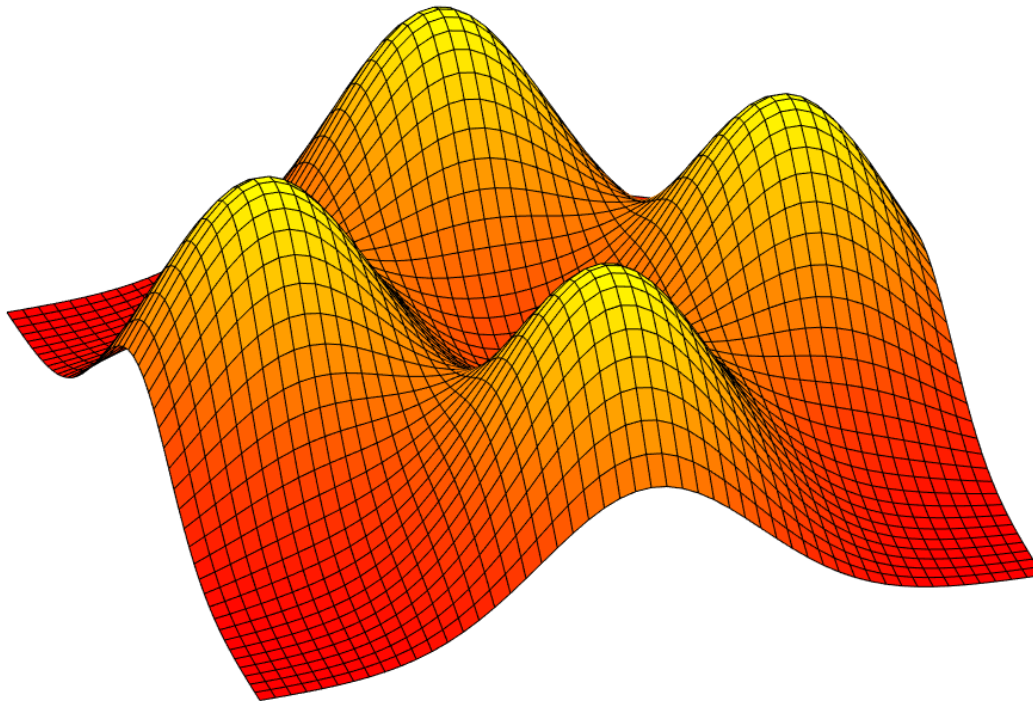**Simulation Infrastructure:**

- Handle arbitrary beam profiles and sail shapes

- Account for deformation and elasticity of the sail

- Account for orbit mechanics

- Material modeling

- Thermal modeling

- Output derivatives
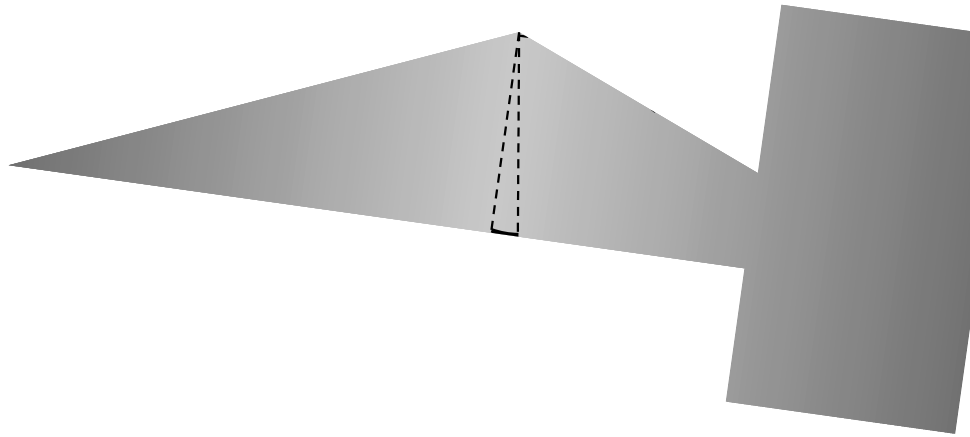
Things To Work On

Realistic Beam Model:

- Understand and model contributions of different noise sources

- Capture effects of atmosphere and adaptive optics

- Ultimate goal: PSD of beam flux on sail

Things To Work On

Optimization:

- Compute stable basins of attraction for sail + beam configurations

- Optimize sail shape and/or beam profile given system constraints

- Populate a trade-space with feasible designs

Questions?