Achieving Near-Atmospheric Levitation of Micron-Thick Materials

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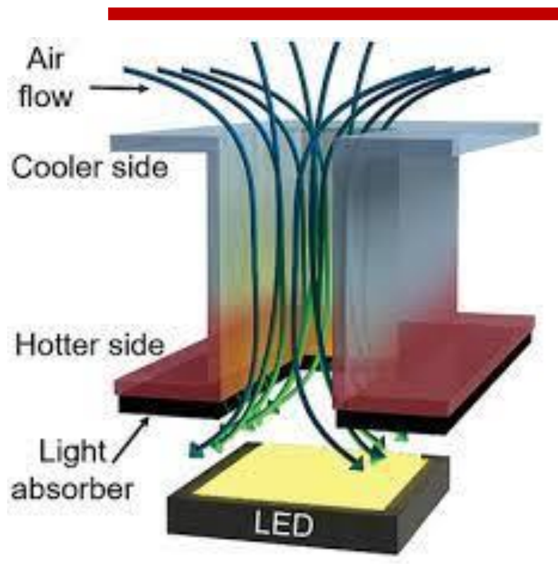
Motivation

- Sustained flight in the mesosphere is difficult as the air is too dense for satellites yet too thin for balloons
- Photophoretic levitation is a promising solution
- High pressure performance could allow low altitude take-offs

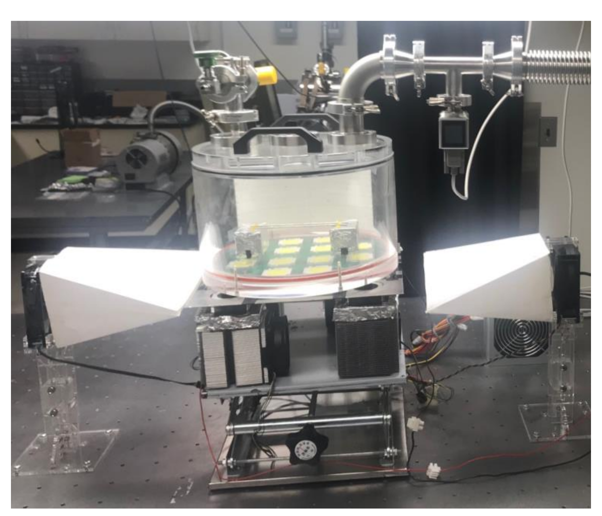
The Photophoretic Force



- Light absorption creates a temperature difference across a material's thickness
- Temperature difference results in molecular gas flow and propulsion
- CNTs/Ge used as absorbers

Methods

- Tested three lightweight materials: Nanocardboard, Dandelion Pappi, and Mylar

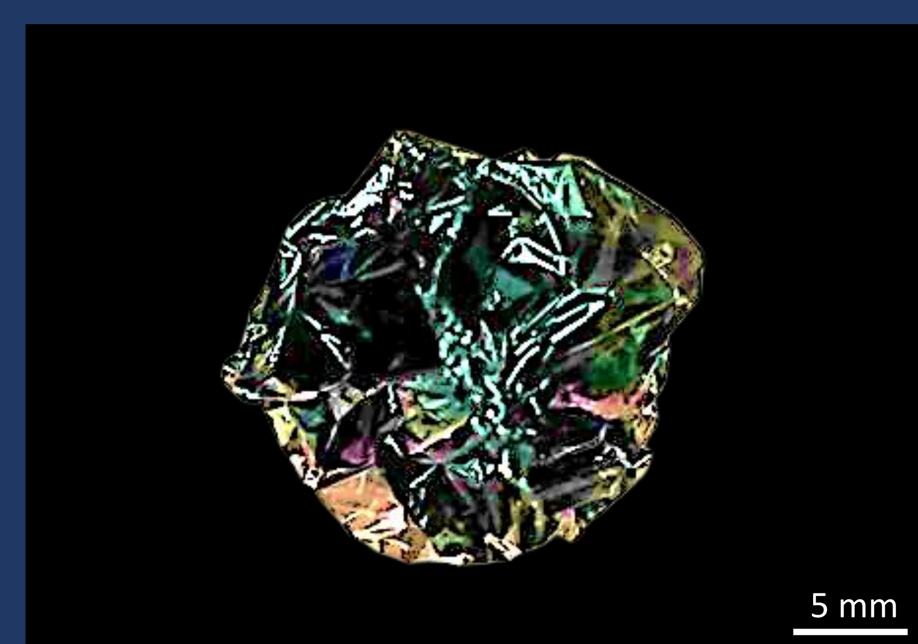


- Materials were exposed to an LED light array
- Up to 8 sun's worth of incident light flux
- Tested in chamber from vacuum to 1 atm

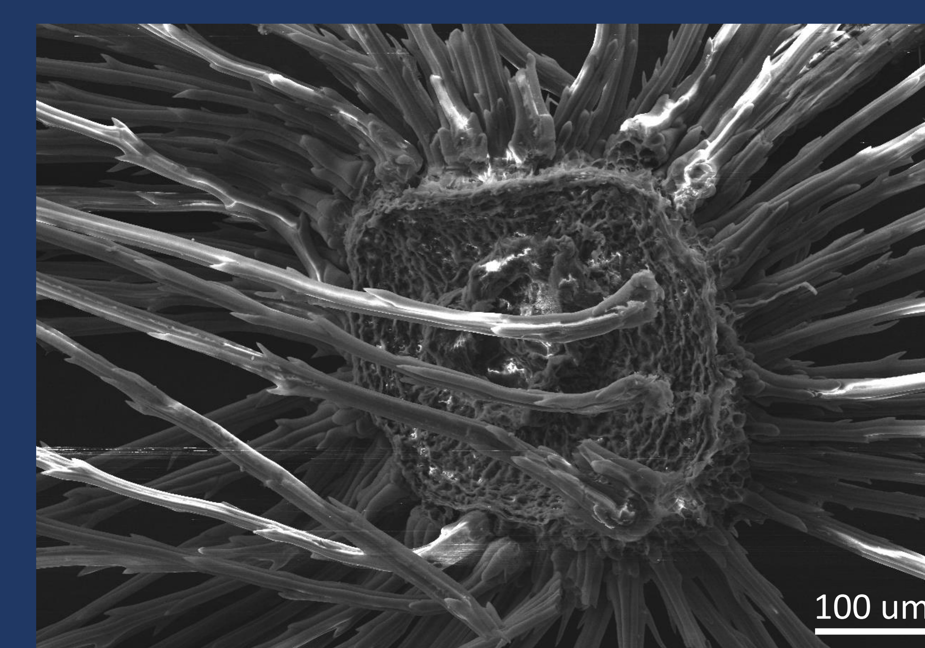
Results

- Nanocardboard: developed model that predicts atmospheric levitation to be possible
- Dandelion Pappus: tests with a diluted carbon nanotube (CNT) solution suggest that photophoretic force may be present
- Mylar Structures: spherical shapes are possible to fabricate and test

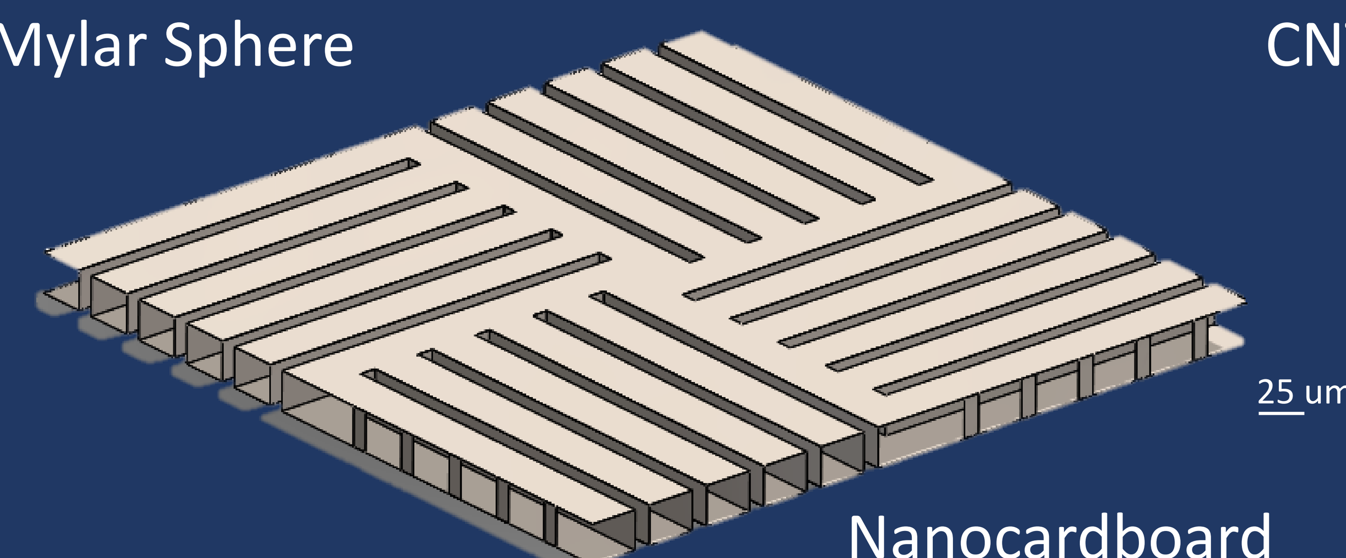
Can we levitate micron-thick materials near atmospheric pressure using light?



CNT Coated Mylar Sphere



CNT Covered Pappus



Nanocardboard SolidWorks Model

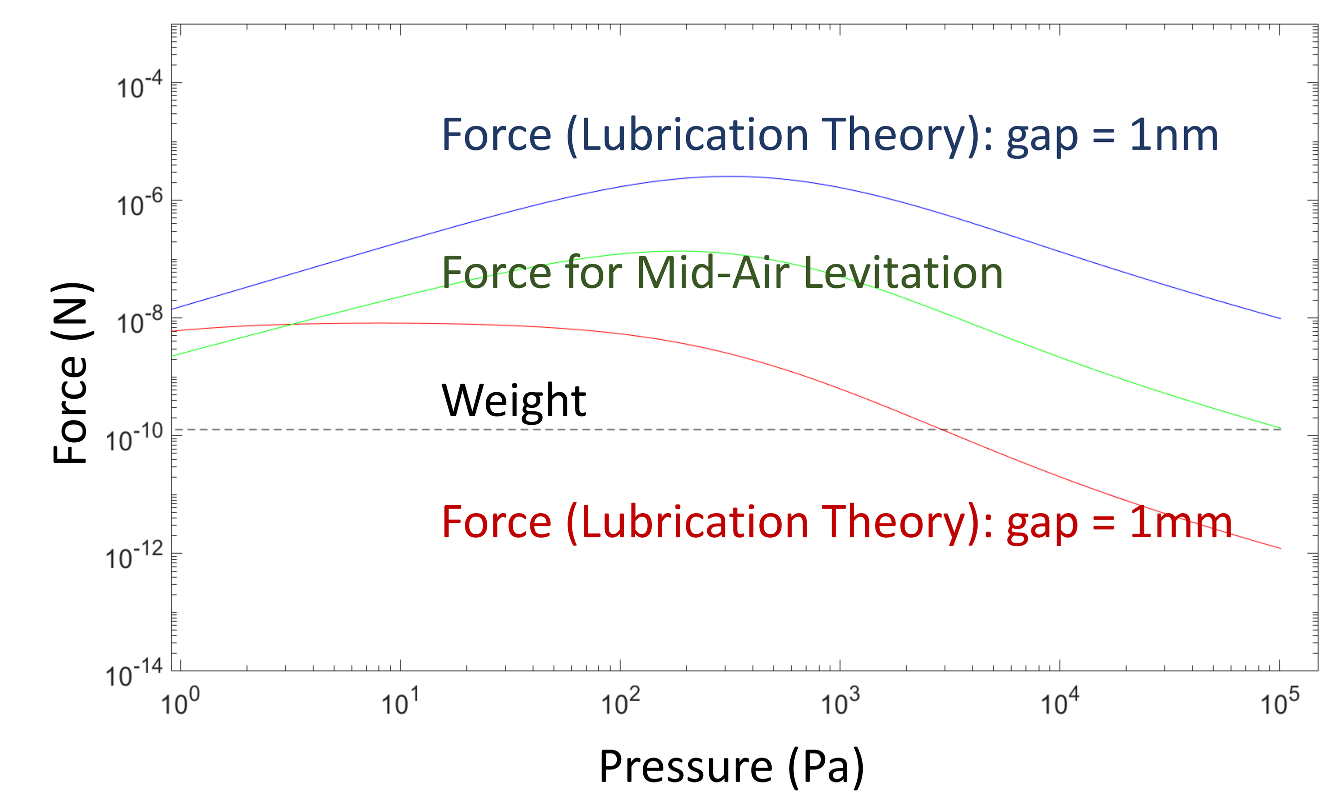
Penn Engineering
University of Pennsylvania

Bargatin Group

PURM
Penn Undergraduate Research Mentoring Program

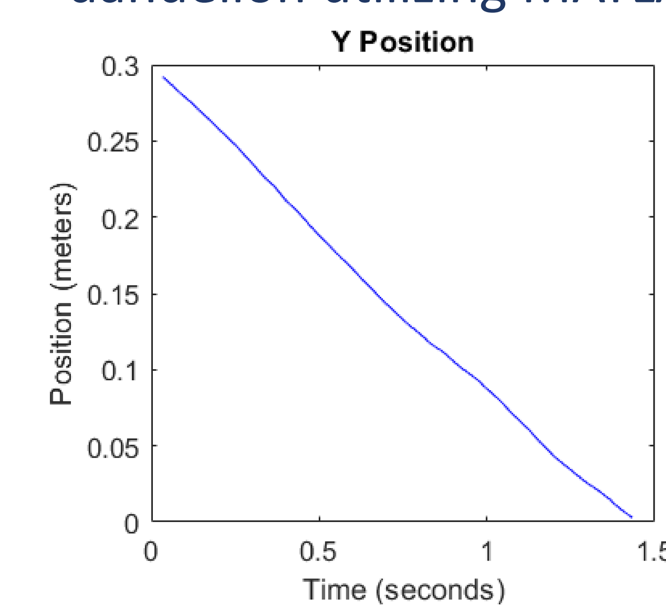
Nanocardboard

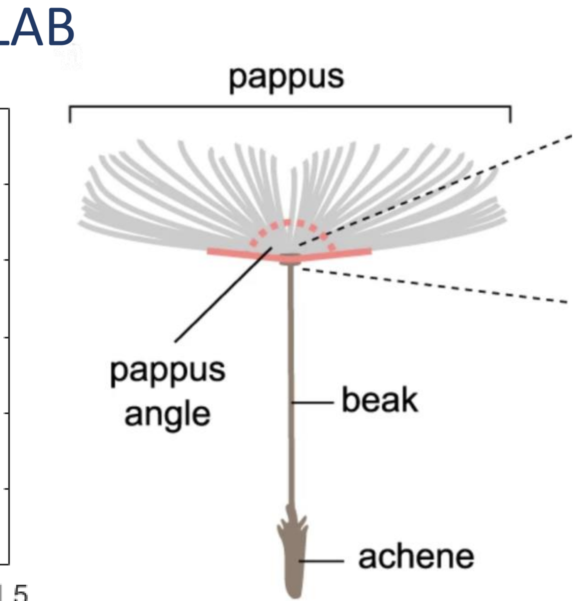
- Model predicts that the following sample may levitate at atmospheric pressure: 300 um side length, 10 nm ALD alumina, 25 um channel thickness, with 8000 W/m² solar flux



Dandelion Pappus

- Explored whether CNT coated dandelion pappi would create an observable photophoretic force
- Tested samples with and without light
- Tracked and analyzed the kinematics of the dandelion utilizing MATLAB

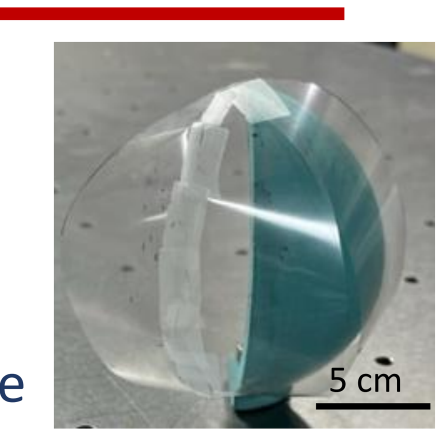




Seale, et al (2022)

Mylar Structures

- Fabrication: fused together mylar sections coated with CNTs to form 3D shapes
- Created "orange peel" jig to help construction of a sphere



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Digital Poster

References

Acknowledgements