

The Heliophysics Big Year

Solar Sails Investigations by Dr. Hilarie Davis 9/3/24



Framework for Heliophysics Education (FHE)

Developed by NASA HEAT in 2022

<https://science.nasa.gov/learn/heat/big-ideas/>

NASA's Big Heliophysics Questions

1. What are the impacts of the Sun on humanity?
2. How do the Earth, the solar system, and heliosphere respond to changes on the Sun?
3. What causes the Sun to vary?

FHE NASA Questions and Big Ideas

1. What are the impacts of the Sun on humanity?

1.1 The Sun is really big and its gravity influences all objects in the solar system. (PS2, ESS1)

1.2 The Sun is active and can impact technology on Earth via space weather. (PS1, PS2, PS4, ESS2, ESS3)

1.3 The Sun's energy drives Earth's climate, but the climate is in a delicate balance and is changing due to human activity. (PS1, PS2, PS3, LS4, ESS2, ESS3)

2. How do the Earth, the solar system, and heliosphere respond to changes on the Sun?

2.1 Life on Earth has evolved with complex diversity because of our location near the Sun. It is just right! (PS3, PS4, LS1, LS2, ESS2)

2.2 The Sun defines the space around it, which is different from interstellar space. (PS2, ESS1, ESS2)

2.3 The Sun is the primary source of light in our solar system. (PS1, PS2, PS3, PS4, ESS1)

3. What causes the Sun to vary?

3.1 The Sun is made of churning plasma, causing the surface to be made of complex, tangled magnetic fields. (PS1, PS2, ESS1, ESS2)

3.2 Energy from the Sun is created in the core and travels outward through the Sun and into the heliosphere. (PS1, PS2, PS4, ESS1, ESS2, ESS3)

Solar Sails Connections to FHE

NASA Heliophysics Question 2: How do the Earth, the solar system, and heliosphere respond to changes on the Sun?

- Big Idea 2.3 [The Sun is the primary source of light in our solar system.](#) (PS1, PS2, PS3, PS4, ESS1)

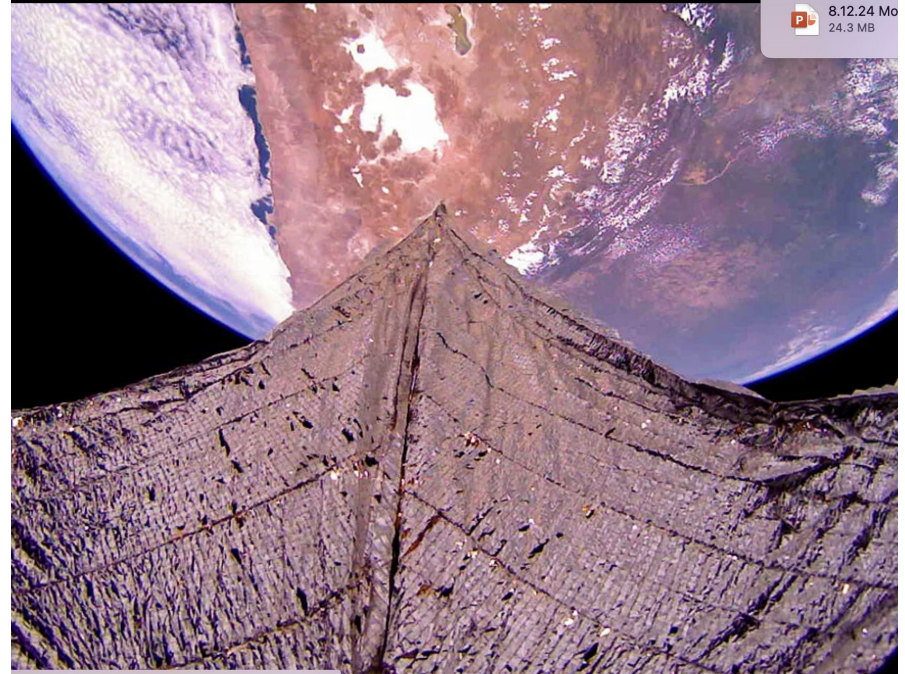
NASA Heliophysics Question 3: What causes the Sun to vary?

- Big Idea 3.2 [Energy from the Sun is created in the core and travels outward through the Sun and into the heliosphere.](#) (PS1, PS3, PS4, ESS1, ESS2, ESS3)

Solar Sails Lightsail 2

Lightsail 2 was in orbit from **June 2019-October 2022**. On this right is the final image returned from the spacecraft before atmospheric reentry after 18,000 orbits and 5 million miles traveled. It drove a shoebox-sized spacecraft with its sails tucked together like origami. Using four tape measure-like booms, the spacecraft unfurled a four-section Mylar sail with an area of 244 square feet.

<https://www.planetary.org/sci-tech/lightsail>



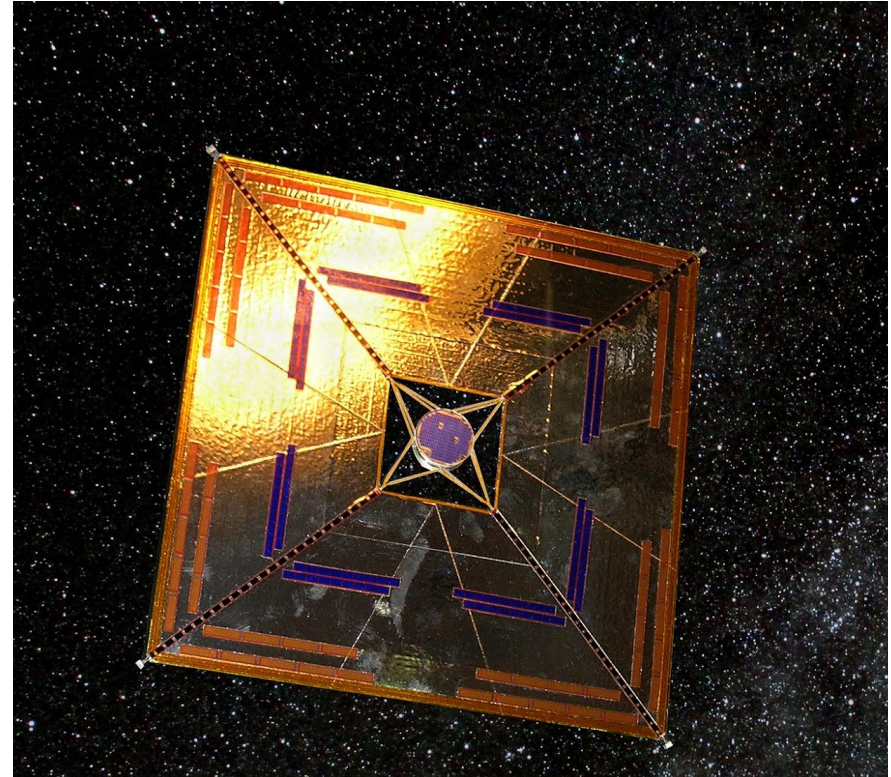
Solar Sails IKAROS

Launched in 2010 by JAXA and still sailing in 2015. It was the first practical solar sail vehicle in interstellar space. It showed that a solar sail could provide propulsion for long-duration missions. It is spin-deployed, with tip-masses in the corners of its square sail which is 20 meters on the diagonal.

https://global.jaxa.jp/countdown/f17/overview/ikaros_e.html

Note-NASA's NanoSail-D deployed in Jan 2011 in low Earth orbit for 18 months

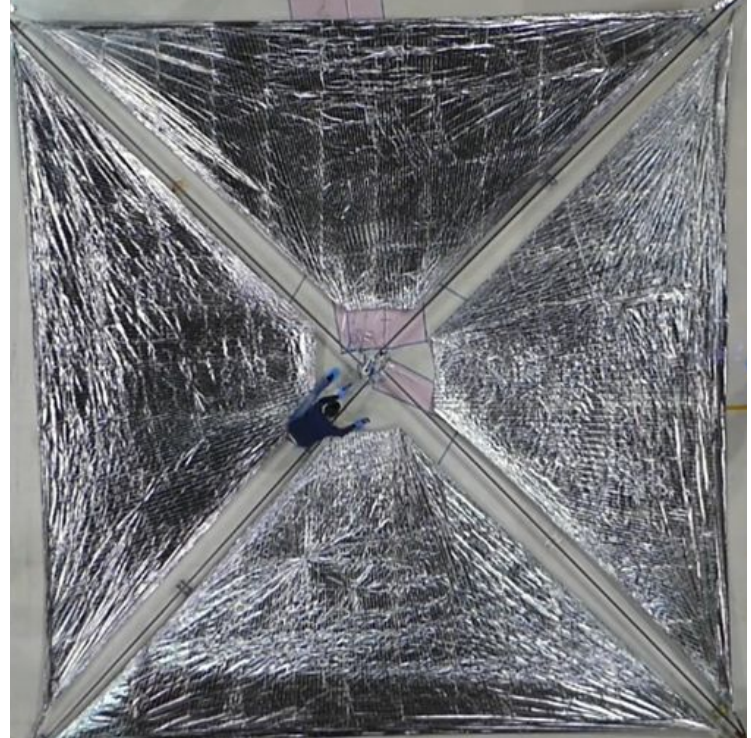
<https://ntrs.nasa.gov/citations/20110015650>



Solar Sails Advanced Composite Solar Sail System

Engineers at NASA's Langley Research Center test deployment of the ACS3 solar sail in **April 2024**. The unfurled solar sail is approximately 30 feet on a side. Since solar radiation pressure is small, the solar sail must be large to efficiently generate thrust. Its novel, lightweight booms deploy from a CubeSat.

<https://www.nasa.gov/smallspacecraft/what-is-acs3/#:~:text=ACS3%20launched%20on%20April%2023,1%20in%20Māhia%2C%20New%20Zealand>



Introductory Level

Who has built solar sails? Why did it take over 400 years from Kepler writing about the idea to Galileo to building one?

- What is a solar sail? <https://www.youtube.com/watch?v=Xe6yoGfTZOk>
- What is solar sailing? <https://bit.ly/3AFCO5k>
- NASA Next-Generation Solar Sail Boom Technology (video)
<https://go.nasa.gov/3Tb4BAR>

Exploratory Level

How do solar sails work?

- The science behind solar sails

<https://www.youtube.com/watch?v=-ZDSvnzpRNI>

- How solar sails are remaking space exploration

https://www.youtube.com/watch?v=Ndx_6J4uo2M

- What is the advanced composite solar system? <https://go.nasa.gov/3XnuT5v>

- How solar sails work – a simulation

https://physics.bu.edu/~duffy/HTML5/solar_sailboat.html

Advanced Level

How does a solar sail propel a spacecraft?

- Solar Cruiser Sail <https://www.youtube.com/watch?v=m5ajxtNWHkA>
- How to Sail on Starlight <https://www.youtube.com/watch?v=j8umNI8gtlA>
- Solar sails and other forms of propulsion for space travel (from AAPT)
https://physics.bu.edu/~duffy/HTML5/solar_sailboat.html

For more information on the **Framework for Heliophysics Education**

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