Using a Directed Energy System to Deflect Asteroids

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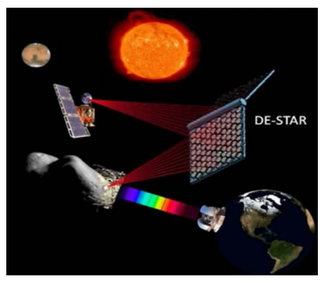
Abstract

Asteroid impacts on or near the earth are a serious and ongoing problem. The DE-STAR project proposes using a directed energy system, in this case - a laser, to vaporize a small part of an incoming asteroid and use the resulting mass ejection to alter its trajectory away from the earth's orbit. However, different asteroid compositions produce varying amounts of thrusts that need to be considered when using this kind of propulsion system. Our project focuses on testing different samples and observing their respective thrusts.

DE-STAR

Deflecting Asteroids



An exaggerated vision of the DE-STAR project in use: A modular array of lasers is focused on an asteroid.

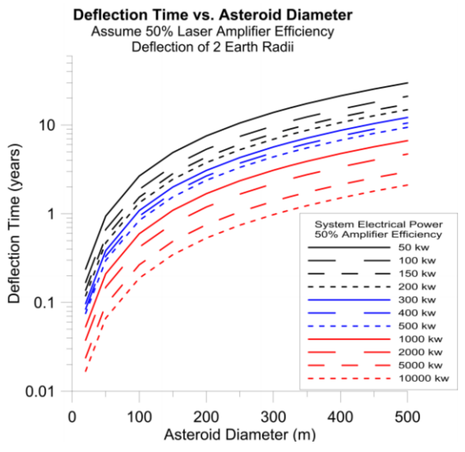
Idea Behind DE-STAR:

- Phased array laser placed in earth's orbit
  - Solar-powered
- Direct at incoming asteroid, cause ablation
  - Specific spot heats up
  - Results in mass ejection plume
- Asteroid is propelled in opposite direction
- Asteroid's trajectory is altered so as not to interfere with the earth
- No collision!

Ablation of porous basalt resulting in a mass ejection plume.

Ultimate Goal:

- Create an automated system to deflect asteroids using the correct amount of thrust

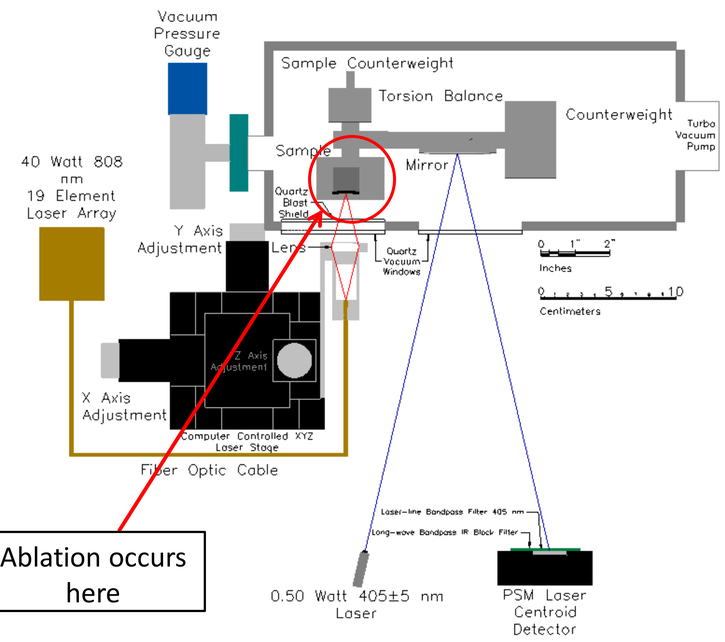


NASA gives us a miss distance of one earth diameter in order to ensure a reasonable safety margin. The graph on the left shows how long it would take different powered lasers to deflect asteroids to the desired distance.

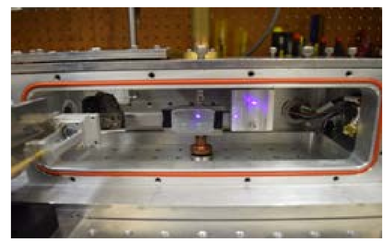
Conceptual design of the deployed spacecraft with two 15 m PV arrays that produce 50 kW each at the beginning of life for a total of 100 kW.

Testing

Lab Setup:



- Measurements are taken by detector outside of vacuum chamber
- Torsion balance holds sample and hangs from the fiber



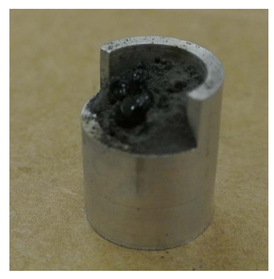
Inside of vacuum chamber

Tests:

- Regular Ablation
- Power Test
- Pressure Test

Materials:

- Porous, non-porous, and crushed basalt
- Zinc Sulfide
- Tuff
- Quartz
- Peridotite

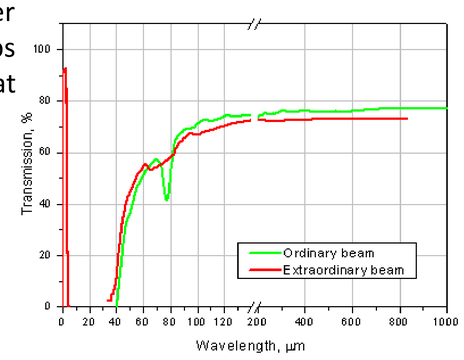


Container used to hold the crushed basalt for testing

Transmittance:

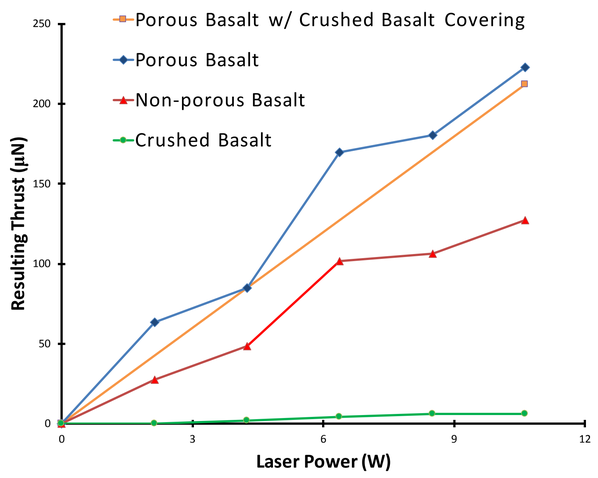
The amount of the laser that the sample absorbs versus the amount that passes through.

The transmittance spectra for quartz.



Results

Basalt:



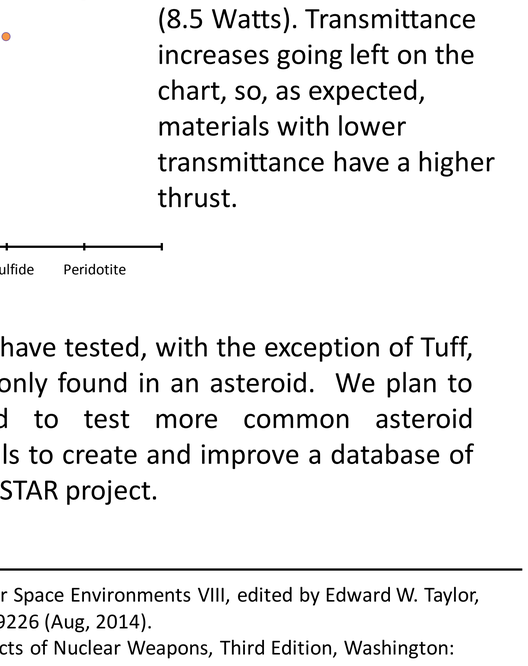
Power Test for different forms of basalt. During all tests, the laser's amps were increased every minute in order to see the difference in thrust at every Watt level.

Asteroids generally do not have a uniform composition.

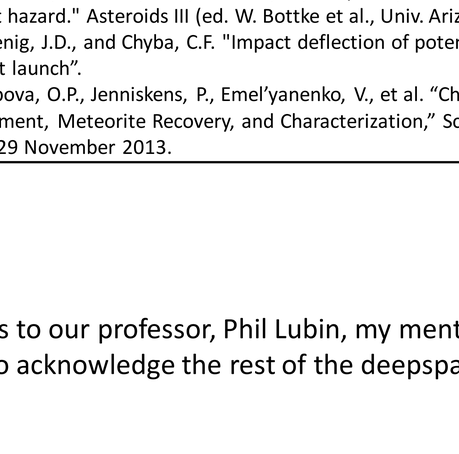
- They are covered in a sandy regolith layer that results from collisions with other asteroids.
- Beneath that layer, an asteroid can either be porous or non-porous.

Porous Basalt being ablated in a space-like environment.

The results for basalt ablation at different pressures. If you decrease pressure you get a better ablation and thus, a higher thrust measurement.



Other Materials:



The different material's thrust measurements at 30 Amps (8.5 Watts). Transmittance increases going left on the chart, so, as expected, materials with lower transmittance have a higher thrust.

All the materials we have tested, with the exception of Tuff, are materials commonly found in an asteroid. We plan to use this data and to test more common asteroid composition materials to create and improve a database of materials for the DE-STAR project.

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