DE-SPINNING ASTEROIDS: USING LASER ABLATION TO MANIPULATE ASTEROID MOTION

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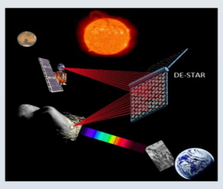
ABSTRACT

The Earth is continuously under threat from asteroids. We in the **DE-STAR** (**D**irected **E**nergy **S**ystem for **T**argeting of **A**steroids and explo**R**ation) Lab are working on technology to defend Earth from this threat. To do this, we use focused kilowatt-class lasers to vaporize a point on the asteroid's surface and create a plume of ejected asteroid material that acts as propellant that changes the asteroid's trajectory and rotational motion. However, our equipment has the potential not only to deflect, but also to de-spin large asteroids for mining, repurposing, or for more effective deflection. This project examined the plausibility of de-spinning an asteroid using laser ablation. We've found that this method is sufficiently effective.

BENEFITS

Multiple uses

- Cleaning up space debris
- De-Spinning for study and mining.
- Deflecting asteroids from Earth collision



Better than impactors

- Less expensive
- Reusable
- Does not shatter asteroid but still delivers megatons of force
- Controlled and predictable

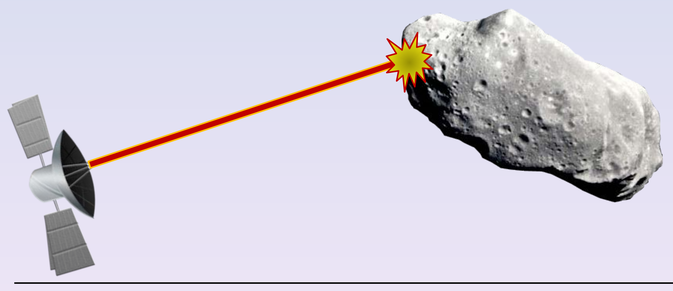
RESEARCH GOALS

Determine de-spin rate formula

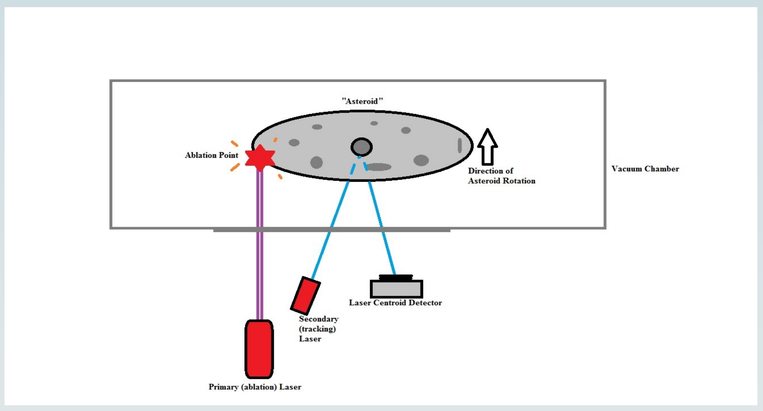
- Based on moment of inertia, rotation rate, laser optical power on target, percentage of time on target, lever arm length

De-spinning by laser ablation

- Effective method of slowing rotation?



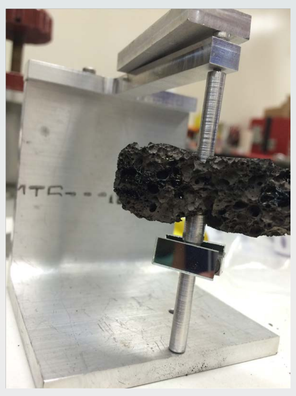
SETUP



- Extremely low friction
- Low pressure environment
- Set in motion before ablation

However:

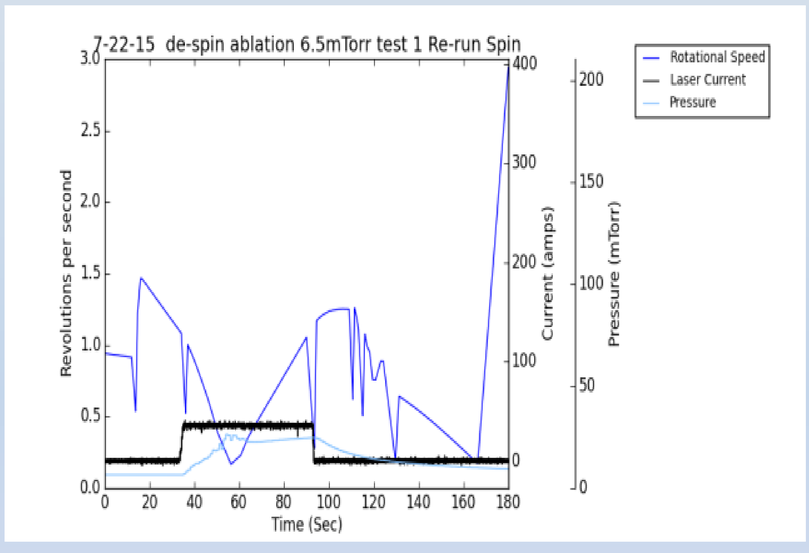
- Two dimensional motion for simplicity



As the asteroid assembly rotates in the vacuum, a secondary laser is reflected off two mirrors mounted on either side of the spindle. The reflected laser beam is analyzed as it sweeps across a laser centroid detector.

FINDINGS

The laser ablation was capable not only of quickly stopping rotation, but even reversing the direction of rotation



Above is a plot of data we received from an experiment.

- (in blue) of the speed of rotation of the asteroid and spindle.
- current (black) is shown to denote at what point the laser is on.
- The noise-free period in which the laser is on and ablating shows an increase in deceleration until the sample stops, and then a reverse in direction and an increasing speed until the laser turns off.

(Due to the rate at which the speed is sampled the plot does not show a point at zero speed.)

DE-SPIN FORMULA

*G*iven initial ω_i and final speed 0:

$$\tau = I\alpha = -I\frac{\omega_i}{t}$$

τ being:

$$\tau = Fl = (\varepsilon P \chi_{incident})l$$

$$F(newtons) = (\varepsilon P(watts)\chi_{incident})$$

$\chi_{incident}$ = incident fraction (fraction of total time laser is focused on target); dimensionless

ε = optical power coupling coefficient $\Rightarrow$ 50 micronewtons/watt: ablation force per watt of optical power absorbed by target

$$t = -\frac{I\omega_i}{(\varepsilon P \chi_{incident})l}$$

CONCLUSIONS

The experimental data confirmed the de-spin formula.

Applying the de-spin formula we can estimate the amount of time it would take to de-spin larger asteroids.

Please watch our video of de-spinning and spinning up an "asteroid like" sample:

https://www.youtube.com/watch?v=e6KMehUsK34

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