CERIAS

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LIGHT CURVE SHAPE INVERSION

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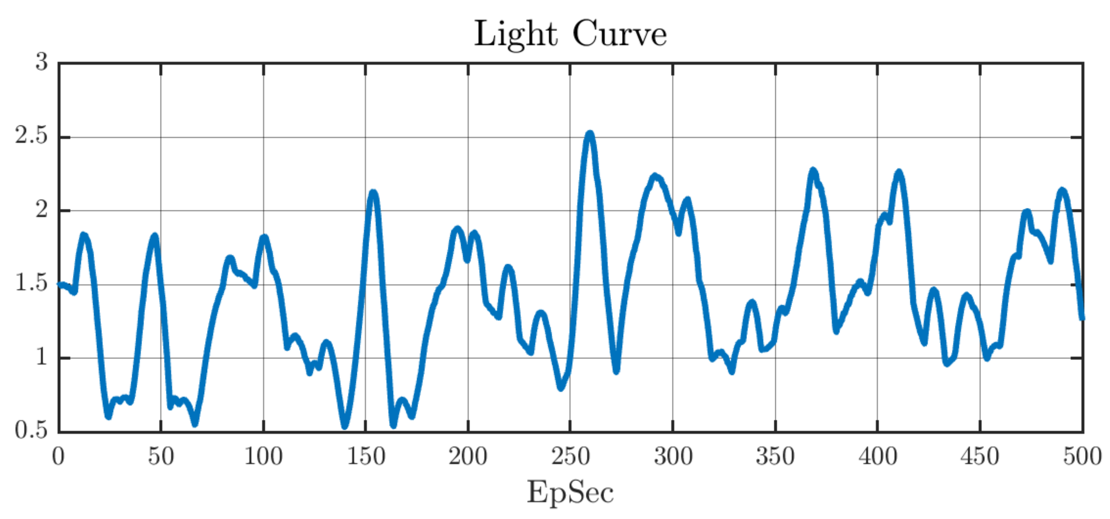


PROBLEM OVERVIEW

Many areas of Space Domain Awareness (SDA) require shape information, but such information is not readily available. With an optical telescope, we can collect resident space object (RSO) brightness data over time, known as a light curve. Since the light curve is a product of shape, attitude, and materials of the object, how can we recover those attributes?

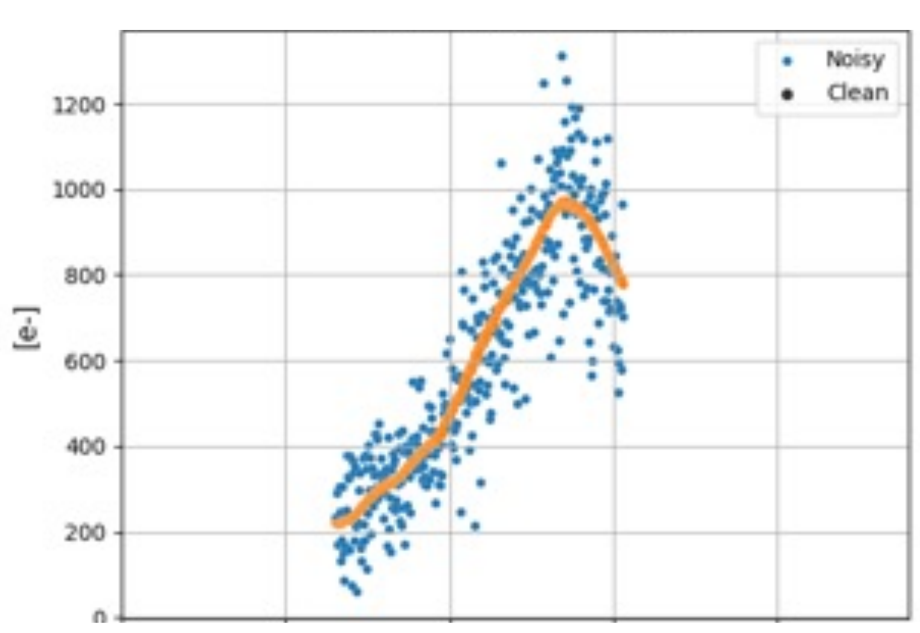
BACKGROUND

When an object is far enough away relative to its size, it becomes unresolvable due to diffraction.

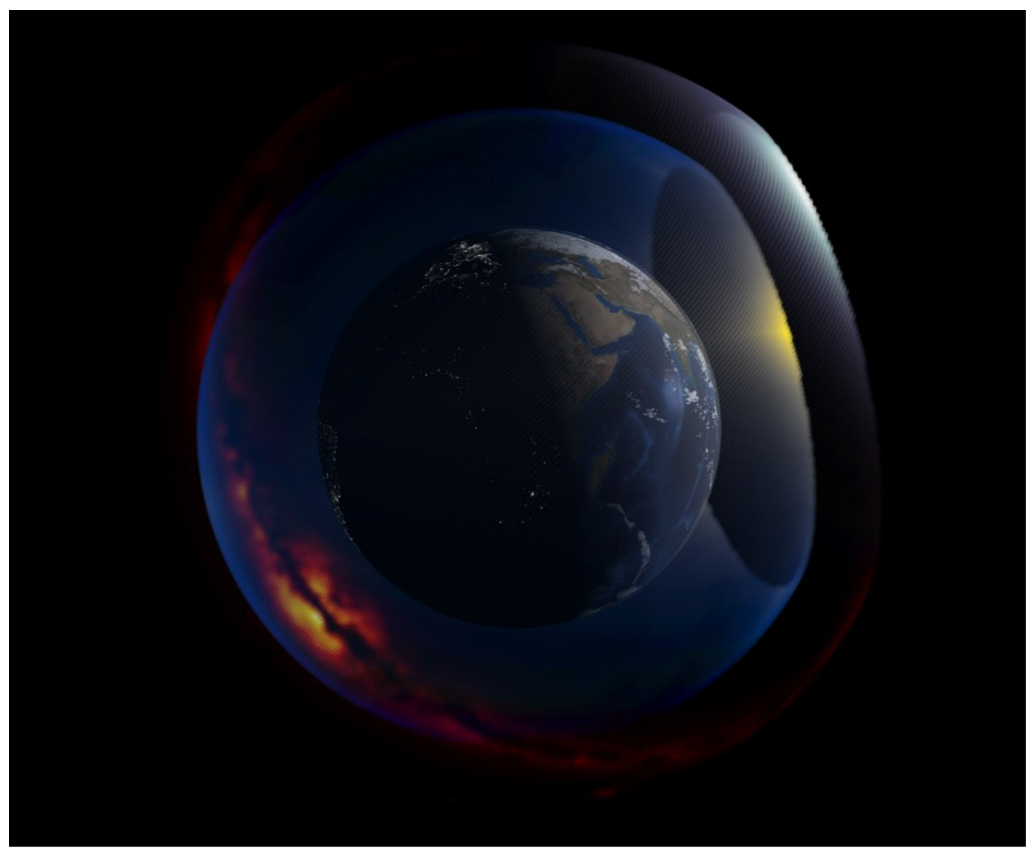
Light curve shape inversion was developed for asteroids. Asteroids often have:

- Uniform material properties
- Simple spin profiles
- Convex shapes

Human-made space objects have none of these characteristics. Further, there are many noise sources we must model.



Synthetic light curve for GOES-17, using high-fidelity background signals and digital twin of Purdue Optical Ground Station



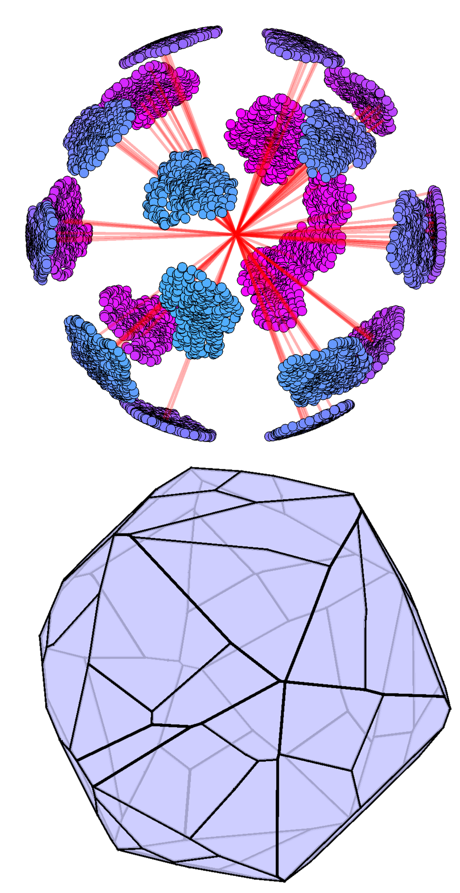
Selected background sources degrading the light curve: integrated starlight (red), scattered moonlight (white), and zodiacal light (yellow)

RESULTS

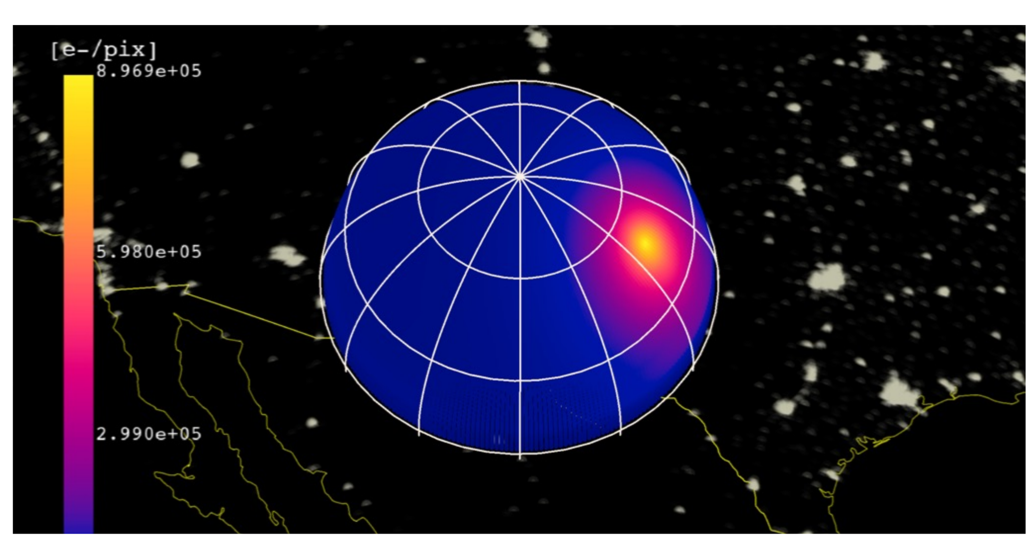
Telescope digital twin produces realistic light curves for arbitrary objects, attitude profiles, and observer.

We can recover convex shapes accurately if the attitude profile and material properties well-known.

Novel contribution: We can locate and size prominent concave features under similar assumptions.



Reconstruction of an icosahedron from its light curve via the Extended Gaussian Image

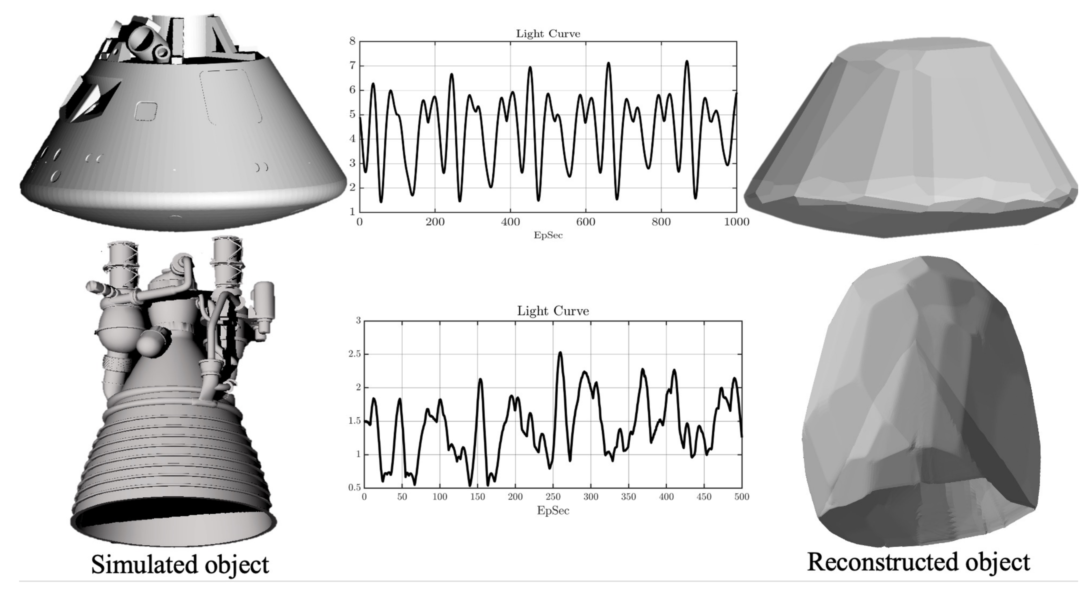


Scattered moonlight signal on the local hemisphere at the Purdue Optical Ground Station.

DISCUSSION

Methods are still limited by knowledge of attitude and material properties

- Multi-spectral measurements promising



Selected convex (top) and non-convex (bottom) shape inversions

Next steps:

- Calibrate background signal model to real observations
- Fuse shape inversion with attitude inversion

CONCLUSIONS

Simulating realistic noisy light curves requires accurate dynamics, environmental effects, and material properties

Given attitude and material information, we can recover convex or non-convex shape estimates from a light curve

ACKNOWLEDGEMENTS

This work was supported through a National Defense Science and Engineering Graduate (NDSEG) fellowship through AFOSR

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