MoonLITE: The Lunar InTerferometry Explorer

The Extreme Instrument for Extreme Solar Systems

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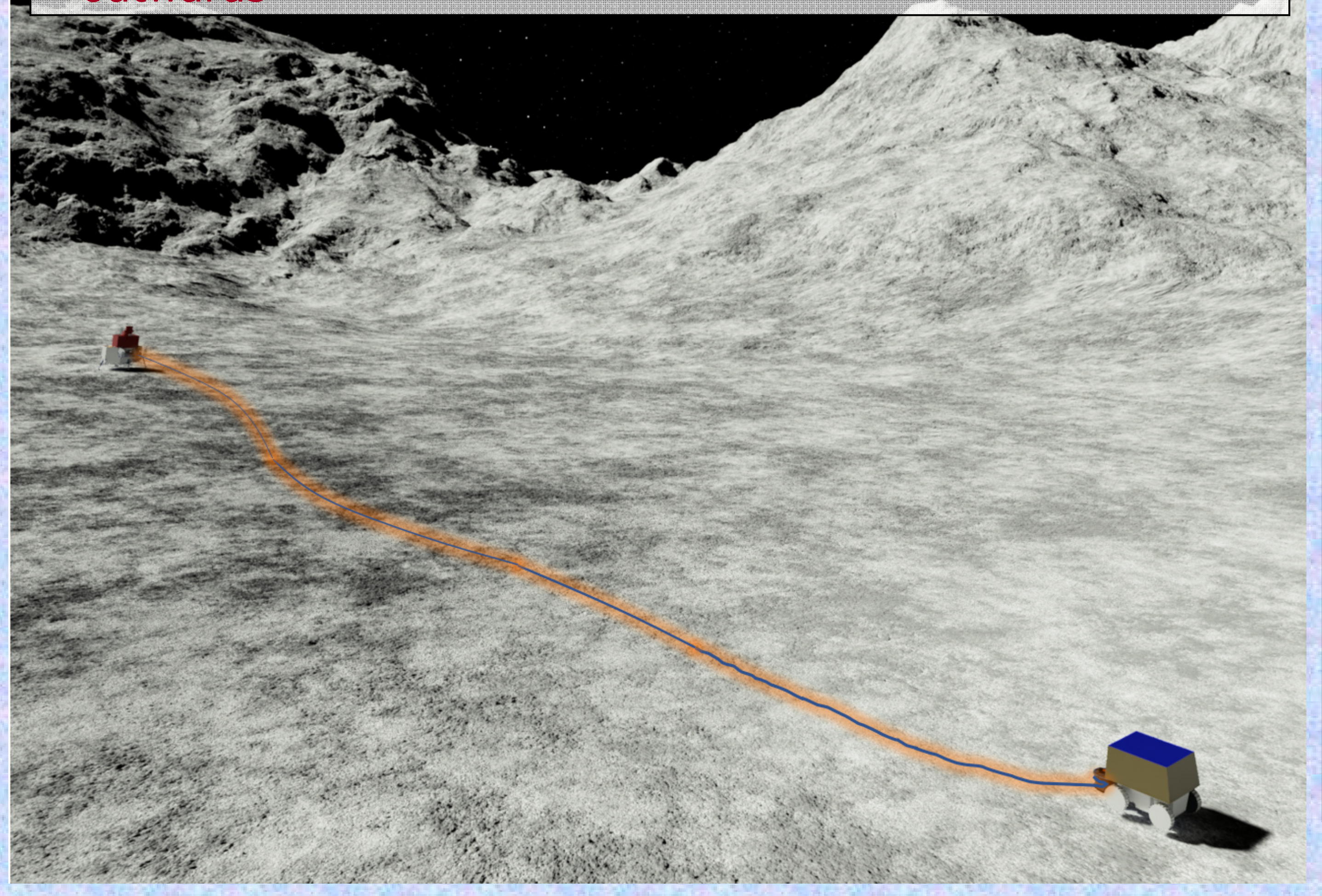
Extreme Solar System Science with MoonLITE

Radii of Exoplanet Hosts
- Includes diameters of lowest mass stars & brown dwarfs

Habitable Zones Sizes
- Refinement of luminosity estimates

Detect the Closest multiples among planet-hosting stars
- Bound companions affect $\eta_\oplus$
- MoonLITE can uniquely fill in multiplicity from 0.01au outwards



Opening up a Future in Lunar Astronomy

Currently available for NASA Pioneers proposals
- Payloads up to 50kg, 200W, 300kbps, lunar daytime operations (x2, after one survive-the-night) aboard NASA CLPS landers

Upcoming SMEX / MIDEX calls could benefit
- **Exoplanet mass measurement** through astrometry at the 0.1uas level – significantly simpler and cheaper than SIM because of stability, absolute reference frame
- Supports HWO preparatory science

Artemis-enabled deployment of observatories
- NASA NIAC-funded AeSI (Artemis-enabled Stellar Imager) study is one such approach

Additional Science with MoonLITE

Young Stellar Objects
- Probe terrestrial planet-forming regions, like ALMA has explored ice giant regions

Active Galactic Nuclei
- Visible-light exploration of AGN cores at scales similar to radio VLBI
- Observationally constrain the “final parsec problem”

Constrain spacetime foam models
- Granular nature of spacetime foam can possibly decohere light from distant QSOs
- MoonLITE’s sensitivity can probe increasing ‘fuzziness’ of increasingly distant point sources

Why the Moon?

Extreme angular resolution with extreme sensitivity

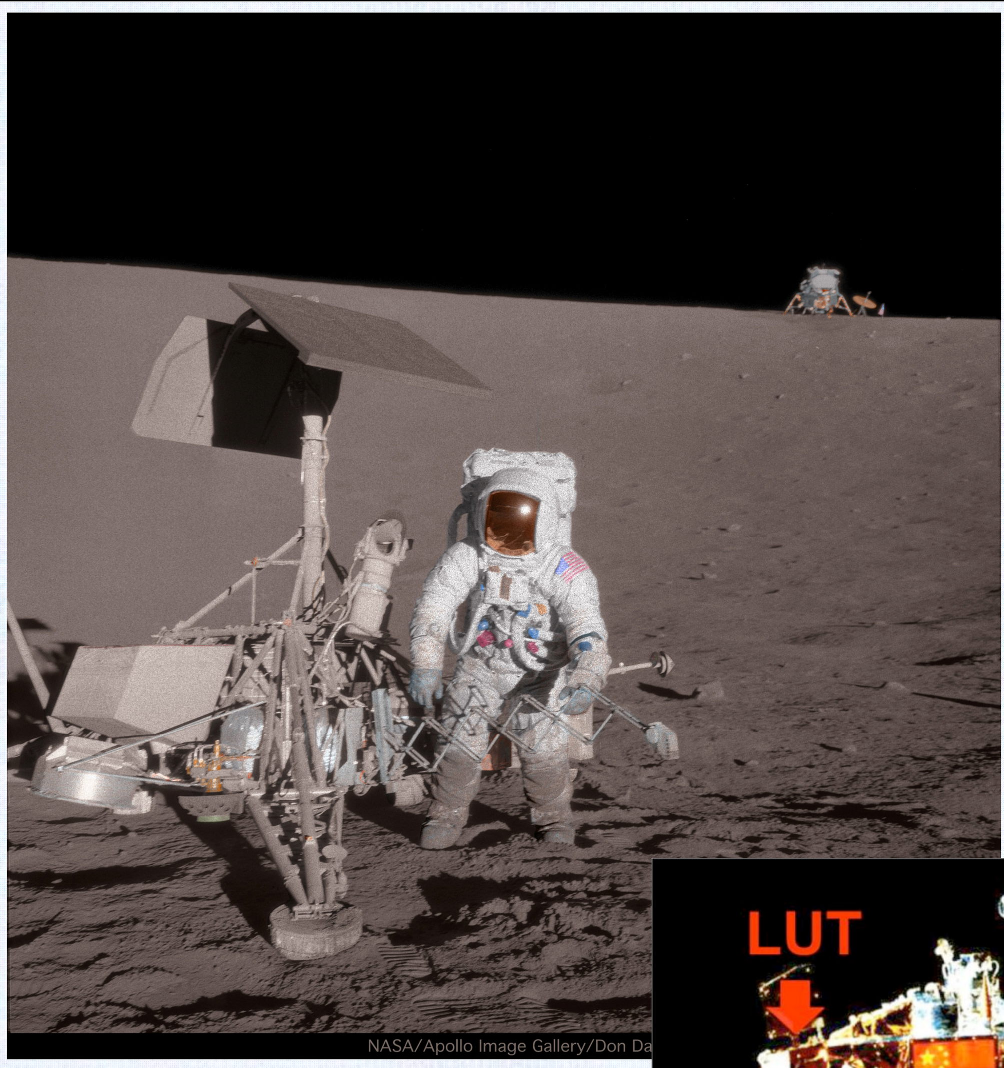
Access now available
- NASA CLPS – multiple missions per year with multiple payload bays
- Artemis – Starship HLS will have ~100 tons of downmass capability

No atmosphere
- Coherence time is limited by instrument (100s to 1000s of seconds)
- On earth, 1ms is typical
- A 2” aperture bests an 8m aperture in its first second of integration (and it keeps on integrating)

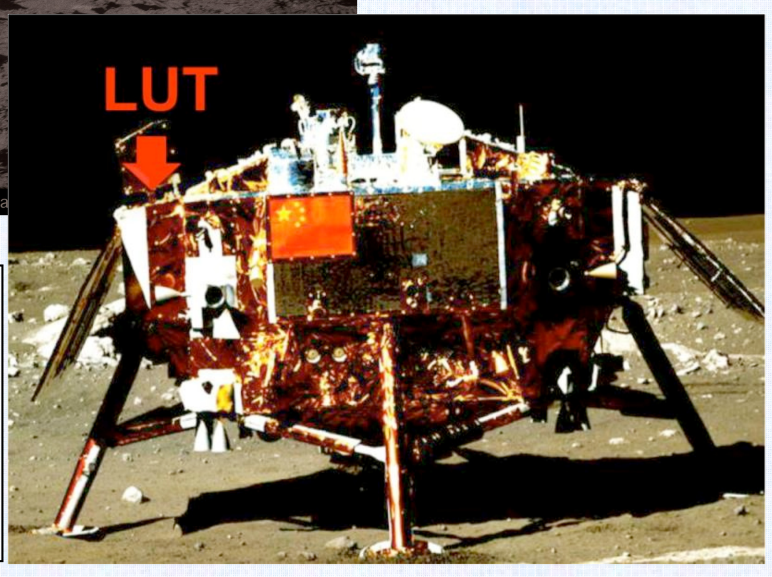
Low vibration
- Apollo seismic data shows a quiet (<20nm) background amplitude on ~weeks timescales

Station keeping & pointing
- No complicated, expensive, risky systems for formation flying; current state-of-the-art does not achieve interferometric requirements
- No reaction wheels for stabilizing telescope / pointing

Dust does not impede operations
- Years of stable operations demonstrated by LUT ultraviolet telescope aboard Chang’e-3 lander



Surveyor 3 and the Apollo 12 LM descent stage have station-kept 180 meters apart for the past 50 years, despite their derelict nature



The Chang’e-3 LUT operated on the lunar surface for more than five years

The lunar surface is ideal for visible light arrays with milli- to micro-arcsecond, highly sensitive capabilities

Mature Operations in Visible Astronomical Interferometry from the Ground

Relativistic, non-Keplerian orbits of stars about Sgr A*
- Cited in 2020 Nobel Prize

Circumstellar disk imaging
- Disk transiting the disk of eps Aur
- Warped disk of GW Ori

Object imaging
- Expanding fireball of Nov Del 2013
- Stellar surface of pi1 Gru, zet And
- Non-spherical surface of Altair
- The dusty veil dimming Betelgeuse

These results are all from marquee publications in Nature or Science, or a Nobel Prize
- Just the tip of the iceberg, much broader swath of astrophysics in past decade from optical interferometry

Multi-beam optical interferometry for astronomy is well-understood

The MoonLITE Team

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- Exoplanet host key science

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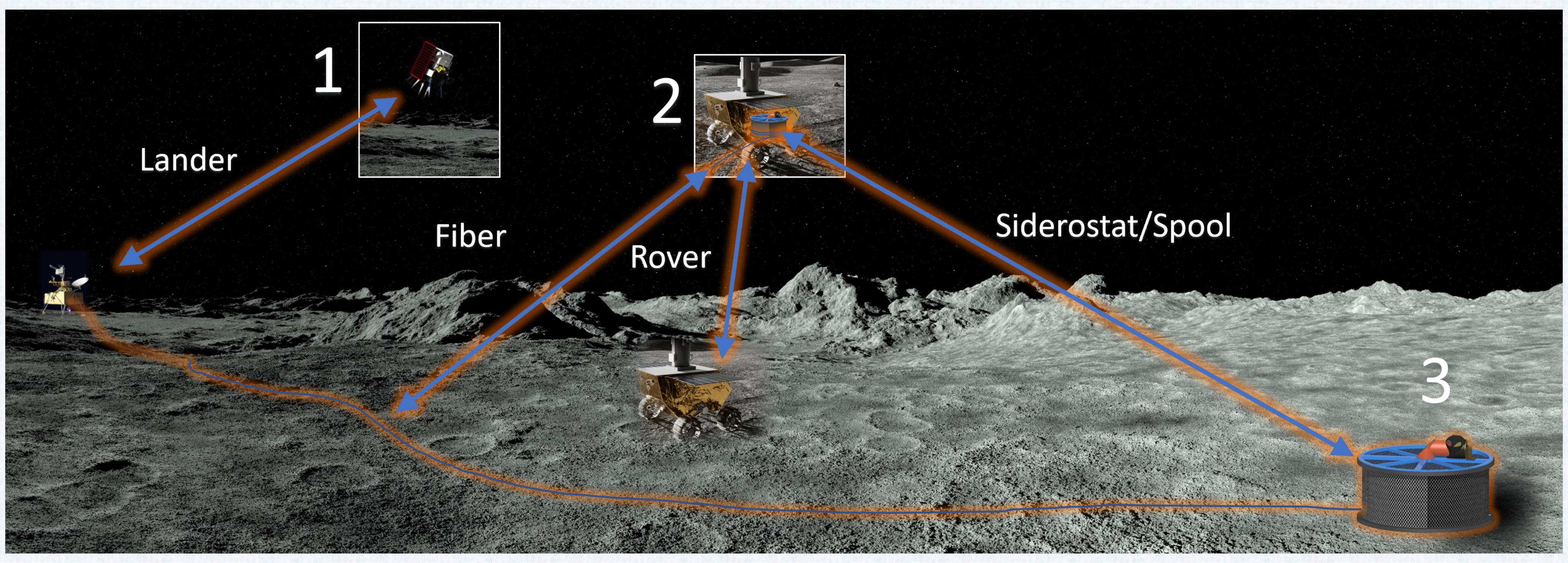
- Young binaries key science

MoonLITE CONOPs



Sensitive, sub-milliarcsecond resolution in the extreme minimum package

(1) Landing aboard a NASA CLPS Lander
- Commercially provided service

(2) Rover deploys outboard station 100m away
- Pre-loaded before liftoff, station gets simply set on surface
- Umbilical unreeled: fiber optic for beam relay, plus wire for outboard power/comms

After a single mechanical operation and the facility is ready to observe

(3) Calibration
- Station pointing models for outboard, inboard stations
- Baseline model from fringe tracking on astrometric references
- Follows standard operations of Earth-based optical arrays

Operations
- Lunar daytime ops, survive-the-night hibernation, and a second lunar day of ops (as prescribed by current NASA Pioneers guidelines)
- 300 hours of science operations per lunar day
- Goal (currently): six days of operations

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ONLINE RESOURCES

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