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P32A-02: Lunar Payloads to Constrain Exospheric Water through the NASA M-STAR program

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- **NASA M-STAR PROGRAM:** Minority University Research and Education Project (MUREP) Space Technology Artemis Research (STAR) was established to promote STEM literacy and to enhance the capability of institutions to participate in NASA's Space Technology Mission Directorate (STMD) opportunities to advance technologies needed for exploration of the Moon, Mars and beyond.
- **DELAWARE STATE UNIVERSITY (DSU):** located in Dover, DE, is a Historically Black University that prides itself in its proven excellence in teaching and research. It enrolls a diverse population of students (~5000) traditionally underrepresented in STEM disciplines.
- **NASA GODDARD SPACE FLIGHT CENTER (GSFC):** located in Greenbelt, Maryland, Goddard is NASA's premiere space flight complex and home to the nation's largest organization of scientists, engineers, and technologists who build spacecraft, instruments, and new technology to study Earth, the Sun, our solar system, and the universe.

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GOALS OF OUR PROJECT

- Develop low mass and power lunar rover payloads to enable long-duration human exploration missions
  - Wavelength modulation absorption spectroscopy (WMS) to detect water ($H^{16}OH$) and isotopes ($H^{16}OD$) in mid-IR (6700 nm)
  - Laser-induced breakdown spectroscopy (LIBS) to detect and correlate water isotopes with elemental composition of lunar regolith
- STEM engagement program to train students through payload development

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LUNAR WATER

- Our understanding of water cycles on the Moon has significantly enhanced recent observations by Chang E-5, Lunar Prospector, and Chandrayaan-1 missions indicating the existence of an active water cycle on the Moon
- Based on the diffusion models (timescales of 15 years and surface temperature of 360 K), it is estimated that the amount of water hosted by impact glass beads in lunar soils may reach up to 2.7 × 1014 kg.

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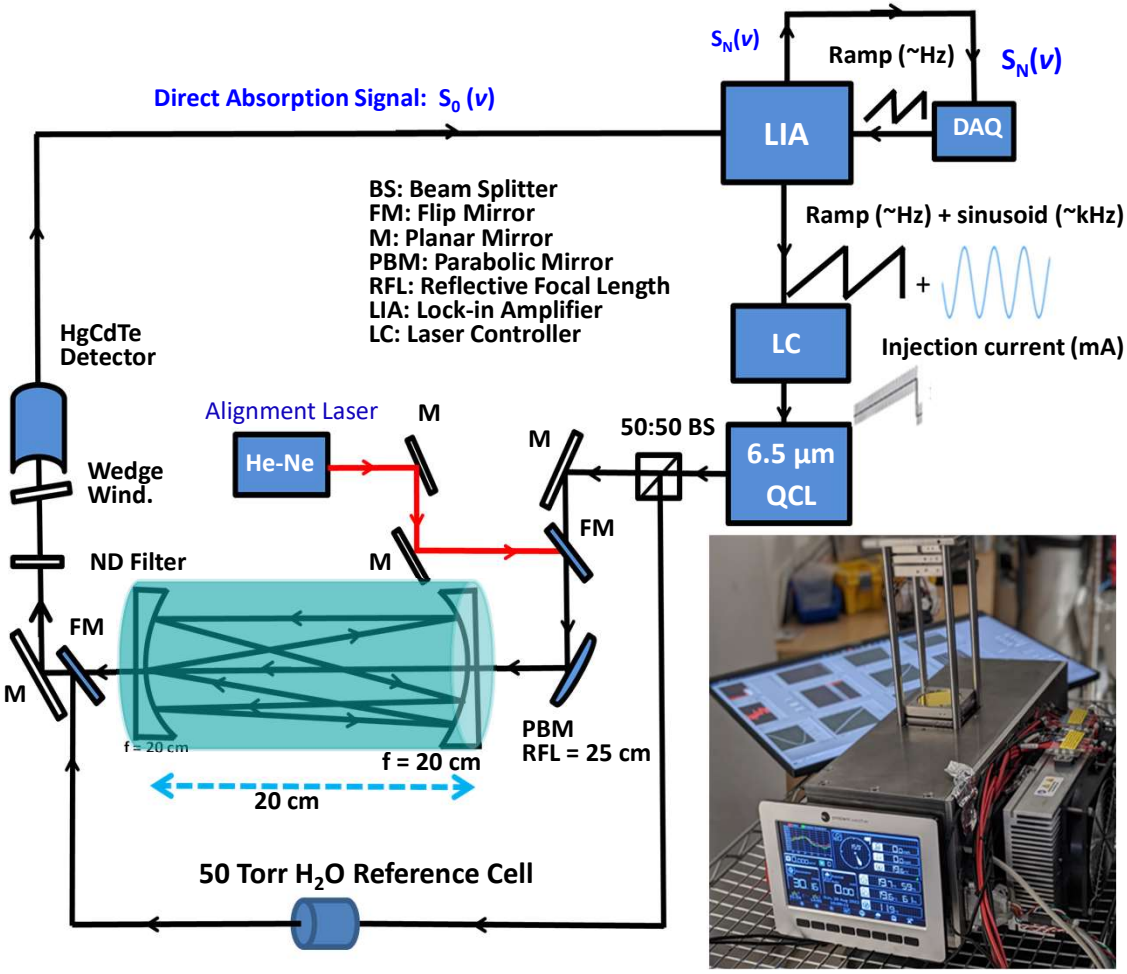
WMS PAYLOAD

- Detects water and isotopes($H^{16}OH$ & $H^{16}OD$) at 6.7 μm in the lunar exosphere
- Schematic of a WMS system and a prototype of an open-path mid-IR sensing system for methane with a custom 30 m Heriot cell
- A combination of 2f and 4f to resolve overlapping molecular line transitions



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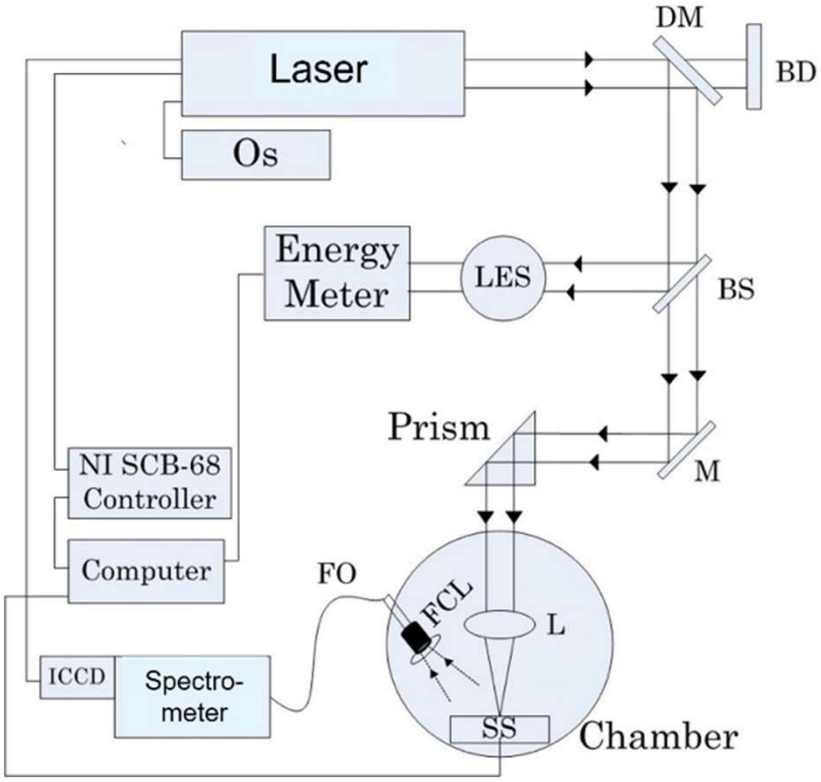
LIBS PAYLOAD

- Elemental composition of the Lunar regolith at the surface
- Ablate a small amount of the sample of interest with laser (Nd:YAG) and turns it into a luminous micro plasma which is then analyzed spectroscopically



BD – Beam Dump
DM – Dichroic Mirror
FO – Fiber Optic
L – Lens
M – Mirror
PD – Photodetector
SS – Sample Stage
FCL – Fiber Collimation Lens
LES – Laser Energy Sensor
ICCD – Intensified Charge-Coupled Device
Os- Oscilloscope

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STEM ENGAGEMENT ACTIVITIES

Goal: Strengthen and develop a workforce training program that engages underrepresented undergraduate and graduate students in NASA mission priority areas

- Recruitment and retention of DSU M-STAR Research interns
- Student training and development of water vapor CubeSat payload
- Workshop of NASA graduate and postdoctoral fellowships
- Summer Research Program, Lunar explorer VR APIs, and Citizen's Science Sensing
- Summer Bootcamps and workshops

Photo credit: Dan Linehan, LLNL

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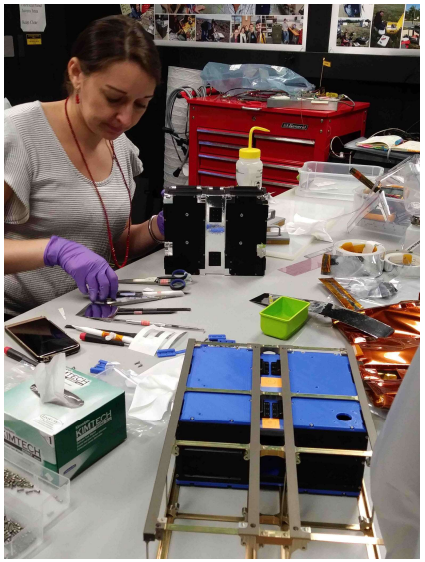
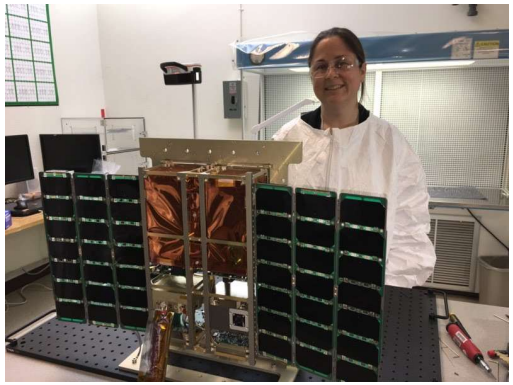
STEM COLLABORATION WITH GSFC

Students will develop CubeSat payloads capable of identifying regions near the lunar surface that have a higher abundance of water vapor





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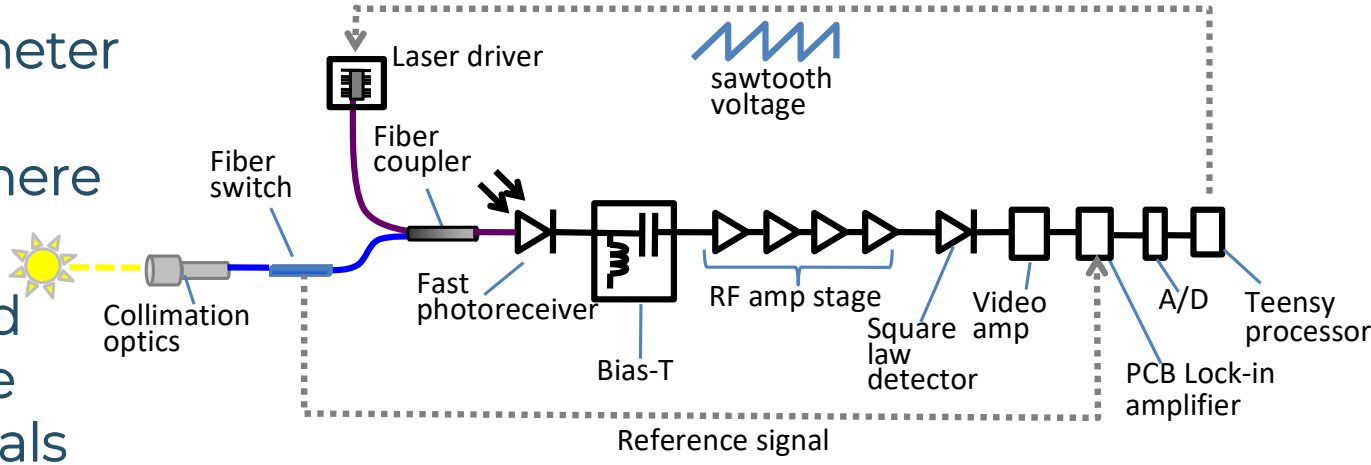
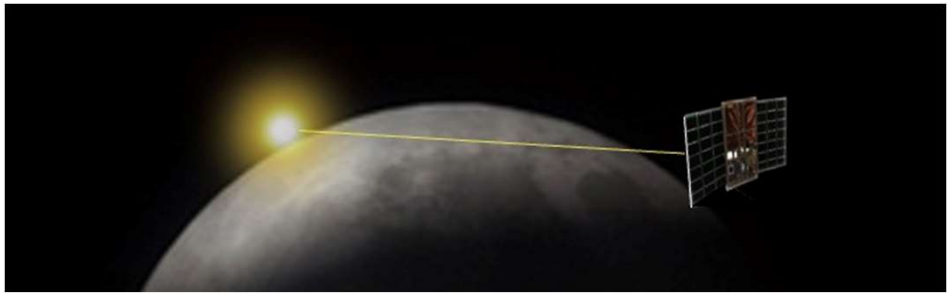
STEM – WATER VAPOR CUBESAT PAYLOAD

- Laser heterodyne radiometer passively observes water vapor in the lunar exosphere at dawn and dusk
- Sunlight is superimposed with laser light in a single mode fiber coupler. Signals are mixed in a fast photoreceiver to produce a beat signal.
- Laser scans across absorption feature





THANK YOU

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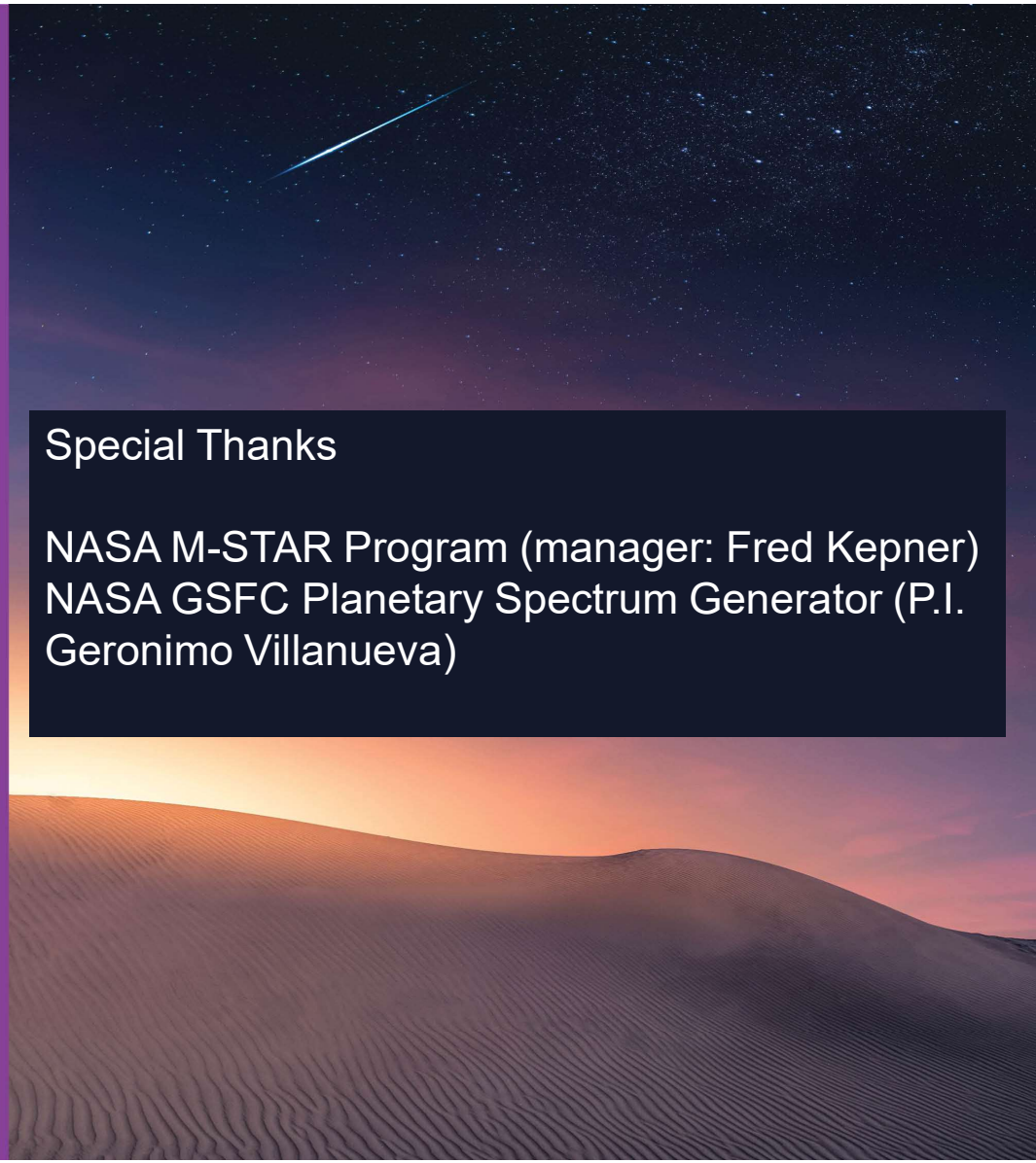

Special Thanks

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