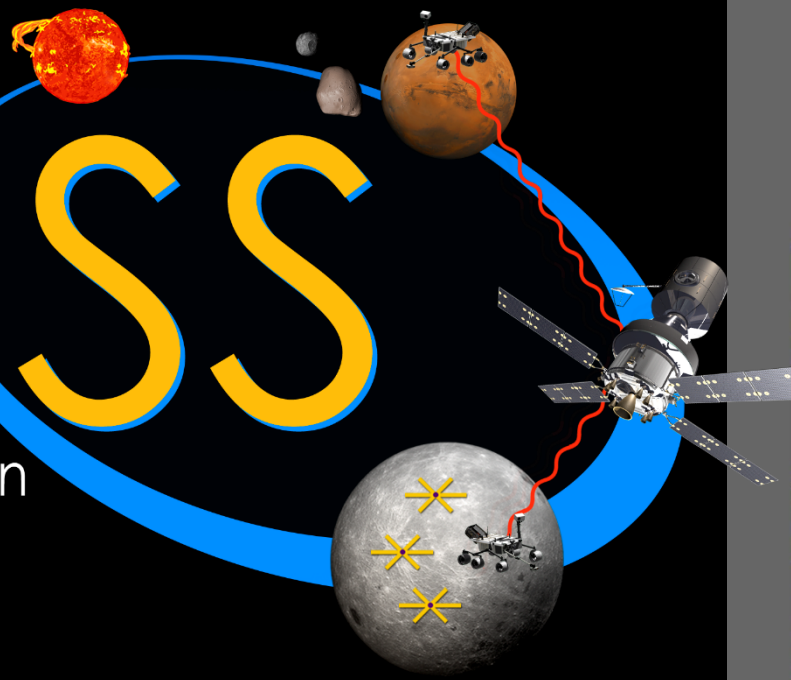
NESS

Network for Exploration and Space Science



SERVI — Solar System Exploration Research Virtual Institute

University of Colorado Boulder

NASA

University of Michigan

UCLA

NRAO

ASU

Caltech

Ball Aerospace

Lockheed Martin

NESS

AAS 232nd MEETING
AMERICAN ASTRONOMICAL SOCIETY
DENVER, COLORADO · 3-7 JUNE 2018

Meeting-in-a-Meeting

June 5 – 6, 2018 · Denver, Colorado

The space environment, particularly the farside of the Moon, will further open a window to the low radio frequency universe. Join us to learn more.

SESSION 1:
Low Radio Frequency Heliophysics from Space

Robert MacDowall (NASA GSFC)
Heino Falcke (Radboud U.)
Sofia Moschou (SAO)
Thejappa Golla (U. Maryland at NASA GSFC)
Justin Kasper (U. Michigan)

Radio cubesats and space-based arrays will investigate the impacts of the Sun's activity, interplanetary plasmas, and interstellar inputs on the energetic particle and dust environment in the inner solar system.

SESSION 2:
Magnetospheres & Space Weather Environments of Extrasolar Planets

Invited Speakers

Gregg Hallinan (Caltech)
Peter Williams (CfA)
Joseph Lazio (NASA JPL)
Rachel Osten (STScI)
Jake Turner (U. Virginia)

Low frequency radio arrays will probe extrasolar space weather and detect magnetospheres of potentially habitable exoplanets.

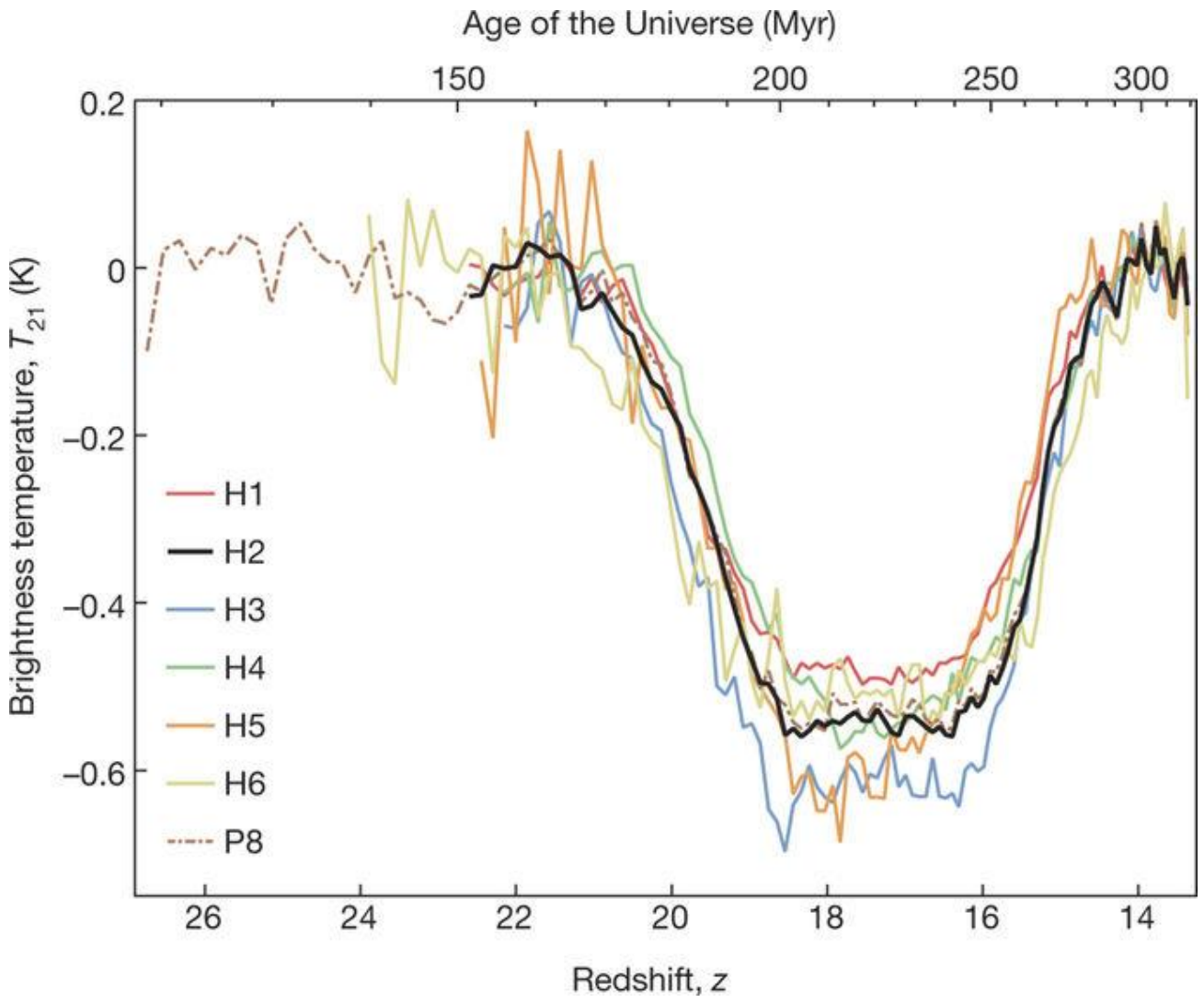
SESSION 3:
Redshifted 21-cm Hydrogen Cosmology from Space

Judd Bowman (ASU)
Jonathan Pober (Brown U.)
Anastasia Fialkov (CfA)
Jack Burns (U. Colorado)
David Rapetti (U. Colorado & NASA Ames)

Hydrogen cosmology with single antennas (monopole) and arrays (power spectrum) will open a new window into Cosmic Dawn.

Please visit the NESS website at www.colorado.edu/ness or the AAS website at www.aas.org/meetings/aas232 for more information.

First Detection of Hydrogen Signal from Cosmic Dawn by members of NESS!

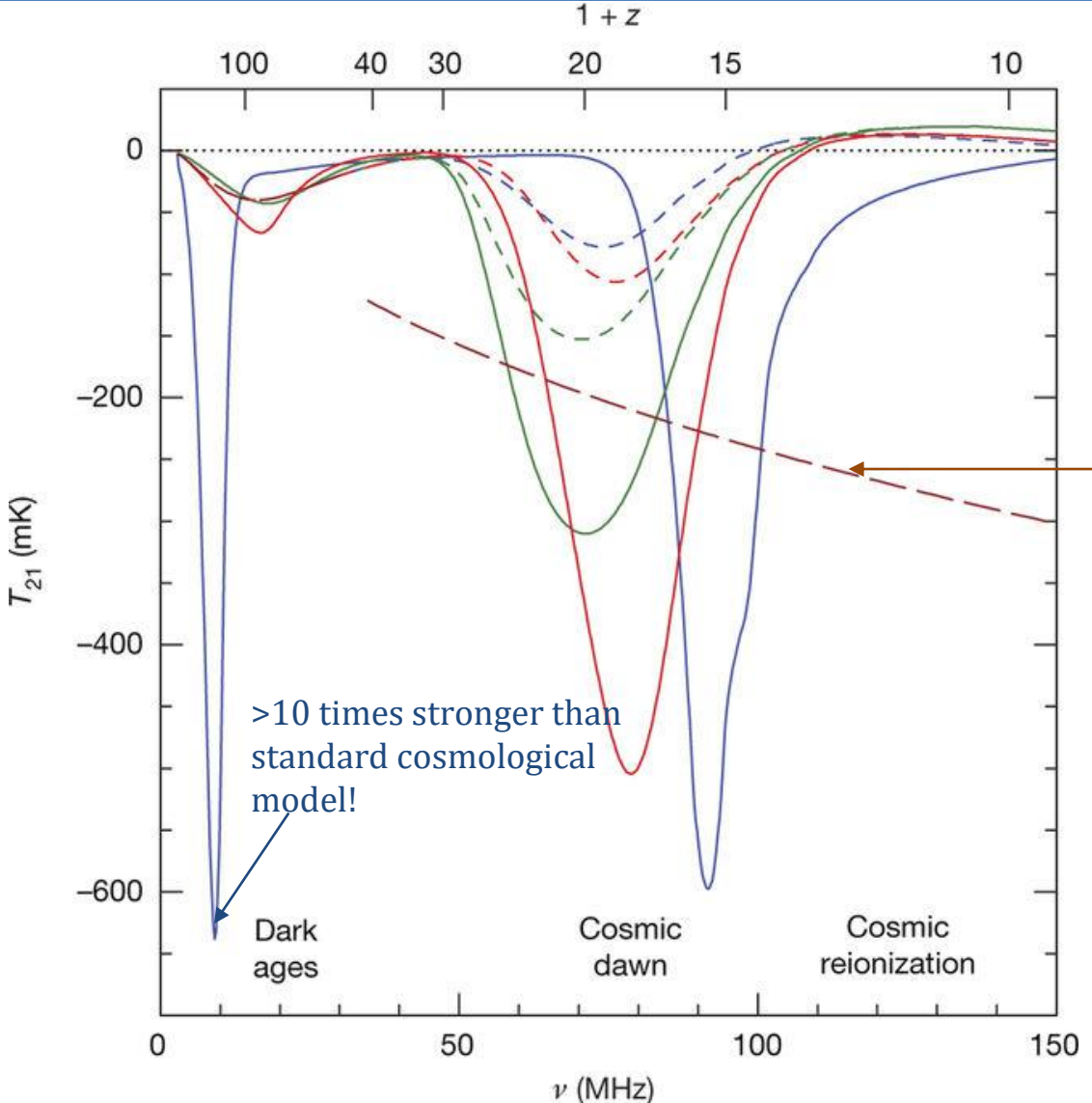


- Ground-based experiment EDGES measures a 78 MHz absorption profile consistent with the global 21-cm from Cosmic Dawn.
- The thick black line is the model fit for the hardware and analysis configuration with the highest signal-to-noise ratio (equal to 52; H2).
- The thin solid lines are the best fits from each of the other hardware configurations (H1, H3–H6).

Bowman*, Rogers, **Monsalve***, Modzen, **Mahesh***, Nature 555, 67 (2018).

*funded members of NESS team

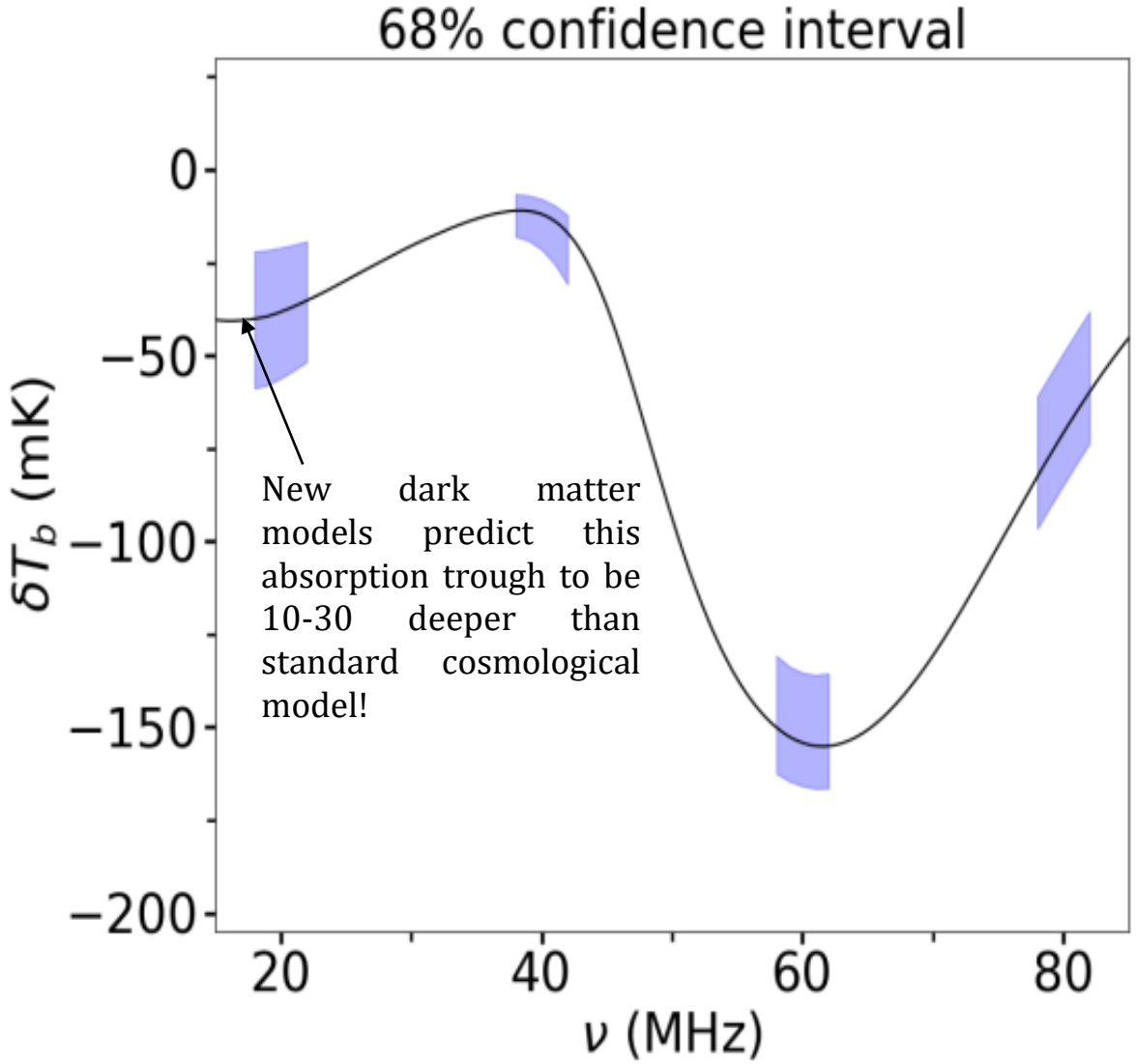
Potential implications for Dark Matter and a Lunar SmallSat mission



- The unexpected depth of the signal triggered new theoretical efforts, including scattering between baryons and dark matter.
- The brown long-dashed line corresponds to the standard prediction for the lowest global 21-cm signal at each redshift that is possible with no baryon–dark matter scattering.

Barkana, Nature 555, 71 (2018)

Dark Ages Polarimeter PathfindER (DAPPER)



- DAPPER is a mission concept for a NASA Astrophysics SmallSat that will detect the expected 21-cm signal at 4 key frequencies operating down to 10 MHz.
- The **black curve** shows the input signal.
- The blue bands include thermal and systematic (instrument + foreground) errors using our Pattern Recognition data analysis pipeline (pylinex).

SSERVI Monthly Report
NESS/PI Burns - February, 2018

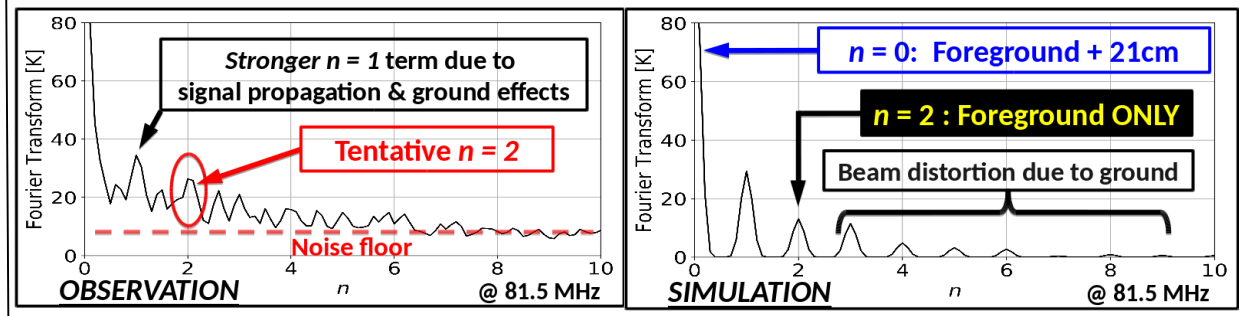
Progress Report

- **Paper:** Airapetian,..., **Hallinan** et al., 2018, "Life Beyond the Solar System: Space Weather and Its Impact on Habitable Worlds", white paper submitted to the National Academy of Sciences in support of the Astrobiology Science Strategy for the Search for Life in the Universe.
- **Seminars:** (1) **Monsalve** presented an NRAO Colloquium in Socorro, NM on February 2 about "Illuminating the Cosmic Dawn with Sky-Average Radio Measurements". (2) **Burns** presented a lecture entitled "Our Future in Space: Humans, Robots, & Telescopes Exploring Together" at the Institute for Human & Machine Cognition, Pensacola, FL on February 22.
- **Organization: Burns** was part of the organizing committee for the *Deep Space Gateway Science Workshop* in Denver from February 27 to March 1 with 300 attendees.
- **Meetings:** a) Papers presented at the Aspen meeting on Cosmic Dawn: (1) **Burns** on "Extraction of the Global 21-cm Signal from Foregrounds Using Dynamic Polarimetry and Pattern Recognition", (2) **Tauscher** on "Using training sets and SVD to separate global 21-cm signal from foreground and instrument systematics", (3) **Bowman** on "Latest Results from EDGES", (4) **Mebane** on "The Persistence of Population III Star Formation", (5) **Monsalve** on "Constraints on the Global Redshifted 21-cm Signal with EDGES Data Over 90-190 MHz", (6) **Mirocha** on "Metrics for Disentangling PopII and PopIII Contributions to the 21-cm Background". b) Papers presented at the *DSG Science Workshop*: (1) **Tauscher** on "The Gateway to Cosmic Dawn: A Low Frequency Radio Telescope for the DSG"; **Mellinkoff** on "Operational Constraints of Low-Latency Telerobotics from the DSG Due to Limited Bandwidth"; **Walker** on "VR Simulation Testbed: Improving Surface Telerobotics for the DSG"; **Burns** on "Space Science and Exploration on the Lunar Farside Facilitated by Surface Telerobotics from the DSG"; **MacDowall** on "Importance of a Low Radio Frequency Interference Environment for the DSG"; **Monsalve** on "Telerobotic Deployment and Operation of a Lunar Farside Low Radio Frequency Cosmology Telescope from the DSG"; **Rapetti** on "Hydrogen Cosmology from the DSG: Data Analysis Pipeline for Low-Frequency Radio Telescopes"; **Bowman** on "Lunar Farside Radio Array Pathfinder Enabled by the DSG"; **Kring** on "Accessing the Lunar Farside and Facilitating Human-Assisted Sample Return with the DSG"; **Cichan** on "Communications Relay and Human-Assisted Sample Return from the DSG"; **Kasper** on "Heliophysics Radio Observations Enabled by the DSG"; **Kring** on "DSG Support of Lunar Surface Ops and Tele-Operational Transfer of Surface Assets to the Next Landing Site"; **Fong** on "Telerobotics of Orbiting and Surface Assets".

Upcoming Events

(1) **MacDowall** will present at the *Triennial Earth-Sun Summit* in Leesburg, VA (May 20-24) on "Complex Type III radio bursts and Their Correlation with Solar Energetic Particle Events". (2) **Hegedus & Kasper** will present at the *TESS* Forum on the topic of lunar radio arrays applied to tracking Type II & III bursts out to .5 AU. They have 2 fluid MHD simulations that will inform radio emission models that will be propagated through different lunar radio array models.

Moment of Science:

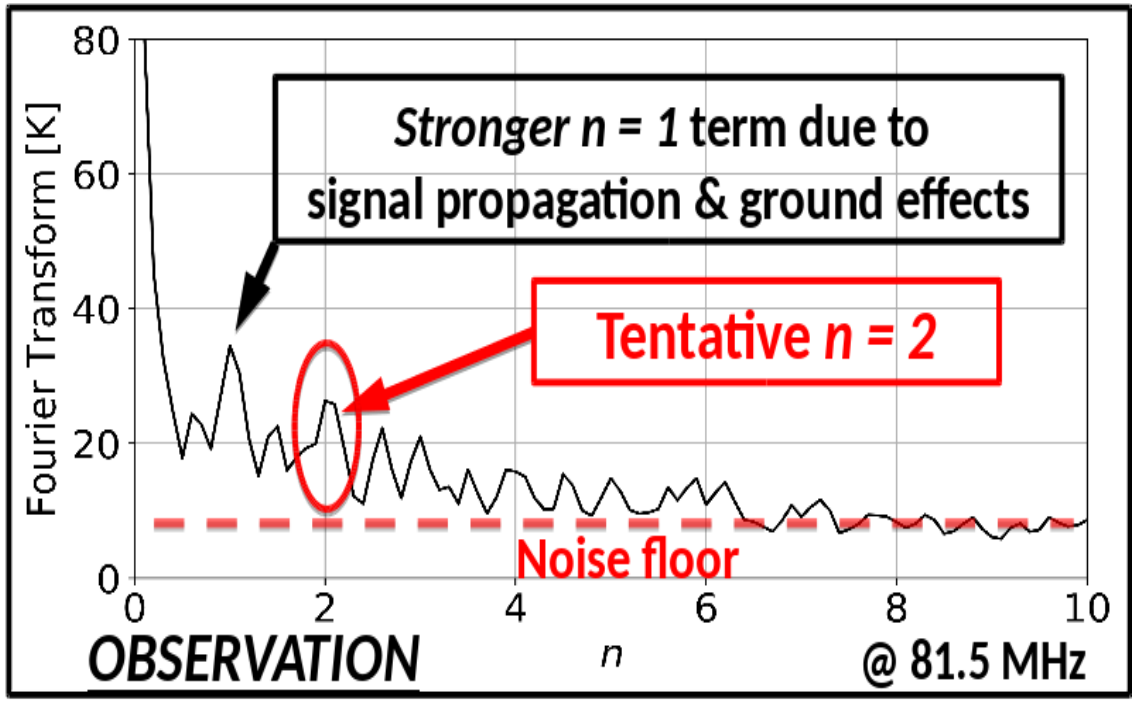


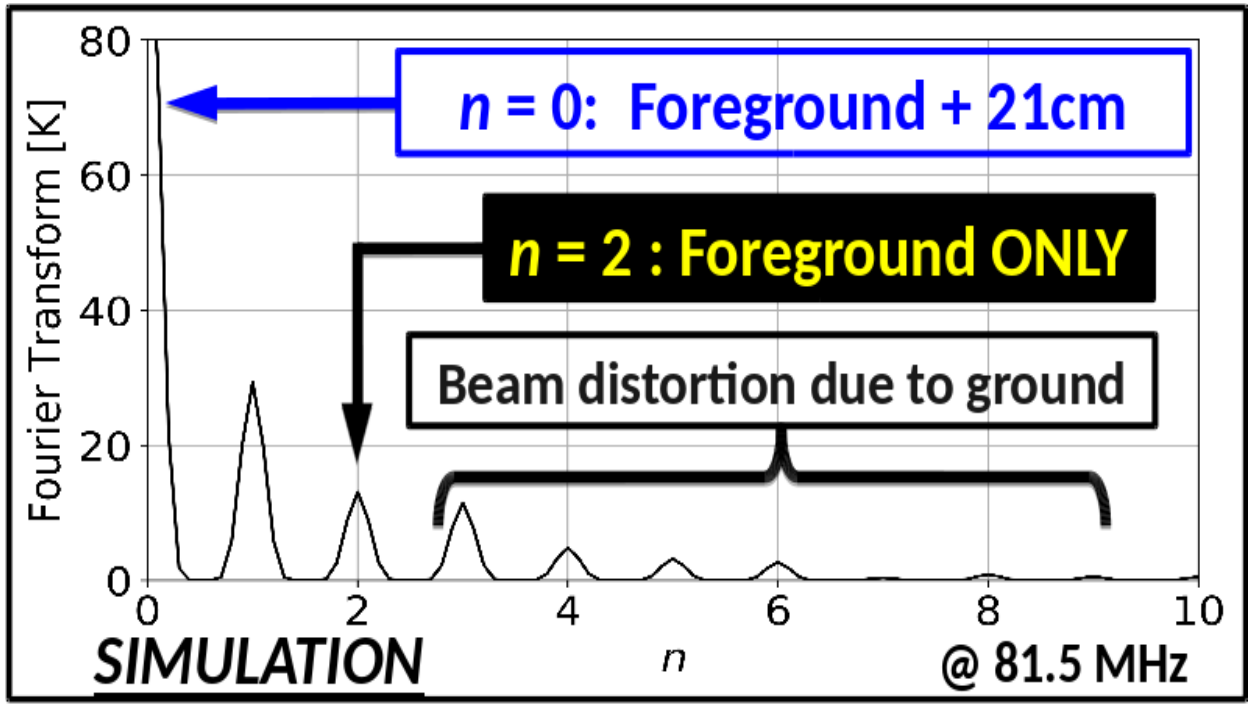
Caption: Preliminary analysis of the Cosmic Twilight Polarimeter (CTP) Stokes Q data at 81.5 MHz (left panel) suggests a tentative detection on the second harmonic (n=2) corresponding to the modulated signature of the projection-induced polarization effect, as predicted by simulation (right panel). The n=2 component represents the twice diurnal nature of the modulation. This twice diurnal signal provides a direct constraint of the foreground synchrotron spectrum without the use of conventional logarithmic polynomial fit. The dynamical characteristic of this twice diurnal Stokes spectrum allows the foreground to be measured without confusion from the isotropic 21-cm background. Polarimetry is a key technology development for a lunar-based low radio frequency cosmology telescope. Research from CU grad student B. Nhan, Co-I Bradley, and Burns.

2/26/2018

February Moment of Science

Cosmic Twilight Polarimeter first measurements

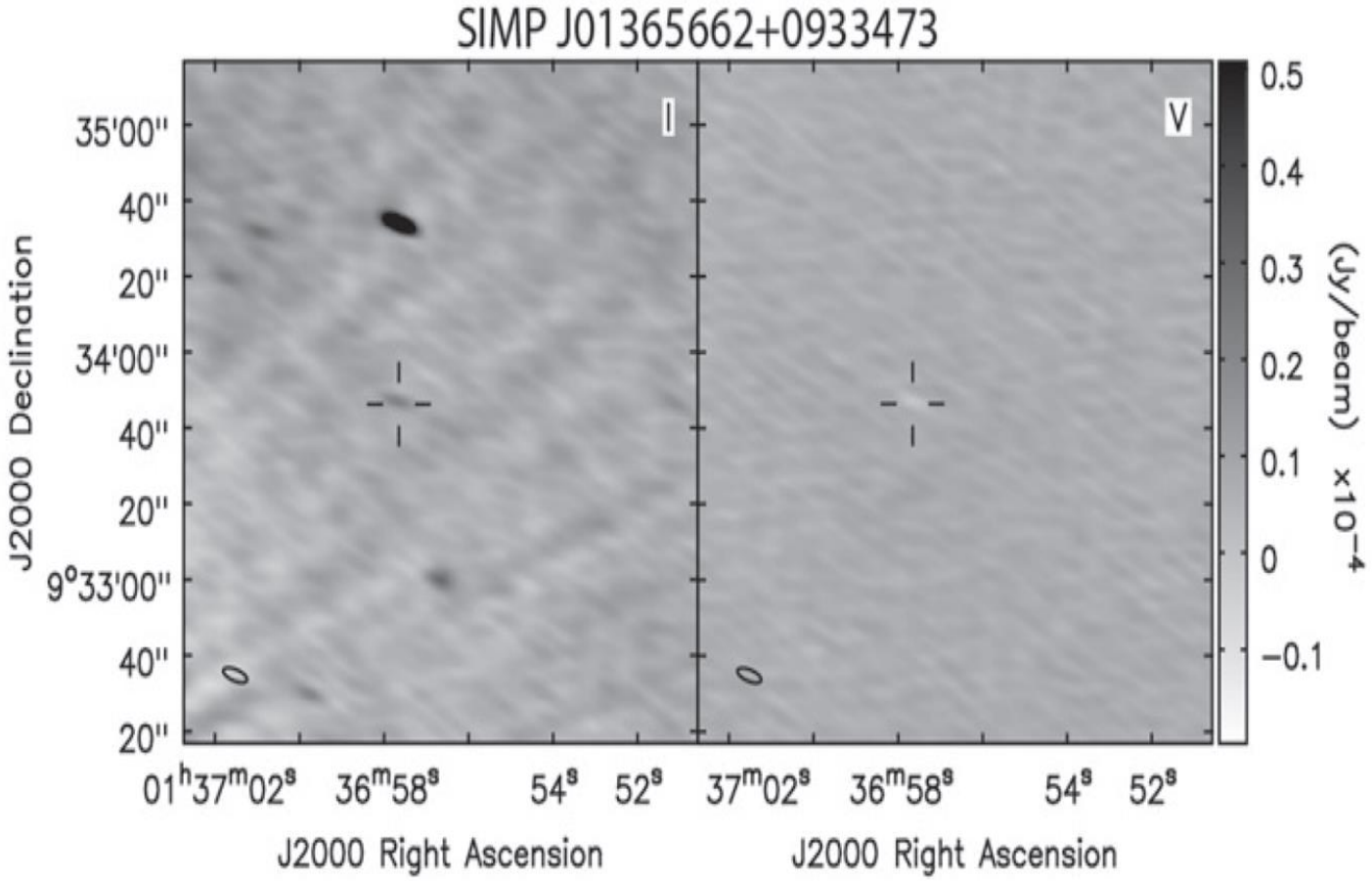




- Preliminary analysis of the Cosmic Twilight Polarimeter (CTP) Stokes Q data at 81.5 MHz (left panel) suggests a tentative detection on the second harmonic (n=2) corresponding to the modulated signature of the projection-induced polarization effect, as predicted by simulation (right panel).
- The n=2 component represents the twice diurnal nature of the modulation, which provides a direct constraint of the foreground synchrotron spectrum without the use of conventional logarithmic polynomial fit.
- Polarimetry is a key technology development for a lunar-based low radio frequency cosmology telescope.
- Research from Colorado NESS-funded grad student **B. Nhan**, and Co-I **R. Bradley**, and **J. Burns**.

Selected Moments of Science

Possible detection of the first radio exoplanet

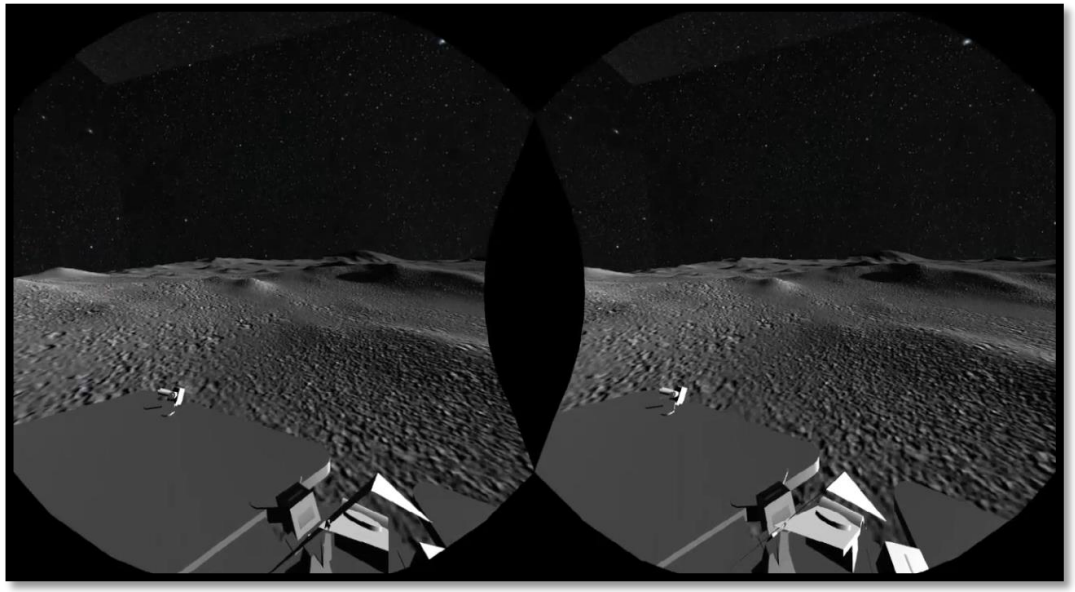


Kao et al., submitted (2017)

- A radio image with the JVLA of the T2.5 dwarf SIMP J01365662+0933473 in Stokes I and V.
- This object was recently confirmed to have a mass of $12.7 \pm 1\ M_{Jupiter}$, and is possibly a free floating planetary mass object.
- It produces a periodic pulse of highly circularly polarized radio emission every 2.4 hours.
- This work is from NESS Co-I **G. Hallinan's** group at Caltech.

Selected Moments of Science

Virtual and Augmented Reality for Lunar Telerobotics



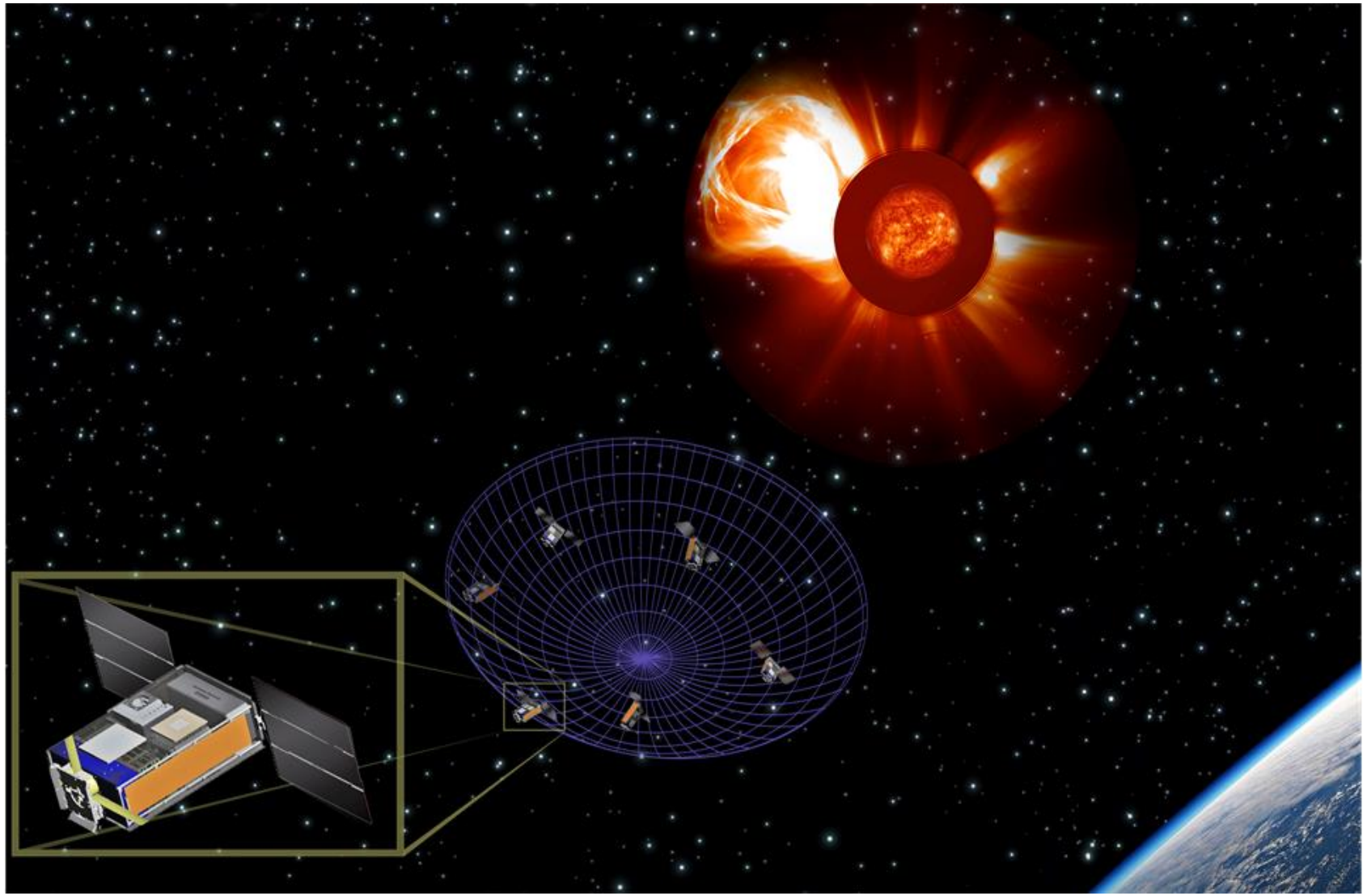
Stereoscopic Lenses

1 km x 1 km area near the Hermite A crater, located near the north pole of the Moon. The synthetic digital elevation model is based on publicly available images and laser altimetry of the Hermite A region that were acquired with LRO. Thanks to T. Fong.

- Virtual rover and lunar surface as seen from a virtual reality head-mounted display.
- This experimental framework allows for 3rd and 1st person rover teleoperation for user studies, user training, and rapid prototyping of user interfaces and rover designs — all without the need of physical hardware.
- This is research led by NESS-funded Colorado Computer Science graduate student **M. Walker**, NESS Collaborator Prof. **D. Szafir**, **J. Burns**, and NESS Co-I **T. Fong** (ARC).

Selected Moments of Science

Sun Radio Interferometer Space Experiment



SunRISE Mission

- The Sun Radio Interferometer Space Experiment (SunRISE) was selected for a Phase A study as a Heliophysics Explorer Mission of Opportunity.
- Specifications: 6 cubesats spread over 10 km, 6U form factor (10x20x30 cm), GEO+ orbit, 0.1-25 MHz, 0.1s time resolution.
- Proposed Launch: July 2022
- SunRISE will image bright solar radio bursts to track the origin and transport of solar energetic particles.
- NESS Co-I **J. Kasper** is the PI of SunRISE.