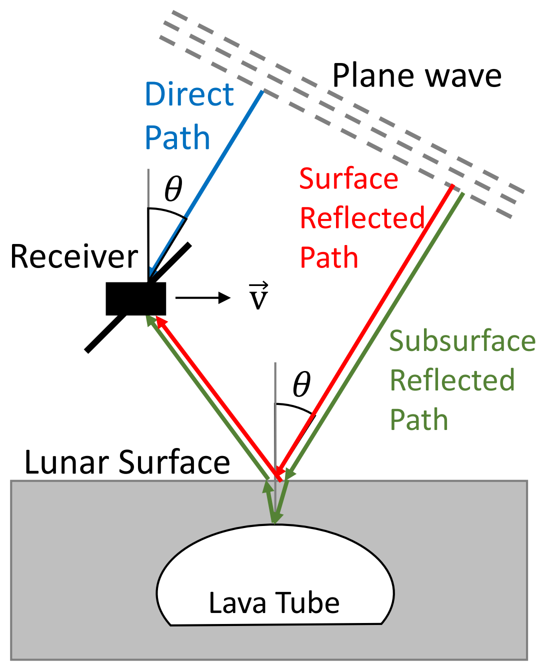
PASSIVE SOUNDING OF LUNAR LAVA TUBES. A. Romero-Wolf[1,*], G. Franklin[1], D. Hawkins[1], M. Haynes[1], M. Lee[1], J. Liu[1], C. Devin[1], S. Peters, D. Robison[1], D. Schroeder[2], [1]Jet Propulsion Laboratory, California Institute of Technology, [2]Stanford University, [*](Andrew.Romero-Wolf@jpl.nasa.gov).

Introduction: Evidence suggests lunar lava tubes exist in the Moon's subsurface and could serve as potential sites for human bases. A passive sounding technique has been developed at JPL to use radio emissions from the Sun, Jupiter, or Earth's Auroral Kilometric Radiation (AKR) as signals of opportunity to detect subsurface reflections from orbit [1, 2] or from the ground [3] using a lander or a rover. The technique was recently demonstrated using quiescent radio emission from the Sun [4]. Passive sounding does not require a transmitter and has significantly more relaxed requirements on the antenna front-end. The inherently lower resource needs of this approach would enable low-cost smallsat or small rover missions aimed at revealing the Moon's subsurface lunar lava tubes. We present an instrument that can survey and characterize lunar lava tubes in the equatorial regions of the Moon. Although this proposal is focused on lunar exploration, the design can be applied for sounding the subsurface of other Solar System objects, exploiting the natural radio emissions from the Sun or Jupiter.

Passive Sounding: This technique works by recording the voltage waveforms from a single receiver and computing the autocorrelation of the signal as a function of delay (see Figure). A reflected signal appears as a delayed and attenuated peak in the autocorrelation. As in traditional radar measurements, the delay results from the propagation path of the signal and the magnitude of the peak is determined by the radar cross-section of the target. Provided the surface roughness is not so extreme as to completely scramble the reflected signal, the random phase of the source is not the main limitation since the correlation technique removes it, as is typically done in radio astronomical observations.

Expected Sensitivity: Jovian L-bursts occur at deeply penetrating frequencies 0.3 – 35 MHz and have a typical instantaneous bandwidth of ~3 MHz [5], which provides a depth resolution of ~50 m. Using a model of the Jovian flux, lunar surface roughness, and lunar soil dielectric properties including attenuation, it is expected that lunar lava tubes as deep as to 300 m depths can be detected with signal-to-noise ratios of 10 dB or greater. The sensitivity is limited by the integration time allowed by the orbital motion of the spacecraft. A rover does not have this limitation which gives it the potential to observe lava tubes up to these depths with ~50 dB signal strength.

Conclusions: The instrument concept presented here has the potential to provide a low-resource survey of lunar lava tubes from a smallsat platform. A lander or rover-based implementation of this instrument could then characterize these lava tubes in significantly greater detail to assess their potential for human habitats



on the Moon.

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References:

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