

LUNAR GRAVITATIONAL WAVE ANTENNA. J. Harms¹ for the LGWA Concept Team, ¹Gran Sasso Science Institute, Via Michele Iacobucci 2, 67100 L'Aquila, Italy, jan.harms@gssi.it

Monitoring of vibrational eigenmodes of an elastic body excited by gravitational waves (GWs) was one of the first concepts proposed for the detection of GWs. At laboratory scale, these experiments became known as resonant-bar detectors first developed by Joseph Weber in the 1960s. Due to the dimensions of these bars, the targeted signal frequencies were in the kHz range. Weber also pointed out that monitoring of vibrations of Earth or Moon could reveal GWs in the mHz band. His Lunar Surface Gravimeter experiment deployed on the Moon by the Apollo 17 crew had a technical failure, which made it impossible to carry out a search for GWs.

Here, we present the Lunar Gravitational-Wave Antenna (LGWA) concept recently submitted in response to the ESA call for ideas for a lunar exploration from the European Large Logistic Lander (EL3) [1] and expanded in a paper [2]. We give an overview of the technical challenges of realizing its science payload, i.e., a high-performance seismometer, and of the deployment and operation of the experiment. The development of the required seismometer technology has already started as part of the R&D for seismic isolation and control systems of next-generation, terrestrial, laser-interferometric GW detectors. Three orders of magnitude in seismometer sensitivity need to be gained relative to the best demonstrated sensitivities today in the mHz band.

Key to the planning of LGWA is our understanding of the lunar interior and the lunar surface conditions. The elastic properties of the Moon from its center to the surface determine the Moon's response to GWs. With the seismic observations from the Apollo era, preliminary models of Moon's interior were constructed, but the information is not sufficient to make accurate predictions of the Moon's GW response in the mHz band. New lunar geophysical missions would provide crucial insight into the lunar interior structure and elastic properties also for the benefit of LGWA. Furthermore, a more detailed understanding of the lunar surface temperatures can strongly impact the design and expected performance of LGWA seismometers. Cold and thermally stable regions are preferred. Regions with temperatures constantly below 40K were found in permanent shadows near the lunar south pole by the Diviner Lunar Radiometer Experiment, which might enable the implementation of superconductor technology. In such environments, even vibration-free Helium sorption cooling might be

an option to further stabilize and reduce the temperature of the system and thereby increase the seismometer sensitivity.

[1] Harms J. et al (2020), ESA: Ideas for exploring the Moon with a large European lander
<https://ideas.esa.int/servlet/hype/IMT?documentTableId=45087631479655658&userAction=Browse&templateName=&documentId=8e0afc17112fe0a1017f5ba30bce54d3>

[2] Harms J. et al. (2020)
<https://arxiv.org/abs/2010.13726>.