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Concept Design of the Astrophysical Lunar Observatory Interferometric Array

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The far side of the Moon is a radio-quiet location uniquely suited to performing sensitive low-frequency radio measurements that are not possible to do from Earth, due to Earth's ionosphere scattering and attenuating radio frequencies below ~30 MHz. In low-frequency radio astronomy, one of the major open questions is what the power spectrum of the redshifted neutral hydrogen signal from the early Universe looks like. This signal provides us with a unique view into the history of the Universe before and during the formation of the first stars, showing the process of structure formation and reionization from z=200 to z=6. This range can be divided into the 'Dark Ages', before the first stars, from z=200 to z=30, and the 'Comic Dawn' from z=30 to z=6.

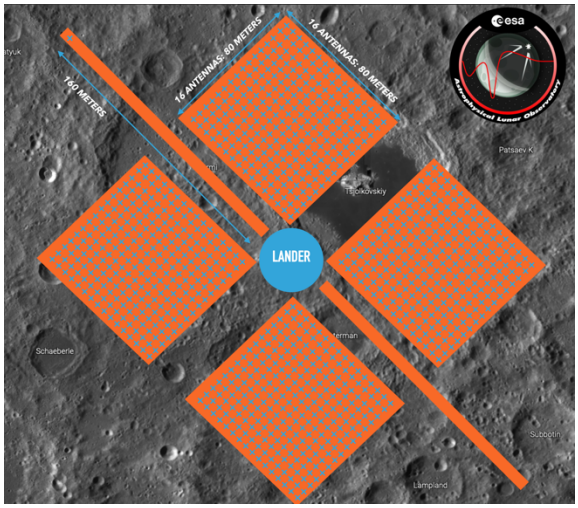

Figure 1: Early concept design for a full-scale interferometric array for ALO. The antenna arrays are printed on kapton foil and unrolled from the lander (middle). Separate outrigger antennas are placed away from the array.

To successfully characterize the spatial power spectrum of the redshifted neutral hydrogen signal, considerable integration time is required over the relevant angular scales on the sky. A compact, dense, regularly spaced interferometric array of dipole-style antennas is the optimal way to obtain sufficient SNR over the measurement period for this measurement [1]. In June 2021, a series of Concurrent Design Facility (CDF) sessions was held online as part of the ESA Astrophysical Lunar Observatory (ALO) Topical Team activities. This topical team operates in the context of the European Large Logistics Lander program to work out a preliminary design for such an array, capable of being delivered as payload on a single EL3 [2]. This CDF involved an extensive team of ESA engineers as well as our low-frequency radio astronomy science team.

In the sessions that were held as part of this CDF, we made use of an online notebook that was capable of simulating the performance of a user-defined low-frequency array regarding the measurement of redshifted neutral hydrogen power spectra. In this talk, I will outline how this simple tool helped in the design iteration process, I will present the results of this CDF session, and I will highlight the required technological developments needed for a full-scale interferometric array as part of the ALO.

[1] Koopmans, L., "The Cosmic Dawn and Epoch of Reionisation with SKA", *Advancing Astrophysics with the Square Kilometre Array (AASKA14),* 2015. doi:10.22323/1.215.0001.

[2] B. García Gutiérrez, "CDF Study Report, ASTROPHYSICAL LUNAR OBSERVATORY: Assessment of an Astrophysical Lunar Observatory on the farside of the Moon", ESA, 2021.