Astronomical Lunar Observatory

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At the European Space Agency (ESA) a concept is currently being developed for a number of repeated Lunar landing missions with a so-called European Large Logistics Lander, or EL3 (see Figure 1). In conjuncture with international initiatives such as the NASA Lunar Gateway, the EL3 program aims to provide European autonomy for combined science and human exploration of the Moon. The EL3 provides up to 1500kg of cargo to be delivered to the lunar surface, and currently the launch date is in the 2027-2029 range, with repeated missions planned every 3 to 4 years. While the first of these EL3 missions aims for the Lunar South Pole, subsequent missions will also target the lunar far side.

Figure 1. Concept of the EL3 lander (credit: ESA/ATG-MediaLab)

From an astronomical point of view, the ability to provide a significant payload to the lunar far side, provides a unique opportunity for **low-frequency radio** science through the absence of an atmosphere and the attenuation of the man-made RF signals (RFI) on the lunar far side. There is a wealth of science to be addressed in the low-frequency radio regime, ranging from the study of Solar and Jupiter emission to the detection of exo-planets, but the real treasure-trove is the detection and imaging of the redshifted 21-cm line emission from the neutral Hydrogen in the pristine periods of the universe known as the cosmological Dark Ages (DA) and the Cosmic Dawn (CD; e.g. Jester & Falcke, 2009 and references therein). The only conceivable signal from the CD and DA comes from the hyperfine 21-cm line from neutron Hydrogen caused by the spin flip of the electron. The high redshift involved causes this emission to appear in the frequency range between 1.4 – 140 MHz, with the global DA and CD signals peaking around 30 MHz and 70 MHz, respectively, and being rather broad, hence requiring space-based or lunar-based low-frequency radio instrumentation. As explained by Jester & Falcke (2009), observing the two-dimensional structure of the neutral and reionized hydrogen gas at different frequencies corresponding to different emission redshifts, can provide a tomographic movie of the Dark Ages. This would require a large **lunar far side radio distributed interferometer** to cover the 1-80 MHz regime with ultimately several arcminute-scale spatial resolution and the ability to detect cosmological milli-Kelvin brightness fluctuations.

Here we report on the formation of a Topical Team to define an Astronomical Lunar Observatory (ALO) for a dedicated ESA EL3 mission opportunity, using the cosmological study of the early universe as the primary science case. The primary objective for the ALO will be to open up the virtually unexplored low-frequency radio electromagnetic spectrum, by placing an interferometric, distributed array of multi-elements radio antennas on the lunar far side. In addition, the topical team will explore **multi-messenger** options for the lunar far side mission, and consider the addition of a UV telescope, Gravitational wave detectors, Seismometers and bio-culture experiments. Finally, the option for having a precursor low-frequency radio instrument to characterize and monitor the lunar environment on the first lunar polar EL3 mission will be explored.

References

[1] Jester , S. , Falcke, H., 2009, New Astronomy Reviews, Volume 53, Issue 1-2, p. 1-26, arxiv:0902.0493