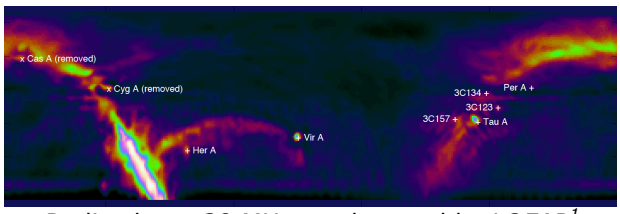
DSL: Discovering the Sky at the Longest Wavelengths

A Long-Wavelength Radio Interferometer in Lunar Orbit
Unveiling the Sky at the Last Unexplored Frequency Range

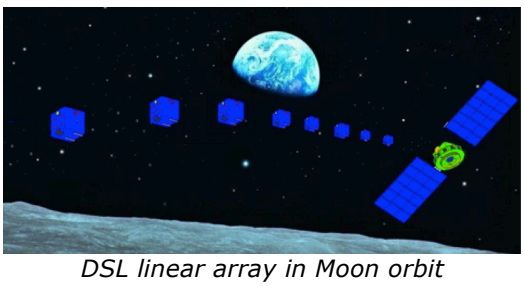
A new window for exploring the unknown
The radio sky at frequencies below ~30 MHz is virtually unobservable from Earth due to ionospheric disturbances and the opaqueness of the ionosphere below ~ 10MHz, and also due to strong terrestrial radio interference. Deploying an Ultra-Long-Wavelength (ULW) radio observatory in space would open up this frequency band for science in astronomy, cosmology, geophysics, and space science.

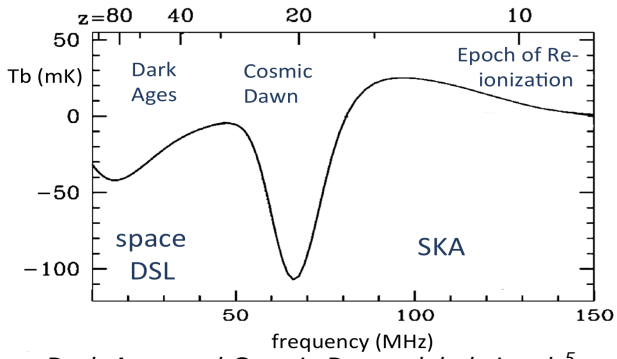


Radio sky at 30 MHz as observed by LOFAR[1]

Mission opportunity
In the context of a joint ESA-CAS mission opportunity[2], a Chinese-European team is proposing an ULW radio interferometer mission DSL[3] (Decametres Space Linear array). The proposed radio interferometer will be deployed in low-altitude lunar orbit, exploiting the radio quietness of the Moon's far-side. The call aims at a launch readiness in 2021.

Mission Concept
DSL will consist of a mother-ship for data transport and control, plus eight small mini-satellites each equipped with three orthogonal dipoles. These satellites form an observatory with adjustable baselines, allowing different scientific observation strategies. The satellites are configured in a flexible linear array in near-identical orbits, guaranteeing low relative drift rates. Short orbital periods and orbit precession ensure quick filling of the interferometric spatial frequency (u,v,w) space[4], enabling high quality imaging.


DSL linear array in Moon orbit



Dark Ages and Cosmic Dawn global signals[5]

Science
The science themes considered for the DSL mission include pioneering searches for the unknown and exploratory science such as:

- Search for signatures of the cosmological Dark Ages, complementing LOFAR and SKA searches
- Full-sky continuum survey of discrete sources, including ultra-steep spectrum extragalactic sources, pulsars, and transients (galactic and extragalactic)
- Full-sky map of continuum diffuse emission
- Solar-terrestrial physics, planetary sciences, and cosmic ray physics

Observational modes
The main frequency band covered is 1-30 MHz extending down to 0.1 MHz, and up to about 50 MHz for cross-referencing with ground-based instruments. DSL will support a variety of observational modes, including broad-band spectral analysis for Dark Ages, radio-interferometric cross-correlations for imaging, and flexible raw data downlink capability. Data processing will be performed at radio astronomy science data centres in Europe and China.

Roadmaps and heritage
DSL science is in line with ESA's Cosmic Vision roadmap[6]. In the Netherlands, the NCA strategic plan[7] mentions space-based radio interferometry for the period 2020+, and the HTSM Roadmap Space[8] includes RF technologies for small satellite missions as a focus point. There is a long heritage of long-wavelength space project initiatives and also of space missions. Together, they guarantee the availability of high TRL technologies, including spacecraft, digital signal processing, and receiver technologies.

[1] S.J. Wijnholds, thesis, TUDelft / ASTRON, 2010
[2] ESA-CAS call: http://sci.esa.int/jump.cfm?oid=55262
[3] DSL: http://www.astron.nl/dsl2015
[4] J. Zheng, DSL Orbit Analysis, NSSC, 2014
[5] After R. Pritchard & A. Loeb, 2012
[6] Cosmic Vision: http://sci.esa.int/cv2015
[7] NCA Strategic Plan for Astronomy in NI 2011-2020
[8] Top Sector HTSM Roadmap Space 2012-2020

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