ASTRONOMY FROM THE MOON: POSSIBLE SCIENCE INVESTIGATIONS AND PRECURSORS. J. Kissi-Ameyaw, E.P. Monaghan, B.H. Foing. ESA/ESTEC, SRE-S, Postbus 229, 2200AG Noordwijk, Netherlands. jkissi@rssd.esa.int, euan.monaghan@rssd.esa.int, bernard.foing@esa.int

Background: The invention of the telescope heralded the birth of modern astronomy. As technology and our understanding of optics developed, these telescopes increased in both size and complexity. Despite these advances, ground-based telescopes are held back by our planet's turbulent atmosphere. It may sustain life on Earth, but it also provides the greatest obstacle to an unencumbered view of the universe.

Limitations of Earth-based Telescopes: There are several issues with Earth-based astronomy. The first and most important of these is weather. It is no coincidence that the main research telescopes on Earth are in areas of high altitude and consistent, arid climate. Light pollution is also a big problem. Not only this, but terrestrial radio sources produce a considerable amount of pollution in the EM spectrum. Other factors include: the blurring effect caused by elements in the atmosphere, which limits telescope resolution; and the fact that absorption means that the atmosphere is opaque to whole ranges of wavelengths.

Limitations to Current LEO-based Astronomy: Current missions such as the Hubble Space Telescope (HST) take advantage of the much clearer conditions outside the bulk of the Earth's atmosphere. However, even here there are problems. While these spacecraft are pointed to the stars, LEO is still exposed to the constant EM noise from Earth as well as the ionosphere.

Another problem is one of stability. There is of course no surface in LEO on which to anchor a telescope, and this can cause issues with pointing the instruments, which are generally solved by gyroscopes and other such systems. This increase in complexity can potentially lead to problems. Indeed, the HST is the only telescope ever to have been repaired by astronauts.

Benefits of Moon-based astronomy: The Moon has an incredibly tenuous exosphere. Direct contact with what is essentially the vacuum of space results in almost no attenuation or absorption when conducting observations in any frequency. Astronomy conducted from the lunar far side would also be shielded from terrestrial radio and ionospheric interference. Current NASA plans for a scientific outpost on the Moon also means that servicing and installation of such a telescope can also be met with greater ease[1].

Limitations of Moon-based astronomy: No atmosphere means no protection from cosmic rays and solar particles. Large shifts in temperature on the lunar day-night cycle (ranging from 100 K to 390 K at the equator) may also cause problems with optical equipment. The shipment of replacement parts etc. is still expensive. The effect of the lunar dust on operational performance must be assessed with precursor missions.

Potential projects: There have been many proposals for telescope technologies based on the Moon. A simple project such as a small radio array of ~10 dipole antennas would be an ideal precursor for Moon-based astronomy[2]. Covering an area of around 2 km, the Lunar Array for Radio Cosmology (LARC), proposed by a team at MIT, would be a logical progression in this process. Probing signals from the early universe and shielded from interference from the ionosphere and terrestrial signals, such an array would not be operable on the surface of the Earth, due to the extreme low frequency of the searched-for signals. Indeed, the 50 kHz - 30 MHz frequency window is the only one through which we have yet to image the universe.

Lunar Transit Telescopes (LTT) have been proposed to survey the sky in multiple wavelengths, and to monitor a variety of cosmic objects. LTTs could provide image quality to measure weak gravitational microlensing and therefore map the distribution of dark matter in the universe.

Another proposal is the Liquid Mirror Telescope (LMT). These make use of parabolic shape formed when a fluid spins. Such spinning fluids become – in essence – mirrors, when reflective liquid metal is used. The main advantage to these types of telescopes are that the weight of the mirror is considerably less than that of it's glass counterpart. The cost is also much less, which can lead to larger 'mirrors' being built. Currently these have to be pointed straight up, as any tilt will cause the mirror to lose its shape. However, there are areas in which these telescopes are ideal. LMT's of 20-100 m diameter could be placed on the Moon to detect objects 100 times fainter than achievable with the James Webb Space Telescope. Such an LMT would also be able to observe the first high red-shift stars and galaxies, for the same reason. Locations ideal for deep-sky cover and long integration times have been identified[3].

Lunar telescopes can perform continuous uninterrupted observations that can aim at exoplanetary transits. Lunar interferometers could be used to detect habitable Earth-like planets around other stars, and measure spectral fingerprints (O_2, O_3, CH_4) of possible biological activity.

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