UZUME: Pioneer Missions to Establish Moon Villages in Lunar Caverns such as Lava Tubes

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In 2009, just 10 years ago, three huge holes were discovered on the Moon in image data acquired by the Terrain Camera onboard the Japanese lunar orbiter SELENE (nicknamed Kaguya). Their diameters and depths are several tens of meters or more. They are possible skylight holes opening on large subsurface caverns such as lava tubes by analogy with similar pits found on the Earth and Mars. Later, this possibility was significantly enhanced by LRO oblique observation data, GRAIL gravity data, and SELENE Lunar Radar Sounder echo data. People and instruments in lunar caverns will be protected from continual micrometeorite bombardments, extreme temperature oscillations, and fatal radiation showers that make the surface of the Moon to be a harsh place. The holes and their associated subsurface caverns are also among the most important future exploration targets from various science view points. We are considering exploration missions to the lunar holes and caverns with naming as UZUME (Unprecedented Zipangu (Japan) Underworld of the Moon Exploration) whose name is after a Japanese mythology. It will provide much information to establish Moon villages, towns and ultimately cities in lunar caverns such as lava tubes.

Astrophysics on the Lunar Surface

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Abstract:

A science case and proposal for building a multi-frequency astrophysical observational base on the Moon. This study and literature review gives the scientific need and justification behind such quest. The fact that the Moon is empty of any atmosphere makes it transparent for the electromagnetic spectrum (EM spectra), which is in contrast with the limited window of observation on the surface of earth. We can add to that the fact of the long lunar diurnal period of 28 terrestrial days. The low gravity makes it possible to build large telescopes without the needing adaptive optics correction, but on the other hand large support structures are needed. A comparison of the earth environment, space born arrangements, and that of the Moon will shows the potential of such an observatory (science – operation – cost). The idea is to build a complex of dedicated observatories ranging in EM spectra from the realm of gamma and X-ray portion of EM energy, small to large mirror optical telescopes (1-m to multi-meter class telescopes), infrared and 1-cm spectra regime (microwave), single dish radio telescopes and interferometry. The far side of the Moon as well as areas near the poles are the ideal places for building such observatories. And in all scenarios, operation of these astronomical facilities can be operated remotely and/or with a crew based on the surface of the Moon.

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Gravitational-Wave Observatory on the Moon

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Recent astrophysical observations are shifting from ground-based observatory into space-borne telescope in many energy and wave regimes. Unfortunately, the lunar surface environment is not so favourable in many electromagnetic wave range because of the large scattered light and thermal radiation from the lunar surface, compared to observations at the low earth orbital or sun-earth Lagrange point (L2). However, it may have significant advantages in the observations of low-frequency radio waves on the opposite side of the moon, where artificial noise from the Earth can be avoided, and gravitational waves. The superiority of moon-based gravitational wave observation is due to the following reasons; advantages of less seismic noise such as no atmospheric gravity wave origin, and less serious spectral characteristics of moonquake compared to the earth's surface[1], and of lower gravitational field, which makes seismic isolator much effective. The gravitational waves associated with the coalescence of middle mass black holes have a spectral center in the low-frequency region, and the observation of gravitational waves at this wavelength is scientifically very important because it provides intrinsically important information on the origin of massive black holes. The existence of massive black holes plays an important role in the evolution of the galaxy, and understanding their causes is of great importance in astrophysics. To realize the moon-based gravitational wave interferometer, the infrastructure of electricity, network environment, and also construction technology in polar craters on the moon are also necessary, and which must be in our hands when we make steady activities on the moon.

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