SOME RECOMMENDATIONS FOR A COMPREHENSIVE LUNAR METEOR CAMPAIGN.
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Introduction: Recent reports of meteors hitting the moon have opened up new opportunities in observational and theoretical astronomy. Since the Leonid meteor storm of 1999, some fifteen lunar impact events have been confirmed, and another twelve are very likely real events, which have not yet been confirmed. Several groups of astronomers, both professional and amateur, have documented the flashes of impacts on the surface of the Moon. There have been a number of attempts by groups of both amateur and professional astronomers to observe meteoroid impacts due to the annual meteor showers, with the only confirmed events derived from the 1999 and 2001 Leonids. Two possibilities why no confirmed events have been seen in the other annual showers may be lack of large objects in the streams and/or the lower number densities of meteoroids as compared with the unusually dense Leonid streams of 1999 and 2001. In this Paper, I outline some recommendations on a comprehensive program to systematically monitor the moon for meteoritic impact events and the benefits derived from such a program.

The Benefits of a Campaign: The Moon provides an excellent laboratory for the detailed study of hypervelocity impact phenomena. Ground-based laboratories are currently only able to generate impacts with projectile velocities on the order of a few kilometers per second. The Moon provides a setting where impacts involving projectiles traveling up to 72 km s^{-1} can be studied. In addition to the natural laboratory setting, the Moon acts as an excellent impact detector. For the study of small-scale structures in meteoroid streams, ground based studies are of good use, but the coverage by each individual observer is limited to their particular geographical location. The Moon presents a large surface area for observations and provides a second chord to sample a meteor stream, in addition to ground-based observers.

As an impact detector, the Moon is a useful target to sample the small bodies that pass through Earth's part of the solar system. Since the impacts observed on the moon tend to be large, and those in the Earth's atmosphere small, it becomes possible to bridge the gap between objects detected by asteroidal surveys and those detected through ground-based meteor observations. The luminous efficiency of high-speed impacts can also be characterized for objects of different velocities, perhaps providing clues to the origins of the impacting bodies and the possible detections of impacts of objects of interstellar origin. Finally, the composition of the Moon's surface, immediate subsurface, and the impactor can be analyzed through spectral studies.

Suggested Components: A successful campaign to characterize the lunar meteor phenomena should have global, multi-wavelength coverage and should take place during annual showers and on a monthly basis. Multiple wavelength observations in the visible and IR are recommended in order to obtain detailed information about the thermodynamic properties of the events. The highest temporal resolution possible is suggested to resolve small-scale variations such as those reported in [1]. High spatial and temporal resolution and high signal-to-noise is essential to construct meaningful multi-wavelength light curves of impact events.

In addition to the imaging, spectroscopy is recommended to probe the makeup of the lunar surface and immediate subsurface, and to determine whether water ice exists below the surface. The annual Perseid meteor stream is best suited for this, owing to its high northerly declination, fairly high meteor velocities and relatively high numbers.

Much advantage is gained if the impacts are observed from a lunar orbiting spacecraft. Impacts some 20 times smaller than what is detectable from the Earth's surface will be accessible to an orbiter some 3,000 km above the lunar surface [2]. This lowered detectability threshold means that the number of detected impactors will increase by several orders of magnitude. Orbiters circling other airless bodies in the solar system may monitor meteoroid impacts to gain information on the composition of the object being orbited as well as the meteoroid environment of that object.

Even more insight into the nature of hypervelocity collisions can be gained by placing a network of seismometers, such as the ALSOP, on the surface of the moon and activating them (and/or reactivating the Apollo seismometers). Seismic data, along with in situ orbital or ground-based data, could provide definite answers as to the luminous efficiency of meteoroid impacts, as well as better determinations of the mass of the impacting object.

References: [1] Ortiz J. L. et al. (2002) *Ap. J 576.,* 567–573. [2] Kosarev I. B. and Nemtchinov I. V. (2001) *LPS XXXII,* Abstract #1544.