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LUNAR OBSERVER LASER ALTIMETER

by

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The exploration and characterization of the terrestrial planets and their satellites requires an accurate understanding of their topography. Understanding the global topography of the Moon is especially important for answering questions concerning lunar origin and evolution. Many outstanding problems in lunar science can be addressed with high resolution topographic data. Some of these include the precise figure of the Moon, the nature of gravity anomalies, and the thermal and loading histories of major impact basins. Others are the styles and volumes of volcanic eruptions, measurements of modification processes, and problems associated with impact catering. The correlation of lunar surface geochemical processes and topography has been examined only in limited equatorial regions, and requires further assessment. Finally, information necessary for the optimal placement of lunar bases will require accurate knowledge of the local relief of the lunar surface.

The severe power, mass, size, and data-rate limitations imposed by the Lunar Geoscience Observer (LGO) and other Observer-class missions are major challenges for all instruments capable of measuring topography. A radar altimeter that meets these strict requirements could obtain a global perspective of lunar topography with a few kilometers spatial resolution and 10 m vertical resolution from a lunar orbit of 100 km. Many of the problems listed above, however, require topographic data with spatial resolution of 100 m or better and vertical resolution of 1 m. The only means of obtaining such high-resolution data is with the small footprints, short pulses, and precise timing available with laser altimeters. The instrument heritage and scientifically useful data from the three successful missions of the APOLLO Lunar Laser Altimeter provide a solid basis for optimizing the technique for LGO. Existing laser altimetry sensors are simple in design; yet require technological improvements in order to provide comprehensive coverage of the lunar surface. Laser lifetime, efficiency, and pulse repetition-rate are the key factors. Conventional solid-state, pulsed laser technology is restricted by flashlamp lifetime to 10^6 pulses, efficiencies on the order of 1%, and 20 Hz repetition rates. The recent breakthroughs in diode-pumping of Nd:YAG crystal lasers have dramatically improved all three of these factors by orders-of-magnitude. Now we have available diode-pumped Nd:YAG lasers with lifetimes in excess of 10^9 pulses, efficiencies of 10%, and repetition rates of at least 100 Hz. At the same time, this new technology has decreased the size of the laser, eliminated closed-cycle liquid cooling systems, and provided a very robust all solid-state laser package. Efforts are still required to demonstrate the production of nsec-duration pulses with these lasers and then couple the lasers into an altimeter system.

We are constructing a prototype model of the Lunar Observer Laser Altimeter (LOLA) capable of continuously measuring the range to the lunar surface with sub-meter vertical resolution within a 30

- 300 m diameter surface footprint. This same instrument is also designed to provide a direct measure of the surface height distribution in the footprint by waveform analysis of the backscattered laser pulse. Both these measurements are to be made in a continuous, nadir profile across the lunar surface from a 100 km orbit. The wavelength of the altimeter is 1064 nm. A short-pulse (2 nsec), diode-pumped Nd:YAG laser combined with a 25 cm diameter telescope, silicon avalanche photodiode detector, ranging electronics, and instrument computer has been designed to make these measurements and meet all the requirements of the LGO mission. The final LOLA package should weigh less than 15 kg, measure less than 35 cm by 25 cm by 25 cm, and consume an average power of less than 15 watts.

The development of the LOLA prototype is being funded at the $100K per year level through RTOP Task: 157-30-80 as part of the Planetary Instrument Development Program in Code EL at NASA Headquarters. The LOLA diode-pumped Nd:YAG laser is being funded at the $500K level at Lightwave Electronics, Inc., Mountain View, California through a Phase II SBIR contract. The completed prototype LOLA instrument will be tested during 1988 from NASA high-altitude aircraft over planetary analog terrain in Arizona, Mexico, and Iceland. The LOLA Project is expected to retain the advantages of a small, self-contained in-house effort throughout the full-scale development of a spacecraft payload.

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