A PROPOSED LUNAR ORBITING GRAVITY GRADIOMETER EXPERIMENT

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Abstract. Analysis of the gravity gradiometer developed by R. L. Forward and C. C. Bell at the Hughes Research Laboratories suggest than an accuracy, in the range 0.1 to 0.5 EU can be expected in a lunar orbiter application. This accuracy will allow gradient anomalies associated with mascons to be mapped with 1% accuracy and should reveal a great deal of new information about the lunar gravity field.

The proposed experiment calls for putting such a gradiometer into a closely circular polar orbit at an average height of about 30 km above the lunar surface. This orbit allows the entire lunar surface to be covered in fourteen days, the gradiometer to be checked twice per revolution and results in successive passes above the lunar surface being spaced at about the resolution limit of about 30 km set both by the satellite altitude and instrumental integration time. Doppler tracking will be employed and the spacecraft will carry an electromagnetic altimeter. Gradient and altitude data from the far side of the Moon can be stored for replay when communication is re-established.

1. The Gradiometer

A dumbbell pivoted about an axis through its center of gravity and perpendicular to its length experiences a torque due to gravity gradients. This torque (Figure 1) is given by

\[ T = \frac{1}{2}I \sin \theta \left( \frac{\partial g_x}{\partial y} - \frac{\partial g_y}{\partial x} \right) + I \cos \theta \frac{\partial g_y}{\partial x}, \]

where \( I = 2mr^2 \) is the dumbbell’s moment of inertia. This torque is measured statically in the well-known Eötvös torsion balance. In the rotating gravity gradiometer conceived by R. L. Forward and described by Bell (1970) the dumbbell is instead rotated about its axis and, as may be seen by substituting \( \theta = \omega t \) in (1), experiences an oscillating torque at twice the rotational frequency. Two such dumbbells 90° apart spinning about a common axis thus experience a differential torque and, if they are coupled by a flexural pivot, will oscillate with a scissorslike motion. In operation the gradiometer is spun at one half the resonant frequency of the scissors oscillation, and the oscillations are detected by means of a piezo-electric transducer attached to the flexural pivot working into an electronic amplifier. The construction of a typical sensor is shown in Figure 2.

This gradiometer has many important advantages. Translational accelerations and

Communication presented at the Conference on Lunar Geophysics, held between October 18–21, 1971, at the Lunar Science Institute in Houston, Texas, U.S.A.
Fig. 1. Differential gravity forces, relative to force at dumbbell center, acting on mass dumbbell in the \( XY \) plane.

Fig. 2. Exploded view of Hughes gravity gradiometer.