THE LUNAR MOMENT OF INERTIA DERIVED FROM COMBINED DOPPLER AND LASER RANGING DATA; W. S. Sinclair, Jet Propulsion Laboratory, Pasadena, California 91103, W. L. Sjogren, Jet Propulsion Laboratory, J. G. Williams, Jet Propulsion Laboratory, A. J. Ferrari, Jet Propulsion Laboratory.

Doppler data from the high altitude (2700 km) orbit of Lunar Orbiter IV are combined with laser ranging data to determine estimates for the moment of inertia ratios ($\beta$, $\gamma$), a complete third degree and order gravity field, possibly some 4th order and degree terms and the lunar gravitational constant. This solution represents the first data reduction in which all six of the lunar moment of inertia tensor components are simultaneously estimated. Estimates for the moment of inertia components can be used in conjunction with the first and second degree topography harmonics and seismic results to determine internal density models (1). With the full moment of inertia tensor the set of geophysical equations is increased by five and allows for more complex modeling.

The sensitivity of these two data types is such that each complements the other thus improving chances for orthogonal parameter estimates. Current research in determining the moment of inertia components have relied on solutions derived from each data type independently (2). This reduction will allow the direct application of the unique constraint between the Doppler triaxial coefficients and the laser ranging parameters $\beta$ and $\gamma$.

$$J_2 = \left[ \frac{\delta \beta + 2\beta \gamma - 2\gamma}{\gamma(1 + \beta)} \right] C_{22}$$

Of all the gravity models thus far determined, the third degree model (3) derived from the Lunar Orbiter IV doppler data has estimates for the triaxial harmonics which best fulfill this relationship. If estimates for $\beta$, $\gamma$ and $J_2$ from this field are used (2), the resulting polar moment of inertia determination follows: $C/MR^2 = .394 \pm .006$. The uncertainty in this determination is so large that a 1 sigma upper bound still allows for a homogeneous moon.

Recent reductions (4) using the long term variation of the Explorers 35 and 45 satellite have determined $J_2 = 2.0272 \pm 0.0148 \times 10^{-4}$, which when used with $\beta$ and $\gamma$ estimates yields a value for the polar moment of inertia of $C/MR^2 = .392 \pm .003$. Although this work has resulted in a sizeable reduction in the formal errors in $J_2$, the sensitivity of this solution to errors in $J_4$ and $J_6$ has not been totally demonstrated. Hence the possibility does exist that these modeling errors could be reflected in the estimates for $J_2$ but not in its formal statistic. Our analyses will include comparisons of the results obtained from separate solutions and a description of the effects of un-modelled parameters.

References: