DISSIPATION IN THE MOON: A REVIEW OF THE EXPERIMENTAL EVIDENCE AND PHYSICAL IMPLICATIONS

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ABSTRACT. Recent analyses of lunar ranging observations have revealed strong evidence of dissipation in the moon's rotation (Ferrari et al. 1980; Cappallo et al. 1981). If interpreted as solid body friction, these results imply a tidal Q of about 25 ($\pm$5) at a frequency of one cycle per month. There is little evidence from other studies of the interior structure of the moon to support such a low solid-body Q. Yoder (1981) finds that turbulent fluid friction between the mantle and a core of radius $\sim$300 km is a plausible mechanism to explain the observed dissipation. An iron or iron-sulfide core of this size is consistent with moment-of-inertia (Blackshear and Gapcynski 1977, Ferrari et al. 1980) and seismic (Goins et al. 1979) data, and is not excluded by conductivity data (Goldstein 1979). Stevenson and Yoder (1980) have proposed a model for formation of a solid iron inner core surrounded by a fluid iron sulfide layer of thickness 65 - 180 km.

Comparison of lunar ranging observations with Eckhardt's (1970, 1981) semi-analytic theory of the lunar rotation suggests a significant free wobble and libration in longitude (Calame 1977, Cappallo et al. 1982). Neither moonquakes (Yoder 1981) nor the flux of meteorite impacts (Peale 1975) provides sufficient energy to excite the observed free oscillations if the damping mechanism is either viscous core-mantle coupling or solid-body friction with Q less than 500 (Peale 1976, Yoder 1981). A recent possibly-observed impact, forming crater Giordano Bruno, could have stimulated the observed longitude libration but not the wobble (Calame and Mulholland 1978). On the other hand, fluid turbulence at the core-mantle boundary may account for both components of the observed free librations (Yoder 1981).

A complete review of this topic has been published recently by Yoder (1981).

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DISCUSSION

Kovalevsky : It is important to know that the two apparently incompatible results of Calame and of Williams et al. can now be brought together by the theoreticians into a single model.

Yatskiv : Would you explain the observational determination of Q ?

King : The assumption is made that dissipation in the Moon acts as a slightly damped linear oscillator. Modelling the rotation with an elastic inertia tensor, retarded in time, a coefficient appears in the equation of motion for the lunar rotation that is the product of the second-degree Love number k_2 and the time delay by which the elastic response is retarded. That product is the dissipation, and is directly related to Q through the linear oscillator analogy. The observational effect appears in the laser ranging data as an offset in the lunar spin axis.

Kovalevsky : Is this Q for a specific frequency ?

King : This model assumes that Q is inversely proportional to frequency, and the value cited is appropriate to a monthly period.