Abstract. In the IERS Standards (1989), for the Moon the adopted value of the tide Love number, \( k_2 \), is equal to 0.0222. In this paper using the latest geodetic parameters of the Moon a group of internal structure models are constructed for this celestial body (see Table V), then the dependence of the Moon's core size on calculated value of \( k_2 \) is explored. The obtained results indicate that the second degree Love number, \( k_2 = 0.02664 \), of the lunar model 91-04 is near its observed value (0.027 ± 0.006). This implies that the Moon may possess an outer core of 660 km radius and of 300 kbar mean rigidity. With the same method the static Love numbers from degree 2 to 30 are computed for the terrestrial planets – Mercury, Venus, and Mars (see Table VII), and the influence of some parameters (such as the rigidity) of the outer core on low degree Love numbers is discussed. Finally, the likely range of the second degree Love numbers is determined for the terrestrial planets (see Table XI). It seems that if low degree Love numbers of a terrestrial planet can be detected in the future space explorations, there is some possibility to improve the planetary internal structure model. For example, as soon as space techniques yield an observed value of \( k_2 > 0.10 \) for Mercury, there will be reason to anticipate that a partly melted iron core exists in this planet.

1. Introduction

Tidal friction plays an important role in the spin evolution of some celestial bodies of the solar system. It has been responsible for significantly altering the primordial rotation rates of Mercury, Venus, and the Earth; and generally alters the spin angular velocity of all the natural satellites toward a value which is synchronous with its orbital mean motion.

The tide generating potential due to a perturbing body can be developed in the sum of spherical harmonics \( W_n \). The additional tidal potential, \( \Delta V_n \), caused by the deformation of the perturbed body is directly proportional to the spherical harmonic, \( W_n \), of degree \( n \), that is

\[
\Delta V_n = K_n(r)W_n ,
\]

where \( K_n(r) \) is an auxiliary function of the radius \( r \). At the surface of a celestial body \( (r = a) \), \( K_n(a) \) is equal to \( k_n \) which is one of the dimensionless tidal Love numbers of degree \( n \).

Apparently, when we consider the tidal response features of a celestial body, it is necessary to estimate its Love numbers.

Generally, it is a perfect approximation to consider the Moon as a homogeneous elastic spheroid. We can then estimate its second degree Love numbers by means...
of some simplified models (e.g., Harrison, 1963; Cheng and Toksöz, 1978; Zhang and Shen, 1988).

As regards the terrestrial planets, since their rheological parameters – rigidity \( \mu(r) \), Lamé constant \( \lambda(r) \), density \( \rho(r) \), and gravity \( g(r) \) in the planetary interior are not determined reliably, we run up against difficulties in deriving theoretically their Love numbers. Hence, either the Love numbers for a homogeneous incompressible spherical body are calculated approximately according to Kelvin’s formula (e.g. Goldreich and Peale, 1968), or the low degree Love numbers of a celestial body are estimated by means of a certain simplified model of this body (e.g. Szeto, 1983; Zhang and Shen, 1988). Not long ago Bodri (1987) computed second degree Love numbers \( (h_2, k_2, l_2) \) for radially heterogeneous compressible models of the terrestrial planets.

In Table I we display these two sorts of the Love numbers \( k_2 \) for the Moon and terrestrial planets. Here \( \bar{\mu} \) is the mean rigidity of a celestial body. It is well known that the Earth’s mean rigidity, is about equal to 1460 kbar. These values of \( k_2 \) in Table I are derived by assuming that rigidities of the terrestrial planets are similar to the Earth’s. As for the Moon we adopted the value of \( \bar{\mu} = 670 \) kbar (Zhang and Shen, 1988). Comparison between the results calculated by using Bodri’s method and Kelvin’s formula shows that there is evident discrepancy. Apparently, it is necessary to find out how to explain this discrepancy.

In this paper we consider again some problems dealing with calculation of the Love numbers for the Moon and terrestrial planets. The major objective of this paper is to try to find out some physical parameters influencing obviously the low degree Love numbers. Section 2 presents the parametric models of internal structure for the Moon and terrestrial planets. Section 3 describes the calculated results of the Love numbers. Section 4 discusses the dependence of the Moon’s core size on the second degree Love numbers in some detail. Section 5 outlines the influence of the outer core rigidities of the terrestrial planets on the low degree Love numbers, and determines the likely range of the second degree ones for each terrestrial planet. Finally, we suggest that one should detect the Love numbers, \( h_2 \) and \( k_2 \), of a terrestrial planet in the future space explorations, so as to check whether the adopted internal structure model of this planet is reasonable.