INTERNAL STRUCTURE MODELS OF MARS

H. ZHANG
Department of Astronomy, Nanjing University
22nd Hankou Road, Nanjing, P.R.China
jupiter@nju.edu.cn

ABSTRACT. Mars Global Surveyor(GMS) presents more precise data, which enable us to understand further the internal structure by modelling Mars. An inverse approach of the problem of modelling the interiors of Mars is proposed. The internal structure with a pure core is recommended according to the elementary calculations.

1. INTRODUCTION

The parameters to directly constrain the internal structure models are the mean density and dimensionless mean moment of inertia of the body. More precise geodetic data, such as polar moment of inertia, are provided by the Mars Global Surveyor tracking data. These data enable us to understand the internal structure by modelling Mars. The following table lists some parameters of Mars(Table 1). R denotes the mean radius, GM product of universal gravitational constant G and mass M, C/MR^2 the polar moment of inertia, and k_2 the second Love number of Mars.

Table 1: Some parameters of Mars.

Parameters	Values	Reference
R(km)	3389.92	Bills and Ferrari(1978)
GM(km^3/s^2)	42823.716 ± 0.0002	Smith et al.(2001)
C/MR^2	0.3650 ± 0.0012	Yoder et al. (2003)
k_2	0.153 ± 0.017	Yoder et al. (2003)

An inverse approach of the problem of modelling the interiors of Mars is proposed. But thermal corrections are not considered. For a real body, it is in the hydrostatic and thermodynamic equilibriums. An improved model, in which the hydrostatic and hydrostatic equilibriums are taken into considered, should be constructed in the future.

2. INTERIORS OF MARS

Three-layer models are considered in detail, which consist of the outer shell, the mantle and the central core. The mantle and the core are assumed to be in the hydrostatic equilibrium. And the equations of state for the mantle and the core can be derived from the empirical bulk moduli, respectively. Bulk moduli of the major silicates (olivine, orthopyroxene, clinopyroxene, plagioclase) are in the range 1-1.3Mbar at normal conditions; and for a pure Fe core, bulk moduli is 1.66Mbar (Kuskov and Kronrod, 2001). Since bulk moduli for an Fe-FeS core is unknown, the values of bulk moduli for an Fe-FeS core is adopted as those for a pure Fe core. Therefore, the Emden equations of the mantle and the core can be expressed, respectively(cf. Zhang and Zhang, 2001). As regards the outer shell, the density is treated as a constant parameter (2.96g/cm^3) and the thickness is assumed to range between 50 and 100 km (Zuter et al., 2000; Turcotte et al., 2002).

With the appropriate imposed boundary conditions, the Emden equation for the core can be numerically solved from the center outwards and the Emden equation for the mantle from the surface inwards. According to the continuity of pressure at the core-mantle boundary, a possible size of the core can be determined.

3. RESULTS

Two groups of models are constructed, from which four typical models are picked out and displayed in Table 2. The first two refer to an Fe-FeS core with the density of 5.15g/cm^3 and the other two refer to a pure Fe core with the density of 8.00g/cm^3. In the tables, ρ_c denotes the central density of the core, p_c the central pressure, r_c the radius of the core, r_m the size of the mantle, ρ_m the mean density of the mantle, h the size of the outer shell, ρ_s the mean density of the outer shell, I/MR^2 the dimensionless mean moment of inertia and $\bar{\rho}$ the calculated mean density of Mars.

Table 2: Internal Structure Models of Mars.

		Mars-01	Mars-02	Mars-03	Mars-04
Core	ρ_c(g/cm^3)	5.15	5.15	8.00	8.00
	$p_c(kbar)$	370	380	470	475
	r_c(km)	2134.4	2168.21	1480.46	1473.77
Mantle	r_m(km)	1205.58	1121.71	1859.46	1816.15
	ρ_m(g/cm^3)	3.213	3.324	3.463	3.504
Outer Shell	h(km)	50	100	50	100
	ρ_s(g/cm^3)	2.96	2.96	2.96	2.96
Total	I/MR^2	0.3661	0.3652	0.3653	0.3549
	$\bar{\rho}$(g/cm^3)	3.93314	3.93309	3.93303	3.93311

The following conclusions can be given from the above calculations.

- If Mars has an Fe-FeS core, it can own a larger core, whose size can reach 2168km. However, the core radii of the models with a pure Fe core are around 1480km, which are similar to the results provided by Yoder et al.(2003).
- The model with a pure Fe core may have a smaller dimensionless mean moment of inertia than that with an Fe-FeS core.
- The central pressure is about 375kbar for the model with an Fe-FeS core.But for the model with a pure Fe, the central pressure is about 470kbar.
- For the same density of the core and the same thickness of the outer shell, the core size of the model increases and the mean density of the mantle decreases as the central pressure p_c increases.
- The Love number k_2 of Mars is larger than 0.1, which indicates a solid core. The models with a pure core are more reasonable.

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