EARTH-LIKE INTERIOR STRUCTURE MODELS FOR THE TRANSITING TERRESTRIAL EXOPLANETS:KEPLER-78B AND KEPLER-93B. P. Futó[1] [1] University of West Hungary, Szombathely, Károlyi Gáspár tér, H-9700, Hungary (dvision@citromail.hu)

Introduction: Two interesting low-mass rocky exoplanets have been discovered by the NASA's Kepler Mission. The smaller-sized planet orbits very close in an 8.5-hour orbit to its late G-type star Kepler-78 [1]. The stellar parameters of the host star are:M_{star} =0.81 $M_{\odot}$,R_{star} =0.74 $R_{\odot}$ and T_{eff} = 5089 K [1]. The planet b is thought to be a terrestrial one slightly larger than Earth with a radius of 1.173 $R_{\oplus}$ [2] ,which can be classified into the category of Earth-sized planets. It is more massive than of our planet with a mass of 1.86 $M_{\oplus}$.

The orbital period is much (by a factor of 36) smaller than the stellar rotation period (12.8 days) [3].The mean density is,slightly higher than that of Earth,calculated to get:5.57 g cm^{-3} this value is consistent with a terrestrial-like composition. Kepler-78 b has an orbital distance of 0,01 AU thus it is an USP (ultra-short period) planet. Its orbit is likely to be tidally-locked due to it being only 100 times farther from the central star than its diameter. The estimated surface temperature is 2250 K, thereupon the top layer of the planet is completely melted, which is covered by lava ocean.

Kepler-93b is a typical hot super-Earth orbiting with a period of 4.7267-day orbit in the proximity of its G-type host star. The radius of this super-Earth-sized terrestrial world is 1.478 $R_{\oplus}$ [4]. The planetary mass has been precisely measured by the HARPS-N spectrograph in 2014 and found 4.02 $M_{\oplus}$ [5]. Its computed mean density 6.867 g cm^{-3} refers to a terrestrial composition,too.

The purpose of this study is to estimate the major physical properties of the interior structures of Kepler-78b and Kepler-93b that have been proposed to have Earth-like compositions.

Modeling: I have determined planetary properties using equation of states [6,7] for calculating the internal structure. Basic physical parameters have also been investigated focusing on central pressure (P_c),surface gravity (g).

Supposing the compositional similarity to the Earth, upper-mantle in both cases composed mostly of olivine [$(Mg,Fe)_2$ SiO4],wadsleyite and ringwoodite. The lower region of the mantle consists of perovskite/post-perovskite phase of $MgSiO_3$ and the central structural unit shows Fe/Ni core. Taking into account the relevant material parameters,zero-pressure densities for the main compounds 8.3 g cm^{-3} (iron), 4,1 g cm^{-3} (silicate-perovskite),4,26g cm^{-3} (post-silicate-perovskite) have been utilized for the calculations.

A power law was applied to parameterize mass-radius relations for small-sized exoplanets ranging from 1 to 10 Earth masses by using of the data of the NASA Exoplanet Archive. Based on the model of Valencia et al. (2006)[8],using the relationship of $M=R^{0.269}$,I utilized the one of the best fits in the category of super-Earths to examine the core mass fraction/mantle mass fraction (CMF/MMF) ratios of massive terrestrial planets.

Composition of Kepler-78b: The central pressure of the planet is larger than that of Earth with an obtained value of 630 GPa and the globally calculated surface gravity is 13.263 m s^{-2}. The core radius is found to be 0.672 $R_{\oplus}$ (Fig.1) which value (computing 57.29 percent of the total planetary radius) is slightly larger than the core/planet radius ratio of the Earth. Hence its structure is approximately analogous to that of Earth. Originally,Kepler-78 b might have had a larger mantle mass fraction (MMF) which had been lost in a small fraction by a mantle stripping process. In present time,the planet may have a slightly smaller MMF than at formation.

Composition of Kepler-93b: The globally computed surface gravity is 17.984 m s^{-2} and the obtained central pressure is 1158 GPa. I found that the calculated interior structure slightly differs from Earth-like composition. Kepler-93b has a slightly larger radius for its measured mass,thus the planet must have a medium-sized core with a radius of 0.774 $R_{\oplus}$ (Fig.2).The core/planet radius is slightly smaller (52.37 percent the planet radius) than in case of the Earth.

Many terrestrial-like planets have been identified in the population of close-in planets. I found that roughly two-thirds of the confirmed terrestrial exoplanets up to date,have medium-and large sized metallic core. Consequently,rocky planets with medium-mass and massive metallic cores might be more frequent than rocky planets with small core.

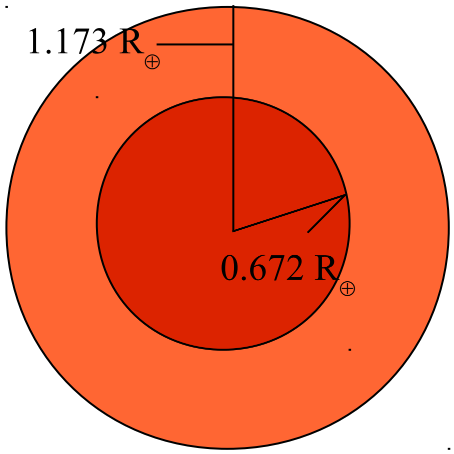

Figure 1. Internal structure model for Kepler-78 b,showing similar ratios in structural units than that of the Earth.

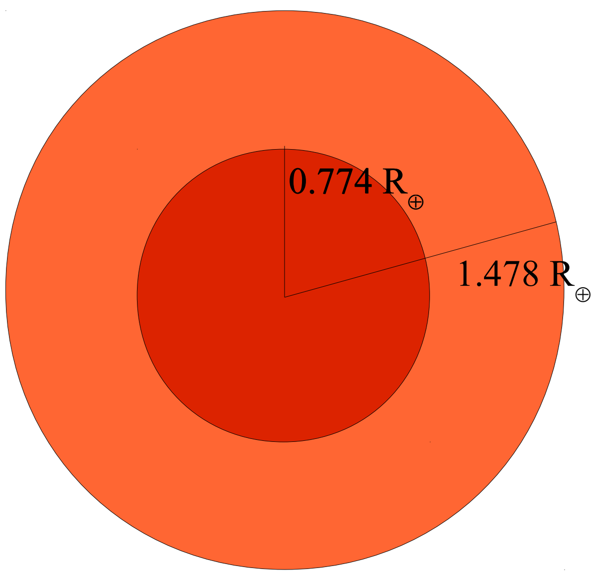

Figure 2. Two-component compositional model for Kepler-93b with a medium-sized core.

Summary: Kepler-78b and Kepler-93 b appear to have a similar internal structure and composition as of Earth. Based on the survey statistics and the compositional modelings,terrestrial exoplanets with Earth-like structures and compositions are might be moderately frequent around G-dwarf and K-dwarf stars of the Galaxy.

References:

[1] Sanchis-Ojeda R. et al.2013.*ApJ*,**774,**54 [2] kepler.-nasa.gov/Mission/discoveries [3] Hatzes A.P. 2014.*Astronomy & Astrophysics*,**568,** A 84 [4] Ballard S. et al.2014.*ApJ*,**790,**12 [5] Dressing C.D. et al.2015.*ApJ*,**800,**135 [6]Vinet P. et al.1987.*J.Geophysical Research*,**92,**9319 [7] Vinet P.et al.1989.*J.Phys.-Cond.Matter*,**1,**1941[8] Valencia D. et al.2006.*Icarus*.**181.**545