POSSIBLE STRUCTURE MODELS FOR THE TRANSITING SUPER-EARTHS:KEPLER-10b AND 11b.

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Introduction: Up to january of 2012,10 super-Earths have been announced by Kepler-mission [1] that is designed to detect hundreds of transiting exo-planets.Kepler was launched on 6th March,2009 and the primary purpose of its scientific program is to search for terrestrial-sized planets in the habitable zone of Solar-like stars.For the case of high number of discoveries we will be able to estimate the frequency of Earth-sized planets in our galaxy.Results of the Kepler-'s measurements show that the small-sized planets are frequent in the spiral galaxies.A catalog of planetary candidates,including objects with small-sized candidate planets,is presented by Borucki et al. [2].Using the measured planetary radius (from transit depth) and mass (by the radial velocity measurements),the average density for a planet can be calculated providing predictions for its composition.Kepler-10b is the first super-Earth-sized planet to be discovered by Kepler's transit measurements.This is an interesting exoplanet orbiting a G-type star (which can be found at a distance of about 565 light years in the Cygnus constellation) at 0.01684 AU.Kepler-10b is a real rocky planet that is being comparable in size to Earth.Owing to the tidally-locked orbit,planet's dayside is very hot and thus lava constitutes the top layer while its nightside is very cold and a frozen gaseous layer covers the surface.Consequently,a new class of terrestrial planets can be defined that is proposed to name *lava-ocean* planets.The other magnificent discovery is a multiple planetary system in which Kepler found six planets orbiting a Solar-like star,Kepler-11(located approximately 2000 light years from Earth in the Cygnus constellation).This six planets are made from metallic,rocky and gaseous compounds,probably.Kepler-11b is the innermost and the second smallest massive planet in the system that orbits close to its star at 0.091 AU.

The discovery of the multiple systems of transiting exoplanets opens new opportunities for the characterisation of exoplanets and helps to understand their formation.

Considering by the observational data,I have made approximate internal structure models for the Kepler-10b and Kepler-11b that are particularly interesting planets owing to their mass and radius.

Composition of the planets Kepler-10b and Kepler-11b: Kepler-10b has a diameter 1.416 times that of Earth and a mass 4.56 times Earth's,yielding a relatively high average density,therefore Kepler-10b is thought to likely be a metal-rich exoplanet.

The planet Kepler-11b has a large radius (1.97 $R_\oplus$) for its mass (4.3 $M_\oplus$),therefore this planet must have a spherical shell that is composed of low-density materials.Considering the planet's average density,it must have a metallic core with different possible fractional mass.Accordinghly,I have made a possible structure model for Kepler-11b in which the selected core mass fraction is 32.59% (similarly to that of Earth) and the water ice layer has a relatively great fractional volume.For case of the selected composition, the icy surface sublimated to form a water vapor as the planet moved inward the central star during its migration.

For an other possibility, Kepler-11b is expected to be mainly rocky with a gas envelope.In this model,the gas material of the envelope is pure hidrogen.Thus,the great mass fraction of the planet's total mass is composed of metallic materials and silicates.

The purpose of this study is to derive possible structure models for these transiting super-Earths using by equations of state :Vinet [3,4],BME [5,6] and the modified Thomas-Fermi-Dirac(TFD) [7],respectively.

A structure model for Kepler-10b:I find that the radius of Kepler-10b's core is 1.022 $R_\oplus$ (Fig.1) which is about 1.245 times larger than if the core radius would correspond to an Earth-like core mass fraction (CMF).It causes the relatively small planetary radius owing to the larger density of Fe and Ni compared to that of silicates.Over the metallic core,the melting behaviour of post-perovskite at high pressures is not known.However it is probably that the complete mantle is not too convective because the mantle mass fraction is relatively small in respect of the faster radioactive heating.If this planet had an Earth-like CMF,its radius would already be approximately 9550 km (~1.5 $R_\oplus$).At 1833 K estimated surficial temperature a lava ocean contributes the surface,probably.

Possible structure model for Kepler-11b:One of the possible composition of this planet is a water-rich structure that include water ice in relatively great fraction.At 62 GPa water ice VII undergoes a phase change to water ice X [8].Therefore in this model, the lowermost layer of water ice shell consisted of water ice X.

Underneath the ice layer,the pressure is more than 300 GPa.At the same time, transition pressure between perovskite and post-perovskite is 125 GPa /2750 K [9].In this manner,the silicate mantle with relatively small mass fraction is fully made of post-perovskite (Fig.2).

If Kepler-11b had an Earth-like CMF,silicate-belt and a pure H gas envelope that accounted for a small fraction of the total planetary mass then the thickness of the gas envelope would be about 26 percent of the total radius.

Estimating the uncertainties in calculations,approximately 1-3 % uncertainties will appear in all model,moreover the detailed composition of different spherical shells is not known

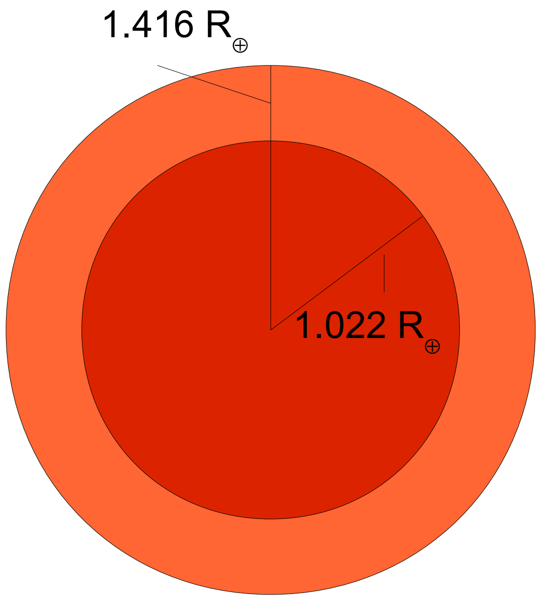

Figure 1. Interior structure model Kepler-10b with 75.2 % by mass $Fe_{0.8}Ni_{0.2}$ core and 24.8 % silicate mantle.

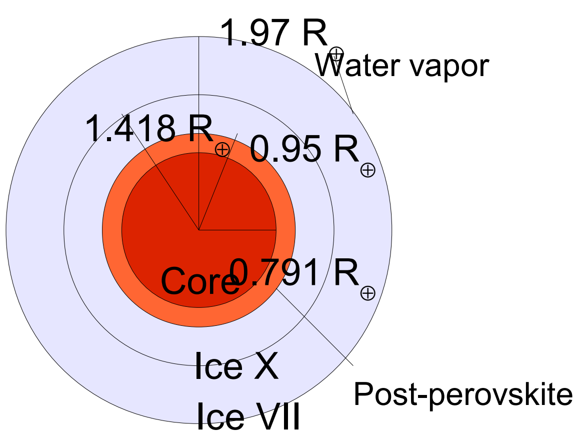

Figure 2. Representation for the Kepler-11b's structure,showing that a great fraction of water-based compounds contributes a larger factor to the planetary radius.

Discussion: Mass of the Kepler-10b and the Kepler-11b is similar but they different in respect of the average density due to their unlike compositions.Kepler-10b is a metal-rich exoplanet while Kepler-11b mainly composed of lower-dense materials. Numerous low-mass exoplanets are expected to announce in the near future,including approximately Earth-sized planets.

References:

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