Poster 170

ESPRESSO observations of K2-106 (EPICA 220674823) and the properties of USPs

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Why are USPs interesting?

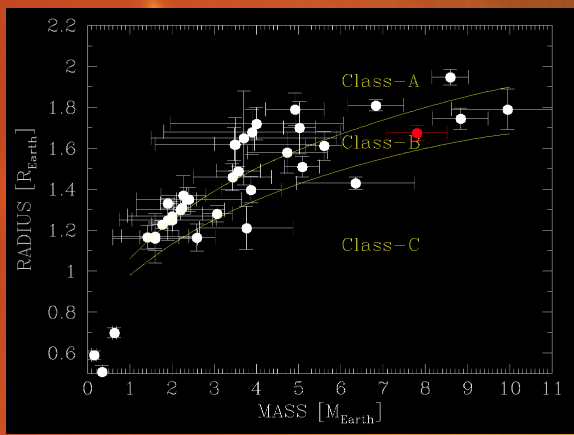
Ultra-short period planets (USPs) are enigmatic exoplanets with orbital periods less than one day. Observationally, USPs have the advantages that their masses, radii and hence densities can be measured with a higher accuracy than for planets with longer orbital periods. Since they cannot have extended atmospheres, they are ideal targets to study the composition and structure of planets.

How do USPs form?

1.) It has been suggested that they are the eroded cores of gas-giants. However, since there are also gas-giant USPs, this seems not to be very likely.
2.) Rocky USPs could have simply formed as rocky planets close to the star.
3.) Rocky USPs could also formed at large distance and migrated inward, either via disk-migration, or via planet-planet interaction.
→ To find out how they formed, we have to study their composition and internal structure and find out, whether they are ins systems, or not.

We define three classes of USPs:

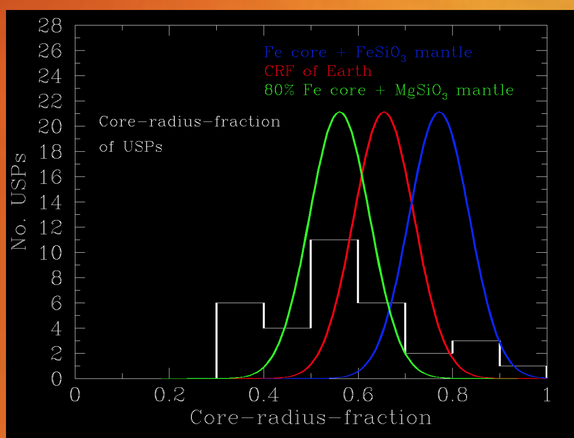
In order to shed more light how USPs forms, we define three classes of planets.
A) Planets with densities that are lower than that of a planet with Earth-like core-to-mantle ratio.
B) Planets with densities that are consistent with an Earth-like core-to-mantle ratio.
C) Planets with densities that are higher than for a planet with an Earth-like core-to-mantle ratio.



The USP K2-106b:

One of the best studied USPs is K2-106. Using ESPRESSO and other instruments, we have determined the masses and radii of its two planets. For the USP (K2-106b, P=0.57d) we find R_p=1.676+/-0.037 $R_\oplus$, M_p=$7.80^{+0.71}_{-0.70}$ $M_\oplus$ and ρ = 9.0+/- 0.98 gcm^{-3}. For the outer planet with an orbital period of 13.4 days (K2-106c), we derive R_p = $2.84^{+0.10}_{-0.08}$ $R_\oplus$, M_p=$7.3^{+2.5}_{-2.4}$ $M_\oplus$, and a density ρ=1.72+/-0.66 gcm^{-3}. The figure at the upper right shows the mass-radius diagram for USPs. K2-106b is the red point (Guenther et al. 2024; MNRAS 529, 141). The curves correspond to planets with an Earth-like core-to-mantel ratio but different compositions. The lower curve assumes a planet with an Fe core and $FeSiO_3$ mantel. The upper curve is for planets that have cores that contains 80% iron and 20% lighter elements, and a $MgSiO_3$ mantel. For both curves we used the planet models from Hakim et al. (2018; Icarus 313, 61).

The internal structure and composition of USPs:



Up to now 40 USPs have been found with masses below 25 $M_\oplus$. At least 60% of them are in systems. We used the HARDCORE model (Suissa et al. 2018; MNRAS 498, 2613) to calculate the marginal core-radius fraction (CRF). The white lines in the figure on the right shows the expected CRF of USPs taking the errors of the mass, and radius determination into account. The green, red and blue curves show the expected CRF distribution for planets with an Earth-like core-to-mantel ratio but different compositions (Hakim et al. 2018; Icarus 313, 61). The green curve is the expected CRF distribution for planets with cores that contain 80% iron and 20% lighter elements, and a $MgSiO_3$ mantel. The blue curve is for planets with an Fe core and $FeSiO_3$ mantel. The red curve is for an Earth-like composition.

→The Core-Radius-Fraction is in general consistent with planets that have an Earth-like Core-to-mantel ratios but different composition of the core and mantel. However, both figures show a tendence that USPs are made of lighter elements, have smaller cores, or perhaps have atmospheres of non-volatile elements.

←The radius of K2-106b has now been determined to an accuracy of 2.2%, the mass with an accuracy of 9.0%. Measurements of similar, or even higher accuracy will be obtained with PLATO. The PLATO-data will allow to constrain the composition of USPs to a much higher accuracy than today. This will help us to understand how these enigmatic planets have formed (Figure from ESA).