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Nuclear planetology: understanding planetary mantle and crust formation in the light of nuclear and particle physics

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The Hertzsprung-Russell (HR) diagram is one of the most important diagrams in astronomy. In a HR diagram, the luminosity of stars and/or stellar remnants (white dwarf stars, WD's), relative to the luminosity of the sun, is plotted versus their surface temperatures (T_{eff}). The Earth shows a striking similarity in size (radius $\approx$ 6.371 km) and T_{eff} of its outer core surface ($T_{eff} \approx$ 3800 K at the core-mantle-boundary) with old WD's (radius $\approx$ 6.300 km) like WD0346+246 ($T_{eff} \approx$ 3820 K after $\approx$ 12.7 Ga [1]), which plot in the HR diagram close to the low-mass extension of the stellar population or main sequence. In the light of nuclear planetology [2], Earth-like planets are regarded as old, down-cooled and differentiated black dwarfs (Fe-C BLD's) after massive decompression, the most important nuclear reactions involved being ^{56}Fe(γ,α)^{52}Cr (etc.), possibly responsible for extreme terrestrial glaciations events ("snowball" Earth), together with (γ,n), (γ,p) and fusion reactions like ^{12}C(α,γ)^{16}O. The latter reaction might have caused oxidation of the planet from inside out. Nuclear planetology is a new research field, tightly constrained by a coupled ^{187}Re-^{232}Th-^{238}U systematics [3-5]. By means of nuclear/quantum physics and taking the theory of relativity into account, it aims at understanding the thermal and chemical evolution of Fe-C BLD's after gravitational contraction (e.g. Mercury) or Fermi-pressure controlled collapse (e.g. Earth) events after massive decompression, leading possibly to an r-process event, towards the end of their cooling period [2]. So far and based upon ^{187}Re-^{232}Th-^{238}U nuclear geochronometry, the Fe-C BLD hypothesis can successfully explain the global terrestrial MORB ^{232}Th/^{238}U signature [5]. Thus, it may help to elucidate the DM (depleted mantle), EMI (enriched mantle 1), EMII (enriched mantle 2) or HIMU (high U/Pb) reservoirs [6], and the ^{187}Os/^{188}Os isotopic dichotomy in Archean magmatic rocks and sediments [7]. Here I present a conceptual model constraining the evolution of a rocky planet like Earth or Mercury from a stellar precursor of the oldest population to a Fe-C BLD, shifting through different spectral classes in a HR diagram after massive decompression and tremendous energy losses. In the light of WD/BLD cosmochronology [1], solar system bodies like Earth, Mercury and Moon are regarded as captured interlopers from the Galactic bulge, Earth and Moon possibly representing remnants of an old binary system. Such a preliminary scenario is supported by similar ages obtained from WD's for the Galactic halo [1] and, independently, by means of ^{187}Re-^{232}Th-^{238}U nuclear geochronometry [3, 4], together with recent observations extremely metal-poor stars from the cosmic dawn in the bulge of the Milky Way [8]. This might be further elucidated in the near future by Th/U cosmochronometry based upon a nuclear production ratio Th/U = 0.96 [9] and additionally by means of a newly developed nucleogeochronometric age dating method for stellar spectroscopy [9-11]. The model shall stimulate geochemical data interpretation from a different perspective, to constrain the evolution and differentiation of planetary or lunar crusts and mantles in general.

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