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# $\partial E$

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Nuclear planetology [1] is a new research field, tightly constrained by a coupled $^{187}$Re-$^{232}$Th-$^{238}$U systematics [2-6], which by means of nuclear astrophysics aims also at understanding the thermal evolution of Earth-like planets after Mercury-like contraction and Fermi-pressure controlled gravitational collapse events towards the end of their cooling period. In nuclear planetology, Earth-like planets are regarded as old (redshift z $>$15), down-cooled and differentiated black dwarfs (Fe-C BLD's), so-called interlopers from the Galactic bulge [7], which are subjected to endoergic $^{56}$Fe($\gamma$,$\alpha$)$^{52}$Cr (etc.) reactions (photodisintegration), ($\gamma$,n) or ($\gamma$,p) and fusion reactions like $^{12}$C($\alpha$,$\gamma$)$^{16}$O. It is remarkable that, beside of its surface temperature T$_{eff}$ of its outer core surface, the Earth shows also striking similarity in volume $V$ (radius $r_{Earth}$ $\approx$6.370 km) with an old white dwarf star (WD; $r_{WD}$ $\approx$6.300 km) like WD0346+246. This major boundary condition for nuclear planetology can be described in terms of $V_{Earth} = V_{WD} = V_{const}$=4•π•$r^3$/3 ($r_{WD} \approx r_{Earth}$). However, in addition to the fact that Earth is habitable, the most obvious difference between a WD and the Earth is their density $\rho$ ($\rho$=$m$/$V$; $m$ mass, $V$ volume): while a WD may contain $1 M_O$($M_O$= solar mass) per $V_{const}$, the mass of the Earth is only a tiny fraction of this, $\approx$3•10$^{-6}$ $M_O$ per $V_{const}$. Therefore, it is crucial to understand $\partial\rho$, or why $m_{Earth}$«$m_{WD}$ for $V_{const}$. Here I argue that the application of principles constrained by the theory of relativity [8] may offer a possible answer to this question: it is generally accepted that mass is directly related to energy, $E$=$m$•$c^2$ ($E$ energy; $m$ mass; $c$ velocity of light) or $m$=$E$/$c^2$. From $m$∼$E$ we derive that any mass change can be described in terms of energy change [8]. Instead of $\rho$=$m$/$V$ we may thus write $\rho$=$E$/$c^2$•$V$, and because of the special scenario $V_{Earth} = V_{WD} = V_{const}$ discussed here, the denominator of this equation becomes a constant term $C$=$c^2$•$V_{const}$ =9.73•10$^{37}$m$^5$s$^{-2}$. From this it follows, that $\rho$=$E$/$C$, or $\rho$•$C$=$E$. Therefore, we arrive at $\rho$ ∼$E$ for the WD/FeC-BLD case or, considering the evolution of the system over time $t$: $\partial\rho$/$\partial t$∼$\partial E/\partial t$.Hence, concerning time integrated planetary evolution it may be concluded that any density change $\partial\rho$ of an old stellar remnant towards a $\approx$3•10$^{-6}$ $M_O$ habitable Earth-like planet is a measure for the system's energy change $\partial E$. In the light of nuclear planetology this result has to be considered to understand the formation and evolution of crusts and mantles on planets and moons.

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