

B10 - GEO

Note Title

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ANTHROPICS OF BIO- & GEOCHEMISTRY

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arXiv:1604.03151

arXiv:1707. soon!

PLANETARY HABITABILITY

- ATMOSPHERE: escape velocity \approx thermal velocity

$$\Rightarrow .3 < \frac{M}{M_{\oplus}} < 4$$

[Rogers 2014]

[Marcy et al 2014]

- PLATE TECTONICS: mantle convective stress \approx crust yield stress

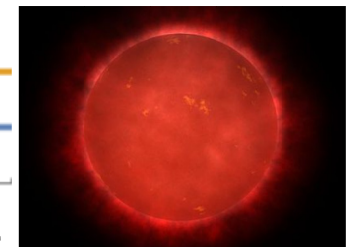
$$\Rightarrow .3 < \frac{M}{M_{\oplus}} \lesssim 16$$

[O'Neill, Lenardic, 2007]

[Foley, Bercoff, Landuyt, 2012]

[Alibert, 2014]

$\log(M/M_{\oplus})$



Earth's Heat

[KAMLAND, 2011]

ELEMENT	U 238	Th 232	K 40
HALFLIFE	4.5 Gy	14.1 Gy	1.3 Gy

α decays

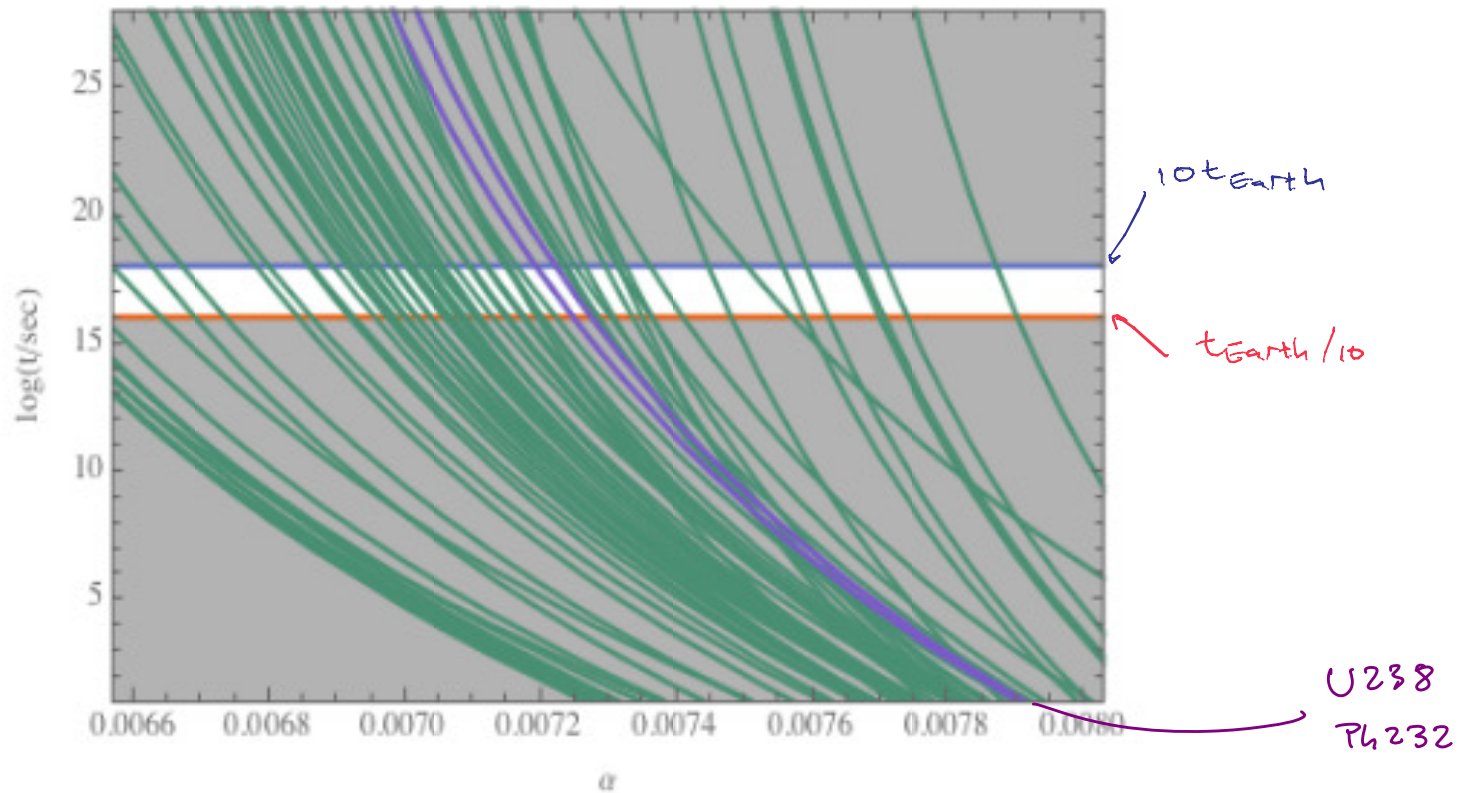
β decay

Geiger-Nuttall: $t_{1/2} \propto e^{\left(\frac{aZ}{\sqrt{\Delta E_b}} \right)}$

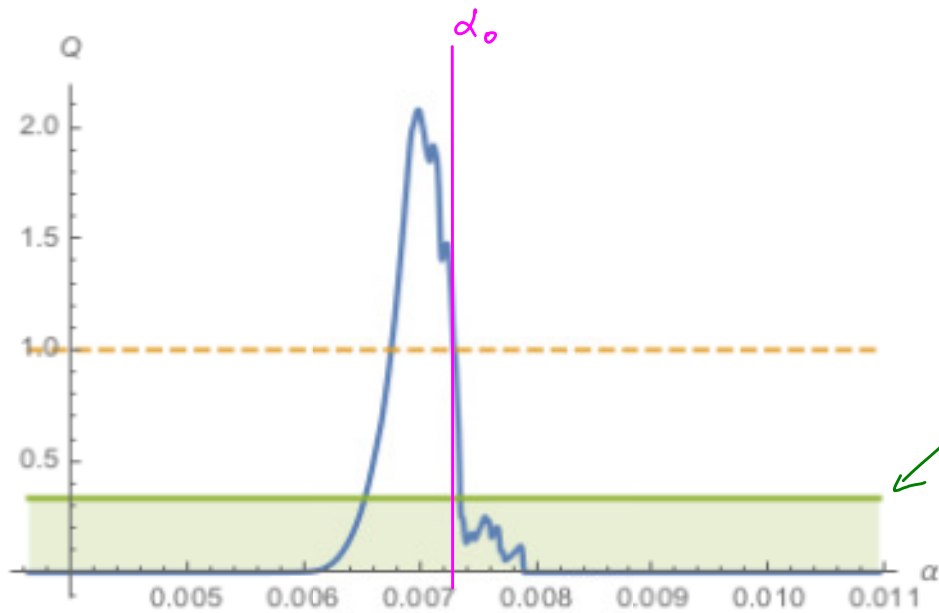
U 238: $\Delta \alpha = \pm .2\% \Rightarrow t_{1/2} = \left\{ \begin{matrix} 10^7 \\ .1 \end{matrix} \right\} t_{\text{Earth}}$

All Elements

- Actually 65 α decays: the relevant ones match the age of the Earth.



All Elements



$Q/3$: no plate tectonics
[Valencia et al, 2007]

- This restricts

$$\frac{1}{153} < \alpha < \frac{1}{136}$$

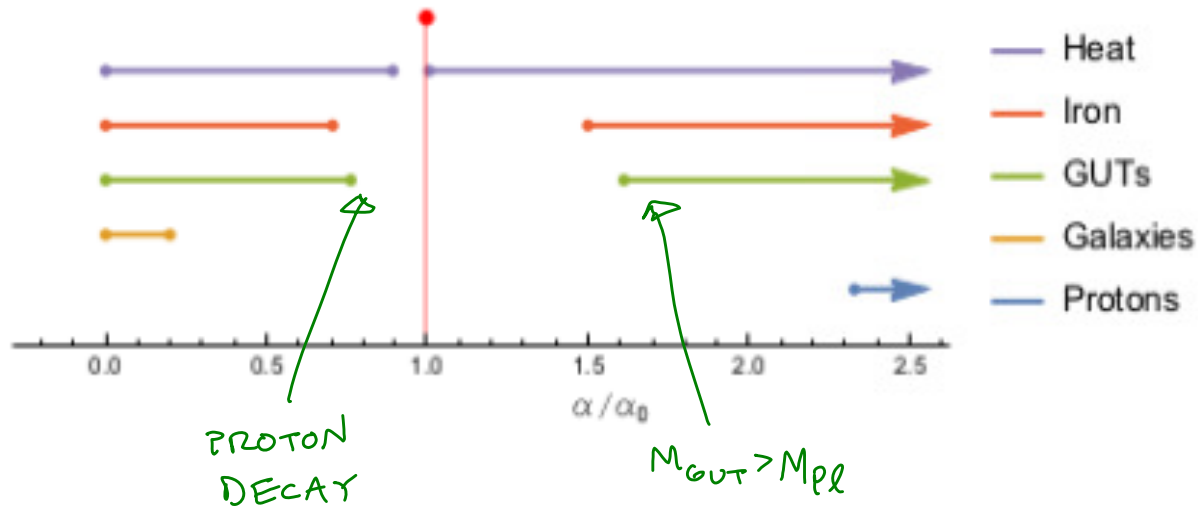
$\alpha_{max} \approx \alpha_{observed}$

Grand Unified Theories

- Strength of forces change with energy, meet at a high scale.

$$\frac{1}{180} < \alpha < \frac{1}{85}$$

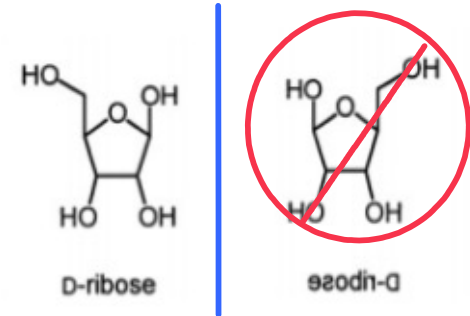
The GUT window [Barrow, Tipler 1988]



and the two overlap. Flexible GUTs?

HOMOCHIRALITY

- LIFE UNIFORMLY CHIRAL. HOW??



- INHERITED FROM WEAK FORCE?

[Vester & Ulbricht, 1959]

- MUST BE INDIRECT: β decay

OBSERVED IN EXPERIMENT!

[Dreiling & Gay, 2014]

- ASYMMETRY PRESENT IN SPACE

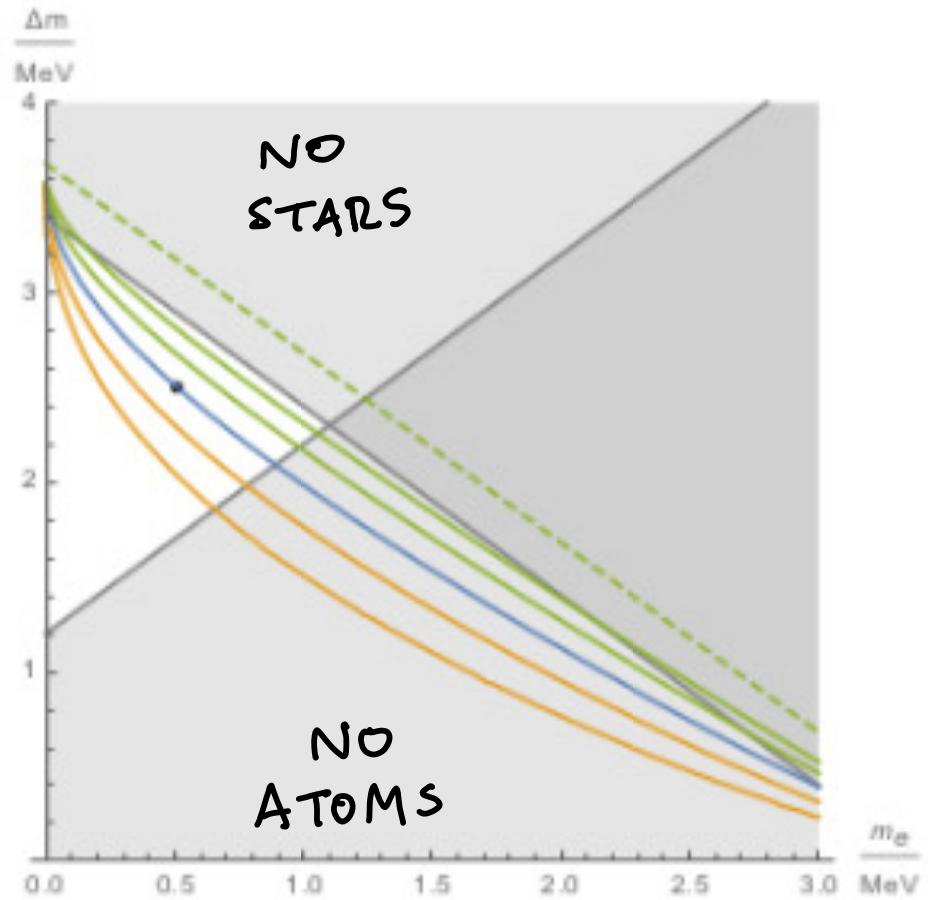
[Cronin, Pizzarello, 1997]

WHICH ISOTOPE RESPONSIBLE? ^{26}Al

[Cline, 2010]

^{26}Al HALF LIFE

Isotope	$t_{1/2}$ (years)	decay	produced (M_{\odot})
^3H	12	β^-	2.8×10^{-19}
^{10}Be	1.5×10^6	β^-	3.8×10^{-24}
^{14}C	5700	β^-	6.7×10^{-9}
^{22}Na	2.6	β^+	9.8×10^{-8}
^{26}Al	717,000	β^+/ec	1.8×10^{-6}
^{32}Si	153	β^-	1.3×10^{-8}
^{36}Cl	3.0×10^5	β^-	5.0×10^{-7}
^{39}Ar	269	β^-	3.5×10^{-9}
^{40}K	1.2×10^9	$\beta^-/\beta^+/\text{ec}$	1.0×10^{-8}
^{42}Ar	32.9	β^-	3.1×10^{-13}
^{59}Ni	7.6×10^4	ec	1.8×10^{-6}
^{60}Co	5.3	β^-	6.3×10^{-14}
^{60}Fe	2.6×10^6	β^-	1.8×10^{-17}
^{63}Ni	101	β^-	5.5×10^{-16}

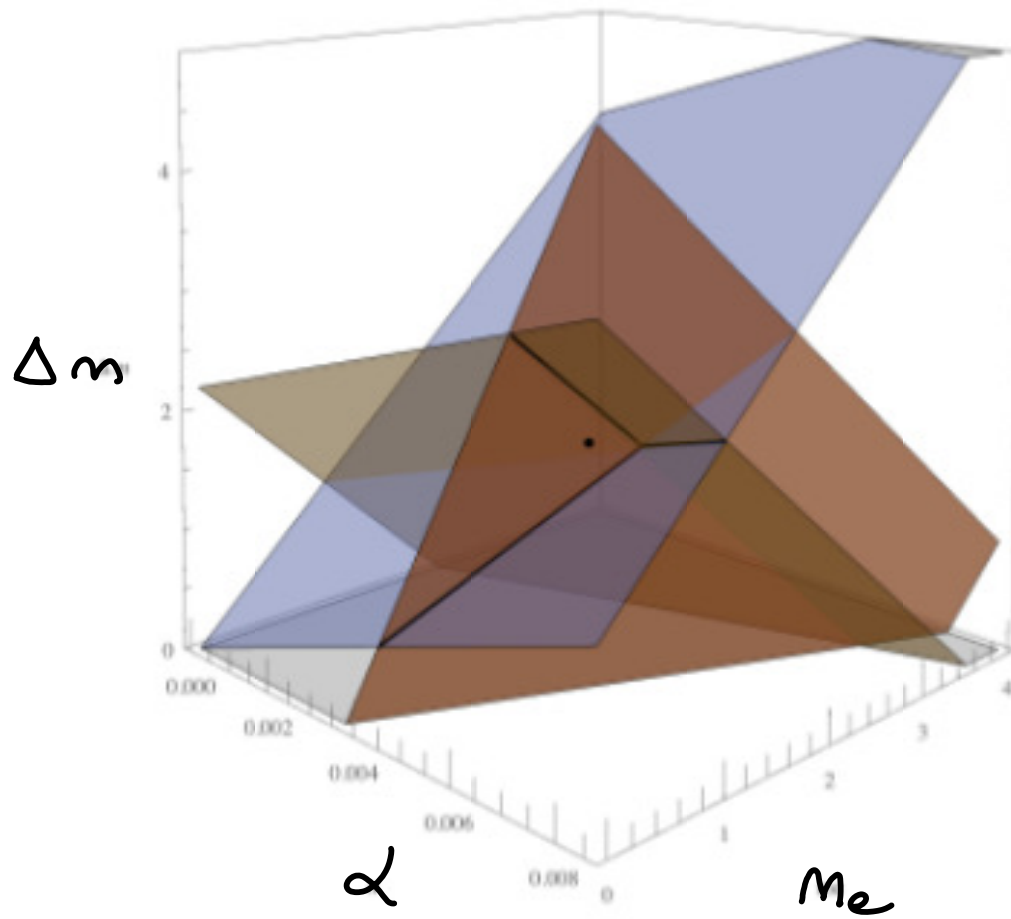


$$t_{1/2} \gg \text{Myr}$$

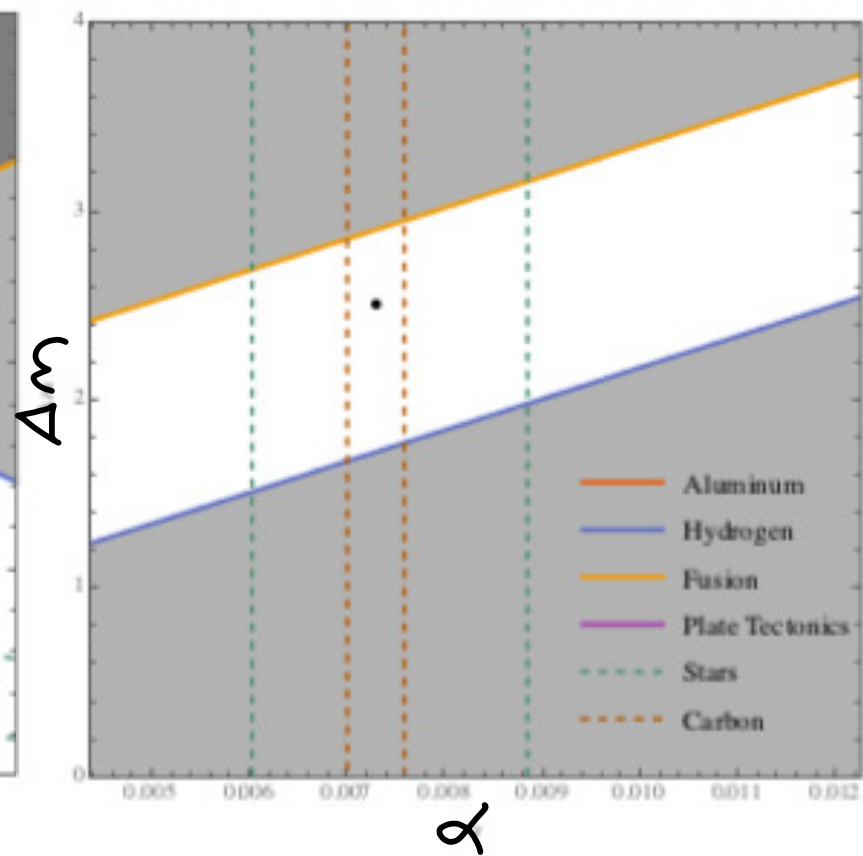
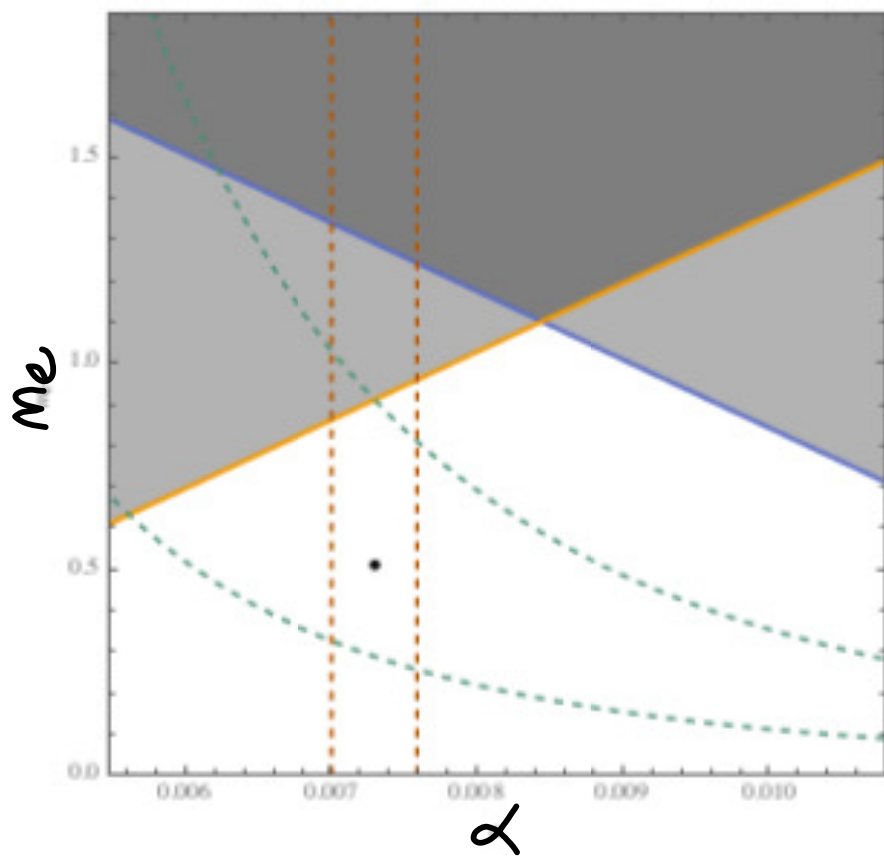
$$t_{1/2} \approx \text{Myr}$$

$$t_{1/2} \ll \text{Myr}$$

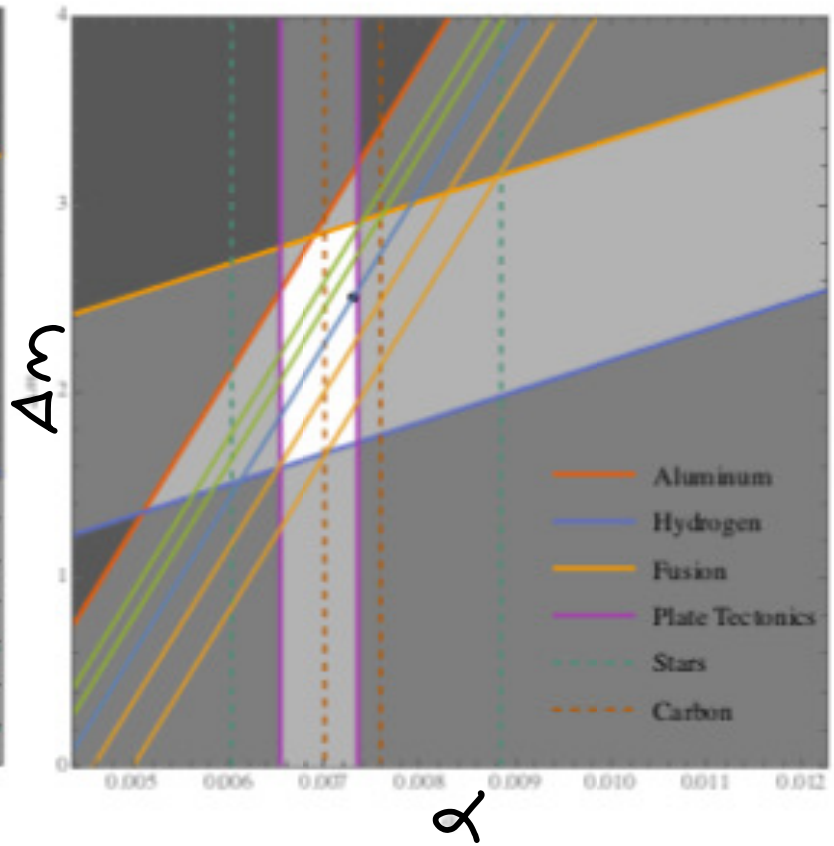
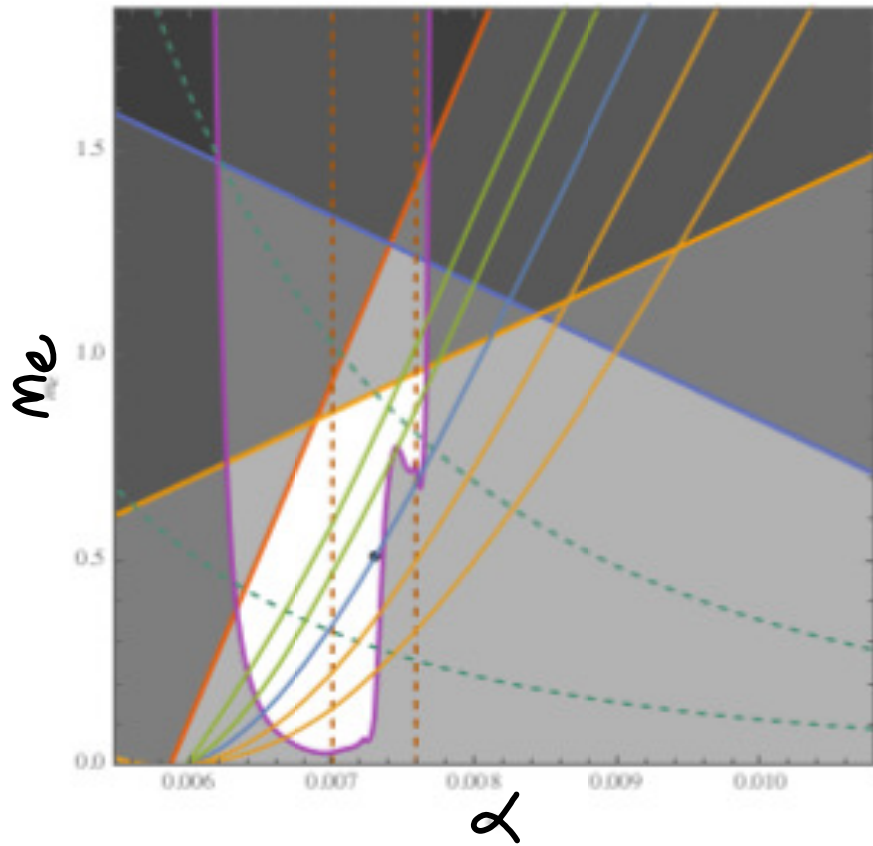
THE PRINCIPLE OF NONCOINCIDENT PERIL



OTHER ANTHROPIC BOUNDS



OTHER ANTHROPIC BOUNDS



THAT'S IT

↳ MORE DETAILED REQUIREMENTS

⇒ MORE ANTHROPIC BOUNDARIES

↳ THE MORE WE UNDERSTAND ABOUT LIFE,
THE BETTER.