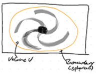
Galaxy with strong Planet Formation Rate of habitable Planets, PFR, yielding Dark Matter contributions by consideration of a modified Holographic Principle



Boundary B(V) ≙ Area A_I Surface of holographic field
(spherical)

Consideration of a Galaxy with a transition from $t_0 < T_{FL}$ (no Life) to $t \geq T_{FL}$ with $t \gg T_{FL}$

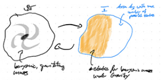
T_{FL} ≙ Onset of First life within Galaxy, depending on Planet Formation Rate (PFR) of habitable Planets.

$$\underline{t < T_{FL}} \longrightarrow \underline{t \gg T_{FL}}$$

Transition described by:
- onset of habitable Planet Formation (PFR)
- Assumption: Steady-state for thermodynamics of Galaxy, i.e. T = const.

With PFR(t) > 0 and the first appearance of habitable Planets, which most likely harbors some kind of life ⇒ within the Holographic Field I the states of life have to be considered?

$t < T_{FL}$



Deriving entropic Force-law according to the Holographic Principle:

$F = T \frac{\Delta S}{\Delta x}$ with Compton wavelength $\Delta x = \frac{\hbar}{mc}$

$\Leftrightarrow \Delta x \frac{mc}{\hbar} = 1$

$\rightarrow \Delta S = 2\pi k_B \frac{mc}{\hbar} \Delta x$

$\rightarrow F = T \cdot 2\pi k_B \frac{mc}{\hbar}$

What is T?

$E = \frac{1}{2} N k_B T$ $\quad N$ ≙ max number of states within A_I

$= \underbrace{Mc^2}_{\text{full mass within Volume } V \text{ in ST}}$

$N = \frac{A_I}{l_p^2}$; $l_p^2 = \frac{\hbar G}{c^3}$

$= \frac{A_I c^3}{\hbar G}$

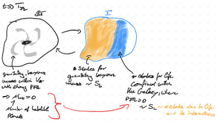
whereas $A_I = B(V_{ST}) = 4\pi r^2$

$\rightarrow T = \frac{2Mc^2}{N k_B} = 2 \frac{\hbar G M}{k_B c\, 4\pi r^2}$

$\Rightarrow F = \frac{2M\hbar G}{c k_B 4\pi r^2} \cdot 2\pi k_B \frac{mc}{\hbar}$

$= G \frac{Mm}{r^2}$ ≙ Newtonian Gravity derived as an Entropic Force

$t \gg T_{FL}$



Deriving entropic Force law:

$F = T \frac{\Delta S}{\Delta x} \rightarrow$ What is S?

$S = (S_b + S_L)$

with $S_b(t < T_{FL}) = S_b(t \gg T_{FL})$

→ no change in thermodynamic states (Annahme)

$S_b \sim 2\pi k_B$ with $E = \frac{1}{2} N k_B T = \underbrace{Mc^2}_{\text{baryonic mass is constant}}$

and $S_L(t < T_{FL}) = 0$

$S_L(t \geq T_{FL}) > 0$

$\Rightarrow \Delta S_L > 0$

$$F = \underbrace{T \Delta S_b \frac{mc}{\hbar}}_{\text{will yield Newtonian Gravity law}} + \underbrace{T \Delta S_L \frac{mc}{\hbar}}_{\text{Modification to Newtonian Gravity law due to extra term, which shows up as additional Gravity } (\rightarrow DM) \text{ due to + sign?}}$$

→ Originating in the Galaxy where PFR > 0 and thus $N_{hab} > 0$?

What are the dependencies of S_L and ΔS_L yielding an additional entropic Force?

$F = T \nabla_x S$ with $x = (x_1, x_2, \dots, x_N, N_p)$, $\nabla_x = (\partial_{x_1}, \partial_{x_2}, \dots, \partial_{x_N}, \partial_{N_p})$

$(x_1, \dots, x_N)$ ≙ Variables to describe the thermodynamic states of baryonic matter

N_p ≙ number of habitable Planets within the considered Volume

$F = \underbrace{T \nabla_x S}_{\substack{F_b \\ \text{entropic Force for baryonic matter} \\ \text{– Newtonian gravity?}}} + \underbrace{T \nabla_{N_p} S^{L}}_{\substack{F_L \\ \text{entropic Force by states of Life within considered Volume}}}$

S_L – by the consideration, that time frame is short enough, that thermodynamic states do not change within the Volume – see Annahme

Annahme: On the considered time frame for the evolution of Life, the thermodynamic states remain constant
⇒ T = const.

⇒ F_b = const. – Newtonian gravity

⇒ What are the dependencies of the Entropy of Life and its states within I?

$S_L \sim \underbrace{\text{\# of states of Life within holographic Field } I}_{\geq N_{LI}}$

N_{LI} in turn depends directly on the number of $\underbrace{\text{habitable Planets, else there would be no Life.}}_{\geq N_p \text{ ≙ } P(t) \text{ in von Bloh (2003)}}$

$\Rightarrow S_L \sim N_{LI} \sim N_p$

From Bousso (2002)
- $S \leq \frac{A}{4}$
- Number, $\mathcal{N}$, of independent quantum states
$\mathcal{N} = e^S = e^{(S_b + S_L)} = \underbrace{e^{S_b}}_{\mathcal{N}_b} \cdot \underbrace{e^{S_L}}_{\mathcal{N}_L}$, whereas here $\underline{N \neq \mathcal{N}}$ (in Bousso N is number of degree of freedom $N \leq \frac{A}{4}$)
with max number of states $\underline{\max}(\mathcal{N}) = e^{A/4}$

What are the dependencies for number of habitable Planets?

→ Following the studies of Behroozi & Peebles (2015) and von Bloh et al. (2003).

PFR → PFR(SFR) whereas PFR planet formation rate for Earth-Like Planets.
→ convolution with probability for being habitable yields number of systems with habitable planets.

SFR ≙ Star Formation Rate

Behroozi & Peebles (2015): $PFR(M_*, t) = n \frac{(Z(M_*, t)/Z_\odot)^\alpha}{\langle m_* \rangle} SFR(M_*, t)$

Werner von Bloh et al. (2003): $N_p = P(t) = \int_0^t PFR(t') \times P_{hab}(t - t')\, dt'$

⇒ For the numerical results for PFR & N_p, see Figures in both manuscripts!

⇒ The number of states, N_{LI}, in I and hence the Entropy of Life, S_L, depends on the Planet Formation Rate, PFR, of Earth-Like Planets, which depends on metallicity and mass of the host Galaxy.

⇒ The entropic Force of Life, F_L, acts as an additional Force and modification to Newtonian Gravity, and which acts due to $F_L \geq 0$ as an additional form of Gravity, that is usually accounted for as Dark Matter.

⇒ This theory yields predictive observations for UDGs, Bullet Cluster, Cosmic Web (also for Dark Energy), Cusp-Core-Problem.