# On the phenomenology of Dark Bodies and their Darker Energies beyond the Cosmic Horizon

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**Abstract**

An attempt to understand Dark Matter and Dark Energy from an earthly point of view is constructed through black hole centric thought experiments. From which it is found that both Dark Matter and Dark Energy are most likely derivatives of baryonic-matter-at-a-distance and "off brane" gravitational radiation living on a nearby horizon that our local horizon is presently encroaching upon. As a consequence the amount of apparent Dark Matter in the Universe should increase over cosmic time which in principle offers an avenue for testing the phenomenological hypothesizes discussed within.

## 1 Introduction

At the present it is widely held that there are only four fundamental forces in nature and that the behavior of only 4% of the Universe is known. The remanding 96% of nature however is believed to reside in a *universe darkly.* Astrophysicists tell us that 23% of the dark universe consist of Dark Matter (DM), which interacts only gravitationally. Whereas cosmologists tell us that the bulk of the dark universe, a whopping 73% in fact, consists not of matter but of a very unearthly Dark Energy (DE) causing the Universe to expand at an ever increasing rate. Thus undoubtedly the two most baffling phenomena in modern non-terrestrial science are the so-called DM and DE problems, or at least in the eyes of well-grounded physicists and theoreticians. The problem historically is that the success of the theory of gravitation (and the whole of science) lay in the principle that *the laws of physics here are no different than there*, but modern cosmologists seem to tell us that principle is just not the case. The current popular trend is to simply just accept DM and DE as physical experimental evidence expo de facto of their discoveries even though they appear to defy scientific principles by requiring selective laws of physics in nature. There is however an attempt at present to preserve physical principles in regards to DM called MOdified Newtonian Dynamics (MOND) c.f. [1] and there are even

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similar proposals for Dark Energy, e.g. [2], although these approaches also appear to be the least popular for a number of reasons [3]. Most surprising is that to date, only two groups claimed to have detected DM directly and both have met with great skepticism and perhaps rightfully as one group describes DM to be light masses with velocities of hundreds of km/s [4], while the other describes DM to be heavy *charged* masses having velocities of a few km/s [5].

Of course all of this begs one to ask: how in an age with an abundance of new astronomical data is it possible that a large portion of the universe has gone dark on us? The answer is simple. We have gotten the analysis wrong. Perhaps the most clear cut evidence for this is the fact that General Relativity (GR) can be used to invoke the properties of DM [6], which would be impossible to recognize from the stand point of Newtonian gravity. If GR is the answer to the DM problem that would then bring known constitutes of the Universe up to 27% thereby leaving the DE as only component of the universe darkly. The use of GR to explain away DE however is problematic because at present there is no known quantum theory of gravity which might explain away DE. Worse yet is that while GR allows for cosmological a constant $\Lambda$ with units $m^{-2}$ which could cause the universe to expand **ad hoc** the observational data for DE has a form more along the lines of $\Lambda(t)$. Clearly something is amis with the universe and it's not the data! So the big question should not be asking whether or not DM and DE exist, but rather can the Universe live darkly without breaking the cherished laws of physics?

# 2 On the strength of gravity below the horizon

Out of the four fundamental forces gravity is believed to be the weakest, a simple relationship between the gravitational and electric force shows that

$$\alpha_g = \frac{F_g}{F_e} = \frac{Gm_p^2}{ke^2} = 8.09 \times 10^{-37}. \tag{1}$$

The ratio between the gravitational force and the electric force seems reasonable as weak magnets of a few grams can over power the gravitational pull of the entire Earth made up of trillions and trillions of kilograms. The contradiction to this rule of thumb however comes in when a "dead" body has a mass $M \geq 3M_\odot$, where $M_\odot$ is a solar mass at this point an event horizon forms and the gravitational force is able to constrain the electromagnetic force. Recalling the limits of GR on black hole mass and assuming the plank mass $M_p = (\hbar c/G)^{1/2}$ to be the fundamental unit of mass then we find that

$$\alpha_{gp} = \frac{3M_\odot}{M_p} = 2.74 \times 10^{38}. \tag{2}$$

Thus it becomes clear that the minimum mass for a black hole in GR has a gravitational strength much stronger than electromagnetic force as seen by $\alpha_g \alpha_{gp} = 221.82$. It is also of note that in quantum theory the strength of gravity can be given in terms of quantum mechanics such that $\alpha_{gq} = Gm_p^2/\hbar c =$

$5.90 \times 10^{-37}$, thus from eq. 2 we would expect that the fundamental critical mass for gravity to become strong within a black hole would be in the ball park of

$$m_{crit} = 3M_\odot \left(\frac{Gm_p^2}{\hbar c}\right) = \varphi M_P = \frac{1+\sqrt{5}}{2}\, M_P = 3.52 \times 10^{-8}\, kg. \tag{3}$$

Although by definition it is worth pointing out that gravitation and the strong force have the same magnitude when $GM_P^2/\hbar c = 1$, which would put eq. 3 at $Gm_{crit}^2/\hbar c = \varphi$, making it again stronger than the Strong Force! However since $M_P = (3M_\odot m_p^2/m_{crit})^{1/2}$ one could redefine the minimum critical mass for a stellar black hole so that

$$m_{mbh} = \frac{3M_\odot}{\varphi} = 1.85\, M_\odot. \tag{4}$$

Assuming that a stellar body is composed of neutrons before it can critically collapse implies that the minimum amount of neutrons required in the core is $N_{mn} = 2.2 \times 10^{57}$ and in accordance to the Schwarzschild radius $r_s = 2GM/c^2$ the core could be no bigger than $r_{mbh} = 5.47\, km$. Thus in terms of current theory a black hole would be born when the density of a body reaches a density of $5.36 \times 10^{15}\, g/cm^3$ or greater, meanwhile the core would continue collapse to a singularity state which may be cutoff at the planck length $l_p = (G\hbar/c^3)^{1/2}$ and would then acquire a density of $\rho_p = c^2/l_p^2 G = 5.2 \times 10^{93}\, g/cm^3$. However in reality it is unlikely the planck density would be reached because the planck mass is essentially defined as being equated to the strong force and hence the strong force in principle should be able to push back on strong gravity.

## 2.1 a more general equation for gravitational radii

To understand what happens within the core of a dead star it might help things if we could define the physical radii of say planetary bodies in terms of $r_s$. Conceptually all that would have to be done to generalize $r_s$ to planets is to find the amount of particles in the body, which generalizes to $N_b = M/m_p$ and multiply that by some constant to deal with the electromagnetic forces in question. Through some trial and error using the critical mass value from eq. 4 we find the gravitational radii of bodies can be described approximately by the following formula

$$R_{ast} = \frac{s_n r_B}{r_p\sqrt{\alpha}} \left(\frac{12}{1+\sqrt{5}}\right) N_b \frac{Gm_p}{c^2} \tag{5}$$

where $r_p = ke^2/m_p c^2$ is the classical proton radius, $\alpha = e^2/2h\epsilon_0 c$ is the fine structure constant, and $r_B = \hbar^{-1} m_e c\alpha$ is the Bohr radius. Bodies with Earth like densities have a good fit with $s_n = 1$ (within 95.9% confidence), however for Jupiter like planets $s_n = 0.04$ is a better fit likely due to the presence of metallic hydrogen cores[1]. It is also worth pointing out that eq. 5 can be converted to

[1]It should be noted that this equation is indeed general and may not fit for all planetary bodies and would require revision to describe bodies such as stars due to active fusion etcetera.

the standard Schwarzschild like radius by

$$s_n = \frac{r_p\sqrt{\alpha}}{r_B} = 2.48 \times 10^{-9} \tag{6}$$

suggesting that the average spacing between particles is $s_n r_B = 1.31 \times 10^{-19} m$, using the formula for classical electric radius suggest a collapsing star mass be composed of particles with an average energy of $1.09 \times 10^4 MeV$, which is close to the top quark mass[2]. From this result we can deduce the density of the core after collapse would not to be planck density as typically expected but rather $\rho_c = m_{mbh}/(4\pi/3)(s_n r_B)^3 = 3.9 \times 10^{83}\, g/cm^3$. If the planck density and $s_n r_B$ have meaning within a black hole this would also suggest an upper limit on black hole mass at $\rho_p(4\pi/3)(s_n r_B)^3 = 4.2 \times 10^{11} M_\odot$ and surprisingly enough observed super-massive black holes do approach this mass and don't appear to go beyond it.

### 2.2 some comments on planck units

For a stellar mass black hole it is clear that fundamental length scale should be $r_{mbh}$ and not $l_p$. Furthermore the final collapse stage in accordance to eq. 5 has a physical density $\rho_c$ which is ten orders of magnitude less than $\rho_p$. Suggesting that the planck mass only seems to have physical significance for the behavior a black holes and not the Universe as a whole because $GM_P^2/\hbar c = m_{mbh}/N_{mn} m_n$. Further since $l_p/M_P = G/c^2$ it can be shown that

$$l_p = \frac{r_{mbh}}{2}\frac{M_P}{m_{mbh}} = \frac{GM_P}{c^2} \tag{7}$$

and from here it is clear that the planck length is not truly fundamental but perhaps still useful as has been suggested before [7]. While eq. 7 puts into doubt the applicability of planck units it does however provide an explanation as to the occurrence necessary for the gravitational force to become strong: being when the physical density of a body passes the critical density

$$\rho_{crit} = \frac{c^2}{r_{mbh}^2 G} = \frac{c^6}{4G^3(m_{mbh})^2} = 4.49 \times 10^{16}\, g\, cm^{-3}. \tag{8}$$

## 3 $G$ in terms of fundamental units including $\Lambda$

One of the must frustrating aspects of Newton's Gravitational constant $G$ is that is purely derived from empirical measure and is known with little precession compared to other physical constants. Morton Spears an electrical engineer however proposed that $G$ could be understood in terms of capacitance [8], a simplification of his methods leads to the formula:

$$G_S = \frac{(r_e e)^2}{2m_e(m_p + m_e)Fm} = 6.68 \times 10^{-11}\ m^3 kg^{-1} s^{-2}. \tag{9}$$

[2]Though this interpretation should be taken with a grain of salt as using the classical result implies that $r_B \to m \ll m_p$.

The problem with the above is that throwing in farad-meter units in the denominator seems a bit of a cheat, a more natural choice would be

$$G_f = \frac{c^2 \alpha r_e}{2(m_p + m_e)} = 5.52 \times 10^{26}\ m^3 kg^{-1} s^{-2} \tag{10}$$

while the units come out correct the magnitude is nowhere in the ball park of $G$. For those familiar with cosmology the square of the Hubble parameter would appear to lower $G_f$ to the correct magnitude, specifically through the relation $G \approx (H_0 c \cdot t)^2 G_f$, where $t = 1s$ as such a new Hubble parameter $h_0$ can be defined as

$$h_0 = \sqrt{\frac{1}{t^2} \frac{2G(m_p + m_e)}{c^2 \alpha r_e}} = 3.47 \times 10^{-19} Hz. \tag{11}$$

Therefore

$$G = \frac{\alpha r_e (h_0 c \cdot t)^2}{2(m_p + m_e)} = 6.67 \times 10^{-11} m^3 kg^{-1} s^{-2}, \tag{12}$$

while the inclusion of $t$ seems a bit of a cheat hear, it would seem less so if a from of cosmic time dilation were to be discovered, but we'll come back to that point later. What is also of interest is the ratio $H_0/h_0 = 6.53$, as it is currently believed that DM outnumbers baryonic matter six fold. Moreover one can now define the cosmological in terms of

$$\Lambda_0 = \left(\frac{h_o}{c}\right)^2 = 1.34 \times 10^{-54}\ m^{-2} \tag{13}$$

and if the Hubble parameter is somehow tied to DM then it would seem that $DE \propto DM$, but we'll return to that later. Surprisingly enough $G$ can be evaluated purely in terms of $\Lambda$

$$G_\Lambda = \alpha r_e \left[\frac{c^2}{2(m_p + m_e)}\right] \left[(\Lambda_0 c^2 t^2)\right] = 6.67 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{14}$$

and from here a cosmological version of the Schwarzschild radius can be given

$$r_{s\Lambda} = \frac{\alpha r_e \Lambda_0 (ct)^2 M}{(m_p + m_e)} \tag{15}$$

without the need for conventional $G$ which suggest that mass could absorb DE and contribute to the curvature of spacetime.

## 4 On Dark Matter and Energy

It is an intriguing idea to postulate that $\Lambda$ may be tied to DM through $H_0$ as it could explain the recent cosmic acceleration reported by Riess [9] and others. For example a recent $\sim 15\%$ accretion of DM into the cosmological intergalactic neighborhood would have risen $\dot{a}(t)/a(t)$ to its present value $H_0$ thereby acting as the source of the recent cosmic acceleration. In MOND theories the velocity of rotation curves is extrapolated through $v_m = (GM_g a_0)^{1/4}$ which could in principle originate from the relation $a_0 \approx c^2\sqrt{\Lambda_0}$, so it might be very well that $DM \propto DE$ as suggested by eq. 15. An oddity is that with the current accepted value for the recession velocity $\dot{a}(t) \approx 71\, km/s$ the Hubble parameter yields an acceleration of $H_0 c = 6.8 \times 10^{-10}\, ms^{-2}$ or $\approx 6a_0$. Therefore it may be possible that the present DM to baryonic matter (BM) ratio is a result of $H_0 c/c^2\sqrt{\Lambda_0}$, thus a simple DM solution for average velocity for galactic orbits would become

$$v_g = \sqrt{\frac{GM_g H_0}{rc\Lambda_0^{1/2}}} = \sqrt{\frac{GM_g H_0}{rh_0}} = \sqrt{\frac{M_g \alpha r_e}{2(m_p + m_e)} \frac{(h_0 ct)(H_0 ct)}{r}}. \tag{16}$$

From the above result one could interpret the MOND acceleration constant at

$$a_0 = \frac{\sqrt{\alpha}\,(h_0 ct)(H_0 ct)}{r_B} = 1.15 \times 10^{-10}\, ms^{-2} \tag{17}$$

which strongly implies that MOND theories are nothing more than an approximate phenomenological average of a galaxies DM content in relation to atomic matter. It is also worth pointing out that from eq. 16 it appears that $H_0 = \phi(r,t)h_0$, which is appealing in that $\Lambda = \text{const.}$, on the other hand it has some serious repercussions for our current understanding of the cosmos. For example applying the DM accretion concept to the DM halo model in regards to the speed at which the Milky Way approaches the Virgo Supercluster $v_{MW} \approx 330 km/s$ suggest DM halos should have a radii corresponding to $v_{MW}\, a(t)/\dot{a}(t) = 4.5\, Mpc$. However since $4.5\, Mpc$ extends beyond the Local Group of galaxies it would represent an unrealistic distance for the current concept of DM halos and so hints at the existence of a possible second cosmic horizon $b(t)$ beyond our own. What is surprising is that once eq. 5 is modified to account for the size of galaxies by using the Sun as an average star we get

$$R_{Gast} = \frac{s_n\, pc}{R_\odot \sqrt{\alpha}} \left(\frac{12}{1+\sqrt{5}}\right) \frac{GNM_\odot}{c^2} \tag{18}$$

with $s_n = 0.14$ to account for star clusters, $N = 4.0 \times 10^{11}$ for the stars in the Milky Way, we find that $R_{Gast} = 5.1\, Mpc$. As such the radius for the Milk Way implied from the above is surprising since the physical radius of the Milky Ways is $\approx 30\, kpc$, however it is interesting to note that when $s_n = 0.14\alpha$, $R_{Gast} = 37.5\, kpc$ becomes an acceptable DM halo radius. It is also worth noting that $\alpha \approx \Lambda_0 c^2/3H_0^2$ which suggest that if DM can be accreted onto our horizon $a(t)$ then the radius of influence is essentially

$$R_{Hast} = \frac{\Lambda_0}{3H_0^2} \frac{s_n pc}{R_\odot \sqrt{\alpha}} \left(\frac{12}{1+\sqrt{5}}\right) GNM_\odot \tag{19}$$

but this begs the question why?[3]

[3]What is interesting is when one reduces the effective radii of astronomical bodies, black holes, and galaxies through the cosmological explanation for $G$ implied by eq. 12. As in

In scalar-tensor-vector gravity DM is treated as an illusion caused by a running gravitational constant $G(r)$ [10] and eq. 16 certainly would seem more realistic if it were the result of a running constant, so if the running constant is tied to an outside horizon as we hypothesized earlier then one would expect $h_0$ to be tied to

$$\phi(r,t) = \left[1 + \sqrt{\frac{a(t)M_b}{b(t)M_g}}\,(1 - \exp(-r/R_g))\left(1 + \frac{r}{R_g}\right)\right] \tag{20}$$

where at the present $a(t)/b(t) = 3.2$, $0 < r < R_{Hast}$, for convenience $M_b = M_g$, and $R_g$ is the physical radius of the galaxy. Therefore $R_{Hast}$ can be understood as the present limiting factor in the running gravitational constant which yields the $H_0$ expansion factor. This result also implies that $R_{Hast} \rightarrow R_{Gast}$ back in time, thus the apparent accretion of DM over time would also induce a rapid increase in the apparent density of DM halos with time[4]. It is also worth pointing out that with a second horizon the Newton gravitational potential becomes

$$\vec{\Phi}(r,t) = \frac{\alpha r_e \phi(r,t)(h_0 ct)^2 M}{2(m_p + m_e)r} \approx \frac{G\phi(r,t)M}{r} \tag{21}$$

so while on galactic scales there appears to be six times more DM than baryonic matter this is really just an illusion with the actual geometric DM count in the three fold range compared to baryonic matter. Therefore assuming a flat isotropic universe the geometrical budget of the universe can be divided as $\Omega_{flat} = 0.06\Omega_M + 0.21\Omega_{DM} + 0.73\Omega_\Lambda$.

By nature the other horizon should essentially behave as the universe we know except that it would be older than our own and have a somewhat stronger gravitational strength. Our horizon having less mass by comparison is thus able to catch up to the first horizon and thus appears to cause an apparent increase of matter within our universe which is purely geometrical and that we presently term DM. This baryonic-matter-at-a-distance (BMAD) interpretation of DM would also explain the present direct lack of verifiable evidence for DM, as on our horizon local galactic matter can't dimensionally posses $\phi(r,t)$ self-interactions and thus feels remote BM at a distance. Further over time the Cosmological Constant should be expressed as

$$\Lambda(r,t) = \left(\frac{\phi(r,t)h_0}{c}\right)^2 \tag{22}$$

making it seem unlikely that the above could be the cause for inflation from our perspective. Though it is interesting that $\Lambda(r,t)$ appears to imply that there is more negative (pressure) energy at the edges of galaxies than at their

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astronomical bodies individual atoms seem to balance out $G_f$, while in black holes $h_0$appears to couple to a DM term, and finally in galaxies it appears that $G$ decreases by the square of the DM term, which turns out to be eq. 20 suggesting horizonal influences on $G$.

[4]This is pointed out because at present it is believed that DM condensed before BM, however this approach suggest that the opposite is the case.

cores, which suggest that BMAD matter may absorb this negative pressure. It is however possible to speculate that $\Lambda(r,t)$ may have drove the expansion of the $b(t)$ horizon and hence would appear very weak in the early history of our horizon $a(t)$, but as we approach $b(t)$ its effects on DM become increasingly undeniable due BMAD accretion.

### 4.1 black holes as Dark Energy stars?

Chapline has recently disregarded the infinite singularity prediction for black holes within GR due to arguments from condensed matter physics [11], thus eq. 15 should give us a hint about DE stars through

$$r_{s\Lambda} = \frac{\alpha r_e \left(\phi(r,t) h_0 t\right)^2}{(m_p + m_e)} M. \tag{23}$$

Thus it would seem that over cosmic time $r_{s\Lambda}$ could grow (DM accretion), also from the above Hawking radiation may reevaluate such that

$$T_H(r,t) = \frac{\hbar c}{4\pi k_B} \left[ \frac{(m_p + m_e)}{\alpha r_e M} \left( \frac{1}{\phi(r,t) h_0 t} \right)^2 \right] \tag{24}$$

so that the mass of the system is conserved over cosmic time. Moreover from eq. 24 a super-massive black hole should not be able in principle radiate less than $1.5 \times 10^{-19}\,K$ of radiation at the present epoch. What is also of interest is that $\phi(r,t)$ suggest that black holes in the center of galaxies will radiate more Hawking radiation than black holes along a galaxy's rim because that is where BMAD curvature is greatest. Therefore the argument for the existence of a DE star in the conventional sense seems unlikely, though it would be difficult to rule one out in the DM form. On the hand if the mass of a black hole is capable of approaching the other horizon where the gravitational strength may very well be of order $G_f m_p^2/\hbar c = 0.047$ it may be very well that a DE of sorts can avert a physical singularity state as implied by eq. 6 that is impossible on our horizon due to remote strong interactions.

## 5 Discussion

The picture painted for DM and DE in this work stems from a distant cosmological horizon which has a higher magnitude for the gravitational constant $G_f$ than on our horizon $G$. In principle $G$ should correspond to $\alpha r_e (H_0 ct)^2/2(m_p + m_e) = 2.6 \times 10^{-9}\, m^3 kg^{-1} s^{-2}$ but has a coupling component with the other horizon $\phi(r,t)$ which yields $G$, but we interpret $G = $ const. as the $t$ component is effectively beyond our horizon. Therefore as our horizon $a(t)$ approaches the other horizon $b(t)$ we attribute our approach to the other horizon as an increase in the DM content in our universe rather than an increase in $G$. Cosmologically as our horizon expands the over all DE density in our universe decreases from our point of view but is also absorbed into DM geometrically as we approach the source[5] and hence contributes to an accelerated expansion rate. In essence the galactic rotation curves could be interpreted as dark (negative) pressure being absorbed by BMAD because kinetically visible baryonic matter desires to escape galaxies but is being constrained by a negative pressure which is currently being incorrectly attributed to DM due to the fact $DE \propto DM$ which is effectively the inverse proposition of [12]. Assuming both horizons are working together to maintain an isotropic universe then one would expect that our horizon would be evolving to the eventual state $\Omega = 0.06\Omega_M + 0.94\Omega_{DM}$. Mathematically the universe would seem to be best modeled where both DM and DE are treated as curvature effects as in [13] with a scalar-tensor-vector twist [10] but containing two or more horizons rather than just one.

While it's apparent that a more effective model is needed beyond the phenomenological approach pursued in this work in order to draw definitive conclusions of DM and DE some generalizations can be made with the present approaches which are testable. The most general and most hypothetical stems from eq. 12, if it can be found that (strange) quark stars exist the local value for $G$ would vary from the Newtonian one due to the star being composed primarily of non proton/neutron matter. Secondly $\phi(r,t)$ should in principle be able fit observations better than existing models. More straight forwardly a 15% decrease in $a(t)/b(t) = 3.2$ from its present would yield at an earlier time the value $2.72 = a(t_e)/b(t_e)$ and should be inputted into $\phi(r,t)$ for redshifts $0.16 \leq Z \geq 0.5$. Therefore the clearest proof for the proposal of our horizon approaching another would be that stars in distant galaxies would be orbiting their host galaxy at slower velocities relative to their visible mass than they do at the present epoch demonstrating that the geometrical DM content in the past had less of an effect than its present value.

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