# Locally Nonuniform Expansion Pressure as a Model for Dark Energy and Dark Matter

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**Abstract**

The paper outlines an early thought experiment regarding cosmology, takes it to further conclusions, and to possible predictions and problems. The model eventually involves the supposition of inhomogeneous negative pressure arising from the vacuum dependant upon void scale, and the effects that might be observed on larger scales as well as implications derived from this idea. It attempts to address the nature of dark matter and the halo problem, dark energy and accelerating expansion, and inflation. The possibility arises that all three (in addition to other observed effects of galactic evolution) could derive from the same modeled effect assumed to be negative pressure from the vacuum arising from non uniform expansion.

## 1. Introduction

This is a paper outlining a thought experiment.

Following and fleshing out the thought experiment led to several emergent properties. They appear to be supported by empirical data and provide a potentially unifying explanation for multiple phenomena.

This paper is broken into a discussion, a section on possible predictions, a section on problems introduced by changing the expectations of current cosmology, a summary, and a section of issues with what the model assumes. It outlines additional problems with the assumptions of this model and contains a collection of errata, references and notes.

The concept is nonstandard. Every effort has been made to analyze it in light of the most current cosmological observations, citing mostly papers since 2000. It has been noted when either the model is no more predictive than other models, or where the initial predictions of the model diverge from existing papers and data.

The ideas presented here mathematically most closely resemble in action a postulated and described “dipolar” gravitational fluid [1], but go in a different direction to produce some predictions that could be potentially verified. It is not the assumption of this paper that there are any fluid dynamics at work.

Essentially, the beginning concept is that negative pressure arises from the vacuum. This negative pressure is nonuniform (over all scales), and coupled with the distribution of matter. It is greatest in regions of low mass and density, decreasing with increasing density and concentration of matter. The effect increases with a hypothetical (perfectly spherical and empty) volume, making it behave after a fashion as an inverse gas (increasing pressure with volume).

This hypothetical localized negative pressure interacts with the normal curvature of spacetime out of which arises the behaviors of dark matter, dark energy and potentially inflation. At the extreme, these properties are imagined as emergent and related, rather than explicitly defined individually, avoiding fine-tuning. Over greater than 100 Mpc scales, however, it would still appear homogeneous. Specifically, the linear nature of the Hubble flow (recessional velocity) with distance could be mimicked with a variable effect that appeared homogeneous at larger scales.

This idea and this paper do not posit an exact mechanism. This is, fundamentally, a thought experiment and description of the characteristics of this idea with a list of consequences for the observable universe. Some attempt is made at characterizing it mathematically.

It could be described as a nonparticulate localized (inhomogeneous) negative pressure that increases with the mean radius of a hypothetical matter-free spherical void space, mimicking dark matter influence. “Nonparticulate” in this sense means a non-particle based influence: it is the vacuum rather than any type of matter.

Voids are defined here as regions of density < .1 atom per cubic cm. Denser regions could (hypothetically) also have this effect, but generally for the sake of this thought experiment, the largest effect a region of void can have in a particular vector is defined by the sphere of largest fit that does not intersect substantial matter.

One outcome of this is a large region dominated by a dark matter halo (effect) can have, as a rule, smaller regions of dark matter influence (sub halos), none of which can be greater in magnitude than the “outermost” halo. All halo substructure must be less concentrated than the outer halo.

The description of this negative pressure varying with the adjacent scale of (hypothetically perfectly spherical) local voids is an essential feature. It points to a reason for accelerating expansion, offers potential explanation for variations in dark matter halos of clusters, and produces simple coarse predictions for clusters of varying densities.

The final consequence is the potential modeling of dark matter, dark energy, and inflation as a single self-limiting effect, which could address the fine-tuning problem. There is no fine tuning if this is a single effect. It is behaving in a self-consistent manner rather than it being three or more separate forces acting serendipitously in concert.

There is the possibility that this might be seen as a naive interpretation of thought-models of an expanding universe; however, the assumption in this model is that the origin and apparent effect of expansion is the reverse of most assumptions. Expansion in this model is not the big bang momentum of matter with the expansion of space as an apparent effect; rather recessional velocity is the apparent effect with expanding space as the “cause” - actual negative pressure arising from expanding space with a measurable and variant force component (in this case, the dark matter effect; again turning the normal cause and effect on its side).

## 2. Discussion

The discussion section will outline more specifically the concept, the basic rules that it attempts to put in place, and some predicted outcomes based on those rules.

### 2.1 Presuppositions

The idea has a few presuppositions.

One is that, for now, we do not include universal, uniform expansion by way of a cosmological constant (additionally any scalars (simple calculations) designed to model expansion as a uniform featureless energy), nor do we include momentum from the big bang as a cause of recessional velocity.

The other is that we suppress current concepts and definitions of dark matter and dark energy (without ignoring their associated data), with implications for the energy density of the universe and cosmological evolution scenarios. The observed effect of dark matter is concrete; this thought experiment interprets the potential source of it in a unique way, as a nonparticulate effect rather than a type of matter.

The model will eventually readdress the data associated with each of these concepts.

### 2.2 Inception and initial thought experiment

This idea started by wondering what anti-gravity would look like - negative pressure, effectively. Not the science fiction anti-gravity or the anti-gravity or photon universe of crank-science “push” gravity, but what the real effect would look like. It is like asking what negative acceleration looks like. It is acceleration, the only thing really negative about it is the vector.

If we suppose that dark matter was not actual mass but instead a localized nonparticulate negative pressure (see introduction), it still works to an extent. But this is simply reversing the sign and vector of gravitational acceleration, an exercise in simple math and not proof of anything.

What would distinguish a negative pressure from normal gravitational acceleration?

The negative pressure has to, in this model, have a source. Given that both dark energy and the cosmological constant were postulated to arise from negative pressure, we assume conservatively that this could be modeled in a similar way (negative pressure is not forbidden), basically a “pressure of expansion.” Why is it not uniform and universal? If we describe it as operating in an opposite fashion in curving space-time, the effect is opposed or suppressed by normal space-time curvature (standard baryonic matter gravitational influence). It could, and would, be suppressed by normal, positive gravitational curvature of space.

The second supposition made is that if it (negative pressure due to expansion) varies, it has to have some rule for how and when it does. MoND (Modified Newtonian Dynamics) relies on the size and radius of galactic-level masses, and has encountered some difficulty with cluster scales and some elliptical galaxies. So we exclude the scale and diameter of visible matter as the sole varying factor in the scale of the negative pressure effect.

The other component in large scale structure that varies is the scale of intercluster voids. If we postulate that the scale of the effect relies on the scale of the adjacent voids (relatively low-density regions of space), increasing in effect with the scale of a void, there would be an in-between region where both would have an effect - essentially, the dark matter profile (shell) of spiral galaxies, and that it would vary more in attendance with the scale of adjacent void space than galactic radius.

Still, this is not enough to distinguish it from dark matter. Up until this point, we have been reversing the signs. So we start to model the observable effects of this idea, absent particulate dark matter and dark energy.

**2.3 Extension of the model to differentiate it from standard dark matter models**
If it is opposed by gravitation (positive curvature), it should exert more effect on small, isolated masses (ones with less mass/imposing less curvature) between larger voids and less on the cores of large masses or masses in a more crowded or dense region.

That is, a galaxy having a Keplerian/standard Newtonian dynamic stellar orbit distribution at its core would correlate with its overall mass. Generally, this is what we see: larger galaxies are more in line with predicted orbital velocities absent dark matter in their distribution at their cores (indicating a more “hollow” dark matter profile). In short, larger spiral galaxies generally have more pronounced central bulges.

But what about galaxies with comparatively less dark matter, as defined by stellar orbital velocities (inferred from redshift measured edge-on)? That is, galaxies with nearly-completely Keplerian distributions (large ellipticals)? These typically are the galaxies cited in critiques of Modified Newtonian Dynamics as not obeying the distance/radius formula predicted for modified gravity and applied to spiral galaxies.

These should still have some dark matter effect at the edge, even at very high masses, unless they were at the center of a still larger mass, concentrated enough to mask out the dark matter effect, or in a region of relatively few voids all of a relatively small scale. The concept of smaller, more compact and less massive dark matter profiles interior to a cluster has been documented and analyzed[11], but again there are alternative explanations.

So, we have one of our first predictions: massive ellipticals (high surface brightness galaxies or early type galaxies ) should be interior to a larger mass, generally on the inside of massive clusters. Spiral galaxies (galaxies with their own dark matter profile) should exist at the edges of clusters, or in isolation or open clusters. This generally appears to hold up, as analyzed in *Galaxy Occupation Statistics of Dark Matter Haloes: Observational Results* [3]:

> ...the observed correlation lengths of early and late type galaxies in the 2dFGRS indicate that the former are preferentially hosted by massive haloes...
> ...
> Among the total population, the fraction of early-type galaxies increases from about 25% in haloes with M ~ $10^{12}h^{-1}M_\odot$ to about 80% in haloes with M ~ $10^{15}h^{-1}M_\odot$. Among the central galaxy population, the increase of the fraction of early types with mass is stronger: in haloes with M >~ $10^{14}h^{-1}M_\odot$ virtually all central galaxies are early types.
> ...
> In addition to a split in central and satellite galaxies, we have also divided the population in early- and late-type galaxies. The central galaxies in low-mass haloes are found to be predominantly late type galaxies, while those in massive haloes are almost entirely early types. This is in good agreement with the occupation statistics obtained from an analysis of the clustering properties of early- and late-type galaxies (van den Bosch et al. 2003a).

The statistics of galactic distribution show up as an emergent property in this idea, and do not take into account theories of galactic evolution. Saying that this validates nonuniform expansion pressure as a mechanism, however, is a potentially hollow assertion (no pun intended). Some of this distribution apparently is already predicted in CDM (Cold Dark Matter) models and simulations. [4]

**2.4 Dwarf galaxy distribution and predictions for large scale structure**

Voids should clear themselves out; if a mass is between two voids of unequal volume, the larger void should exert more force, and the smaller void (losing influence as it shrinks) will be unable to oppose a larger void on its own. Voids should clear themselves of matter.

Given the above behavior, it should be the tendency of a void to clear itself of galaxies, if expansion is imbalanced: there should be a net force that acts in the direction of more dense regions.

This means that in this model, voids between clusters should be relatively empty - that is, not full of low surface brightness or even dark dwarf galaxies. This diverges from the predictions of some dark matter models, and would be a discerning testable prediction.

**2.5 Galaxy types and morphology**

In the speculative mental model presented so far, in a crowded enough region, not only is any major effect masked, but the nearby voids are too small to generate much of any effect locally. Additionally, the extrapolated consequences include the possibility that in larger groups, the dark matter halo effect would be asymmetrical on individual peripheral galaxies - masked more to one side than another. A general observation of lopsidedness in galaxies with increase in group size possibly supports this idea as well.[9]

The implication of this is that a galaxy's type is determined by its position relative to other masses and voids, not only by its overall age.

> The early– and late–type galaxy populations exhibit a significant segregation in mass: late-type galaxies dominate at low masses while early–type and intermediate objects dominate the high mass tail.[6]

We take this further - what happens to a spiral galaxy that moves towards the center of a large cluster (into a region of smaller voids and more mass)? In the environment of this idea, it would become more shielded from the dark matter effect, and would lose its spiral profile. The mass that was kept in check by its dark matter shell would spin out into the intracluster medium.

> At z=0 we find evidence for strong evolution induced by the environment (Nurture). Transformations take place mostly at low luminosity when star forming dwarf galaxies inhabiting low density environments migrate into amorphous passive dwarf ellipticals in their infall into denser regions. The mechanism involves suppression of the star formation due to gas stripping, without significant mass growth, as proposed by Boselli et al. (2008a). This process is more efficient and fast in ambients of increasing density. In the highest density environments (around clusters) the truncation of the star formation happens fast enough (few 100 Myr) to produce the signature of post-star-burst in galaxy spectra. PSB galaxies, that are in fact found significantly clustered around the largest dynamical units, represent the remnants of star forming isolated galaxies that had their star formation violently suppressed during their infall in clusters in the last 0.5-1.5 Gyrs, and the progenitors of future dEs.[7]

This also means that we should see spiral galaxies undergoing distortion in the absence of other masses as they move towards the interior of a dense cluster. Unlike tidal stripping or ram-pressure stripping, this version should result in relatively little heating of the galaxy losing the mass. Any former elliptical galaxies would slowly regain a spiral profile if they moved out of the interior of a dense cluster (a potential explanation for “ring” galaxies, now able to retain the high velocity gas and dust from aging stars going supernova).

The outcome of this is that the intracluster medium should resemble the gas and dust that ellipticals lack. To an extent, this is true; however, the ratio of gas and dust in the intracluster medium differs from predicted rates of element production from type Ia and type II supernova of later generations of stars alone, possibly representing ratios produced by type II sn of early population III metal-poor stars[8].

The generally accepted theory for explaining the loss of star-forming gases is ram-pressure stripping of galaxies passing through the intracluster medium. While this is a factor, there are some anomalous results that show a continuum of the ram-pressure stripping force with distance from a cluster center irrespective of the density variations in the ICM (intracluster medium)[10].

**2.6 Extrapolated behaviors**
There should be no galaxies in isolation outside of a cluster or other large mass that lack dark matter.

There should also be no higher density knots of dark matter interior to another shell of dark matter (that is, densities higher than the outer profile).

Since the dark matter effect is reliant upon void "scale" (the larger an adjacent void, the higher the vacuum pressure), the effect of dark matter on galaxies should appear to be less backward in time (generally as voids would have been smaller). Spiral galaxies should become better defined over time, and be better defined outside of clusters.

The vacuum pressure should accelerate (increase over time) as regions of vacuum expand and merge. This does match somewhat the discovery of accelerating expansion, but isn't truly a test. If this were also the effect of expanding space time, it would explain one of the conundrums of dark energy: the manifestation of local expansion, which would depend on adjacent voids and hence be relatively minor especially as measured in a region of relatively small adjacent voids (such as in a laboratory). It would mean the dark matter effect is the local effect of dark energy.

**2.7 Calculations and rough estimates of scale of effect**
If the mean void diameter is between 7 Mpc and 17 Mpc (ref needed) then it would explain a "linear" hubble flow with falloff, as the maximum expansion pressure and therefore maximum change in expansion velocity would increase linearly with distance above this scale.

First, one takes some ratios of dark matter to visible matter, and presume that they represent (for the sake of argument) the relative magnitude of the dark matter effect. So, for now, the effect is measured in solar masses ($M_\odot$)

Take some local separations (Milky Way ~ Andromeda) and some calculated mass fractions of large clusters, and start with a rough estimation of the separation between major masses/groups/overdense regions, using the radius of the space calculated as a sphere as the factor for magnitude.

.5 Mpc = .524 $Mpc^3 \sim 1 \times 10^{12}$ (1 Mpc radius, roughly Milky Way to Andromeda: mean Milky Way dark matter given between $9 \times 10^{11}\ M_\odot$ and $2.1 \times 10^{12}\ M_\odot$) So start with a rough equivalence of .5 Mpc radius yields $1 \times 10^{12}\ M_\odot$ effect

Extrapolate based on this relation:

1 Mpc = 1.8 $Mpc^3 \sim 2 \times 10^{12}\ M_\odot$

2 Mpc = 33.51 $Mpc^3 \sim 3 \times 10^{13}\ M_\odot$

The next is the lower mean radius that encompasses 75% confidence level of void diameter (~7Mpc)

4 Mpc = 268.08 $Mpc^3$ ~ 2 x $10^{14}$ M⊙

...while the following is the upper intracluster mean radius that encompasses 75% confidence level of void diameter (~17 Mpc)

8 Mpc = 2.144 x 10^3 $Mpc^3$ ~ 2 x $10^{15}$ M⊙

16 Mpc = 1.72 x 10^4 $Mpc^3$ ~ 2 x $10^{16}$ M⊙

So, given the above calculations, we try and find roughly what magnitude the void has to be to be one solar mass...

.05 Mpc = 5.24 x $10^{-4}$ $Mpc^3$ ~ 1 x 10^9
.005 Mpc (5 kpc) = 5.24 x $10^{-7}$ $Mpc^3$ ~ 1 x $10^6$
.0005 Mpc (500 pc) = 5.24 x $10^{-10}$ $Mpc^3$ ~ 1 x $10^3$

.00005 Mpc (50 pc) = 5.24 x $10^{-13}$ $Mpc^3$ ~ 1 x $10^0$ (1 M⊙)

And, at a rough calculation, here's the scale at which we see the effective "push" of one solar mass : 50pc

Taking it further...the effect at ~1/2 parsec (a light year and a half...)

.000005 Mpc (5pc) = 5.24 x $10^{-16}$ $Mpc^3$ ~ 1 x $10^{-3}$ (1/1000 M⊙)

.0000005 Mpc (.5pc) = 5.24 x $10^{-19}$ $Mpc^3$ ~ 1 x $10^{-6}$ (1/1000000 M⊙)

(this is roughly the volume between Sol and Alpha Centauri - so one-one-millionth of a solar mass “push” outside the radius of Sol )

...and still further:
00000005 Mpc (.05pc) = 5.24 x $10^{-22}$ $Mpc^3$ ~ 1 x $10^{-9}$ (1/1billionth M⊙)

Now, we can roughly calculate the effect at a radius of 1 meter:

First, convert solar masses to kilograms...
1 Ms = 1.99 x $10^{33}$ Kg (One solar mass is approximately 2 x $10^{33}$ Kg)

...and calculate the number of Mpc in one meter...

1 meter radius (2m diameter sphere) at this rate:

~ 1.426 x $10^{-67}$ Mpc3 ~ 1 x $10^{-54}$ M⊙ at one meter = 1.99 x $10^{-24}$ Kg

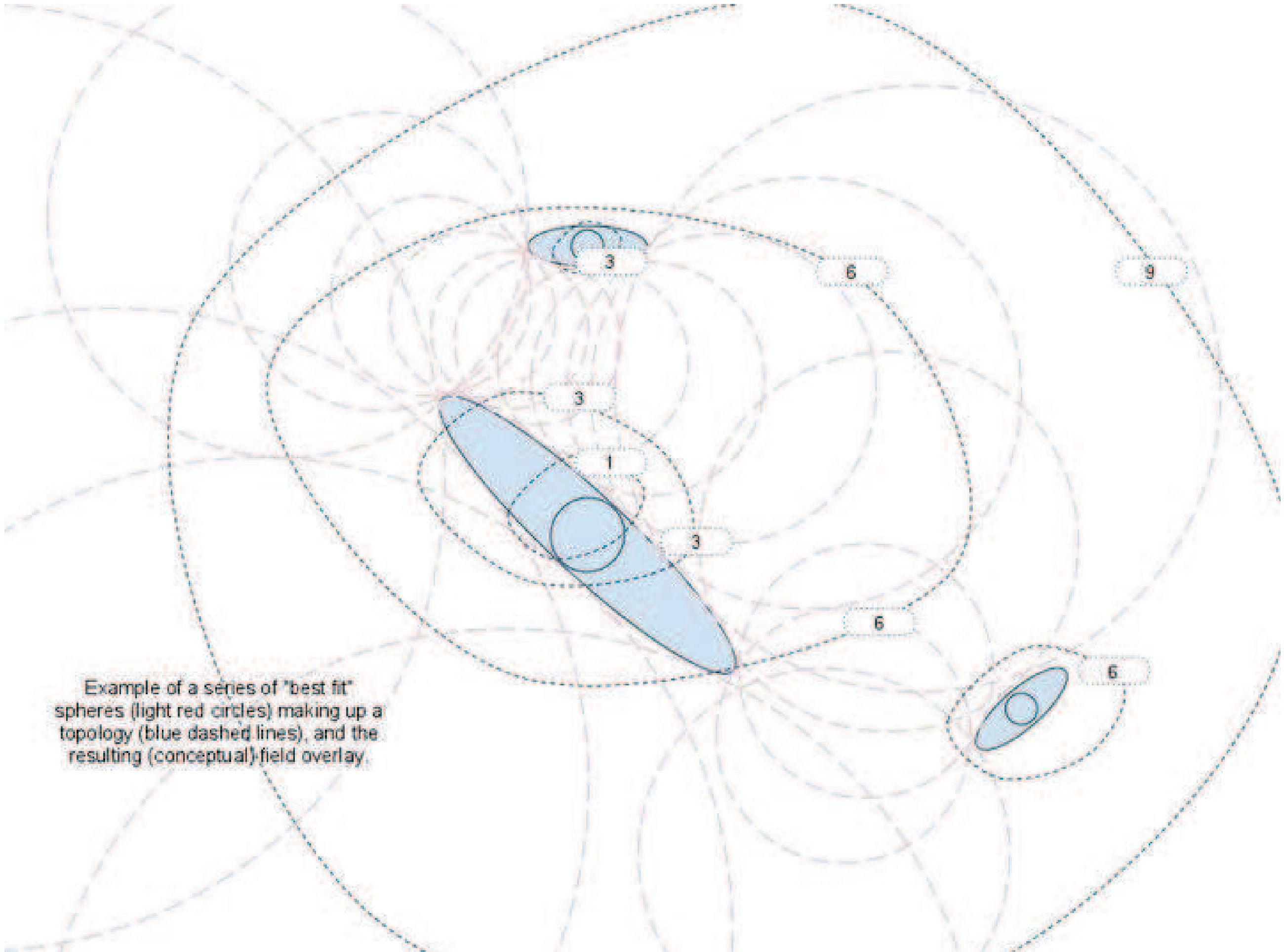
So, at a radius of one meter (in a two-meter-diameter vacuum) the "push" on the border would be, roughly, the same magnitude as a "pull" by a mass of 2 x $10^{-21}$ grams - a very, very small force, if at all.

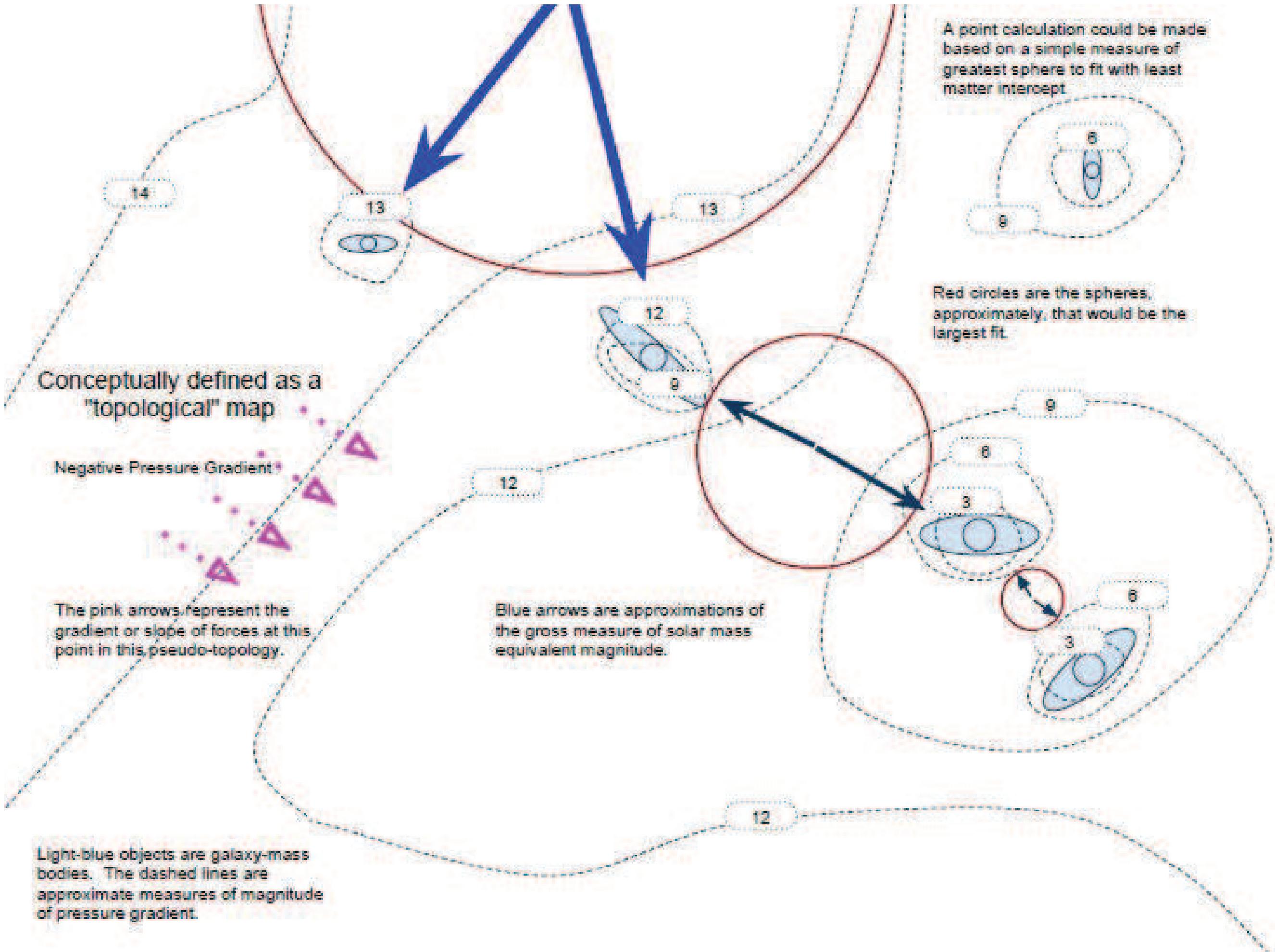
Currently, it looks like the base form of this idea is in an equation like so:

$F_N$ (in perceived solar masses) = $\frac{4}{3} \pi r^3 \times C_E \times d_m/d_i$

Where $F_N$ is the measure of the force of negative pressure, currently given in perceived effect in solar masses, and CE is the expansion constant (a ratio of solar masses to cubic parsecs in the current idea), and dm/di is a ratio of the mean distance between particles in the region over the ideal distance between particles in the region (fraction of 2r or 2r, effectively).

**2.8 Graphical representation of postulated effect**


3
6
9
3
1
3
6
6
Example of a series of "best fit" spheres (light red circles) making up a topology (blue dashed lines), and the resulting (conceptual) field overlay.




**3. Possible Tests and Predictions**

This paper has outlined a few observational consistencies which can be put to empirical analysis. Mathematical models with the outlined self-limiting parameters might also bear this out, possibly by providing a model with little to no required fine-tuning, and capable of modelling conditions starting with just after recombination and ending with the current nearby universe.

Based on interactions on the Bad Astronomy/Universe Today forum, it could be estimated that this idea would predict a reduced dark matter influence in a straight line between the Milky Way and the Andromeda Galaxy - a distortion in each, a diminishing or imbalance in the dark matter halo.

A recent conversation has pointed out that evidence might be testable or recoverable based on the lensing effects of the proposed idea potentially differentiating it from CDM models. Given that a number of observations regarding predicted and observed gravitational lensing do not match[14], it might be possible to present ideas to more closely model observation with prediction in lensing data, and provide some support or refutation.

The author of this paper initially did not know about ram-pressure-stripping, lopsided spirals, the general trend of elliptical and spiral populations, the constituent gases of the intracluster medium, reheating, or many other aspects of cosmology. Many of these effects emerged as potential tests of the initial idea, however given that all were already established observations and many have alternative explanations, it remains to establish a testable, falsifiable scenario or prediction of this idea.

It might be possible to test this effect at a local level, if measurements could be taken that were accurate enough.

More recent calculations have approached a magnitude of perhaps eight gold atoms influence ($2 \times 10^{-21}$ grams) given a volume with a radius of 1 meter, which would be nearly impossible to measure on earth.

However, creating a hard enough vacuum in a large enough region, one might be able to measure an effect versus gravitational acceleration on a small mass suspended near another surface, and differentiate it from other tests not performed in a large hard vacuum but otherwise similar.

In other words, the antigravitational magnitude of the vacuum is not something that is amenable to harnessing for a flying car.

**4. Problems**

Removing dark matter and the cosmological constant present problems that have to be accounted for if this model is to be thought of as remotely plausible.

First, absent dark matter, the early structure problem resurfaces.

If we suppose that we have two forces driving matter to higher concentration (gravitation and negative pressure) we can then look at both high and low concentrations of matter as driving structure, each reinforcing the other when it comes to creating concentrations of matter and spaces of void. One idea of the outcome of this would be concentration of early matter into sheets of density around nearby voids.

Next, absent a cosmological constant or uniform dark energy, shouldn't there be disparities in measures of acceleration and expansion (if it is piecemeal and not uniform)?

Over long distances (megaparsec scales (100 Mpc +) beyond our local group) it would not affect the measure of expansion to an appreciable degree, since concentrations of mass and vacuum expansion would average out (the universe appears homogeneous at scales above approximately 120 Mpc).

The next problem we encounter is that inflationary cosmology currently relies on amounts of dark matter being created to slow expansion after inflation, otherwise resulting in continued high rates of expansion and a resulting lack of structure due to the amount of dark energy. Add to this the estimates of matter versus dark energy required to make the universe appear “flat.”

If dark energy equalled vacuum pressure, then the expansion is self-limiting. The amount of vacuum pressure is limited to the scale of a region of void in large scale structure, which in the early universe is rather small. As time passes, its influence would increase as its expansion would cause voids to expand and merge, increasing its effect.

Inflationary cosmology also might be addressed as instead an initially massless vacuum. In the model presented in this paper, such a vacuum would expand extremely rapidly. At high enough expansion rates, it might be possible that the random fluctuations of the expanding vacuum would produce energy from an effect similar to Hawking radiation near a black hole: the expansion rate, exceeding the velocity of light, might be enough to separate virtual particle pairs. The energy produced would serve to halt the exponential vacuum expansion that caused it (the energy/particles) to precipitate in the first place, as the formerly free vacuum would be full of energy and thus mass. Inflation in this model is analogous to this non uniform dark energy and is self-limiting as it approaches this rate of expansion: there is a flashover point, and expansion stops abruptly, slowly ramping up again until the void scale is large enough for the cycle to repeat.

The problem of course is calculating the magnitude and density of energy released, as the prediction of element abundances is one of the great successes of inflationary cosmology.

**5. Summary**

We start with a supposition that the vacuum expands in the absence of matter. The more vacuum (the larger the void), the more the expansion, so it accelerates over time. This expansion produces a local negative pressure, but over megaparsec scales averages to nearly uniform expansion. This negative pressure manifests as the dark matter effect (a surrounding of negative pressure indistinguishable, currently, from a shell of matter). Because it is negative pressure, the effect diminishes in the presence of matter that exerts normal (positive) curvature of space time.

Larger clusters of galaxies can shield central galaxies from this effect, just as individual galaxies in open clusters can shield their own central bulge (diminishing dark matter profile towards the center of galaxies and clusters). In the absence of matter, conceptually the expansion could become so rapid that, much like Hawking radiation around a black hole, it would separate virtual particle pairs, releasing massive amounts of energy and producing enough energy and mass to halt its own acceleration. This requires a massive region of expanding relatively empty space (much larger than any current voids by orders of magnitude) and it should be stressed that this is not akin to a steady-state universe model of continuous matter generation. Rather, we are far away from any such state, specifically 13.7 billion years away, and essentially the future state of expansion (which most likely would occur over the horizon from existing masses) would resemble the initial inflationary conditions of the early universe.

This idea so far appears to have support in its predictions from observation, and the author's ignorance of the current state of research and data meant surprise on finding out some of the predictions appeared to have empirical correlation; however, there is not currently a "fine" or differentiating test outlined here that would move this from a simple idea to a viable idea, so for now it remains an interesting thought experiment, nothing more.

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**6. Cited Articles**

[1] ***Model of dark matter and dark energy based on gravitational polarization***
*Physical Review D, vol. 78, Issue 2, id. 024031*
Luc Blanchet* and Alexandre Le Tiec†
GRεCO, Institut d'Astrophysique de Paris—UMR 7095 du CNRS, Université Pierre & Marie Curie, 98 bis boulevard Arago, 75014 Paris, France
http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.3518v2.pdf

[2] ***Void hierarchy in the northern local void***
*Cosmological Parameters and the Evolution of the Universe. Edited by Katsuhiko Sato. Publisher: Dordrecht, Boston: Kluwer Academic, 1999. ("Proceedings of the 183rd symposium of the International Astronomical Union held in Kyoto, Japan, August 18-22, 1997"., p. 185*
Faint structures in low density regions of the nearby Universe
U. Lindner and K.J. Fricke and J. Einasto and M. Einasto
Universit¨ats–Sternwarte, G¨ottingen, Germany and Tartu Astrophysical Observatory, T˜oravere, Estonia
http://arxiv.org/PS_cache/astro-ph/pdf/9711/9711046v1.pdf

[3] ***Galaxy occupation statistics of dark matter haloes: observational results***
*Monthly Notices of the Royal Astronomical Society, Volume 358, Issue 1, pp. 217-232.*
Xiaohu Yang1,*, H. J. Mo1, Y. P. Jing2, Frank C. Van Den Bosch3
1Department of Astronomy, University of Massachusetts, Amherst MA 01003-9305, USA
2Shanghai Astronomical Observatory; the Partner Group of MPA, Nandan Road 80, Shanghai 200030, China
3Department of Physics, Swiss Federal Institute of Technology, ETH H¨onggerberg, CH-8093, Zurich, Switzerland
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[4] ***Theoretical Models of the Halo Occupation Distribution: Separating Central and Satellite Galaxies***
*The Astrophysical Journal, Volume 633, Issue 2, pp. 791-809*
Zheng Zheng,1,2,3 Andreas A. Berlind,4 David H. Weinberg,1 Andrew J. Benson,5 Carlton M. Baugh,6 Shaun Cole,6 Romeel Dav´e,7 Carlos S. Frenk,6 Neal Katz,8 and Cedric G. Lacey6

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[5]***Hierarchical Disk Galaxy Assembly as the Origin of Scatter in the z  1 Stellar Mass Tully-Fisher Relation***
*e-Print archive*
Nicola Atkinson1, Christopher J. Conselice1⋆, Nicole Fox1
1University of Nottingham, School of Physics & Astronomy, Nottingham, NG7 2RD UK
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[6]***The evolution of early and late type galaxies in the COSMOS up to z~ 1.2***
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http://arxiv.org/PS_cache/arxiv/pdf/0906/0906.2810v1.pdf

[7]***A snapshot on galaxy evolution occurring in the Great Wall: the role of Nurture at z=0***
*Astronomy and Astrophysics, Volume 517, id.A73*
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http://arxiv.org/PS_cache/arxiv/pdf/1003/1003.3795v1.pdf

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*The Astrophysical Journal, Volume 620, Issue 2, pp. 680-696.*
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[11]***Truncation of galaxy dark matter halos in high density environments***
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**9. Issues**
Issues brought up recently include:

1. Accounting for disparities in reporting and analysis regarding the amount of dark matter in elliptical galaxies (“none” versus high radius/cuspiness analyzed by x-ray) the assumption of this paper thus far is that the dark matter shell in ellipticals is far enough out (‘cuspy’ enough) to preclude any observational change in rotational velocity (the ‘disk’ falloff is beyond their furthest edge, as in the center of dense clusters). Due to commentary and ongoing research, the terms have been revisited and changed to ensure that the extreme “no dark matter” was removed, as there exists no research supporting the contention of ellipticals completely without dark matter. This did, interestingly enough, lead to discovery of papers detailing lopsidedness in spirals[9],

and the trend of dark matter profiles in crowded conditions[11]. Thanks is owed to Ethan Siegel, PhD, a theoretical astrophysicist at Lewis & Clark college in Portland, OR, for his time and astute analysis of these unresearched assertions.

2. The falloff rate of the dark matter shell in dwarf galaxies (some reports suppose this is either a data artifact or a result of a sample that is too small for proper analysis).

3. Further research into the positional features postulated here appear to hold in a general sense for non-dwarf galaxies in open versus high-mass high-density clusters, including features of lopsidedness and increasing populations of high mass ellipticals. The "positional" predictions given in this idea (for instance: open versus dense clusters: specify 'critical' density?) which appear to not bear out. Analysis on this will include attempting to ascertain the relative position of ellipticals (is "within a cluster" a hard and fast rule, or a general observation?) Information on the position of ellipticals (high surface brightness) was obtained second-hand, see "voids" report below (low surface brightness outside of large and superclusters, high surface brightness generally seen within (usually meaning low dust/older and nominally elliptical)). There appears to be an evolving relationship where the ratio of dark matter to visible matter does not change for some redshift intervals in spiral galaxies:

> There is also no evolution in the stellar mass-total halo mass relation at the same redshifts (Conselice et al. 2005a), suggesting that the stellar and dark mass components of disk galaxies grow simultaneously throughout this period. This result was later also found to be the case by e.g., Flores et al. (2006) and Bohm & Ziegler (2006).[5]

4. The latest dark matter research and simulations versus observation, matching and non-matching (prediction not correlating with observation).

~~To properly address these issues, more research will be undertaken to accumulate measures of hot X-ray emitting gas (primary current indicator for dark matter shells around elliptical galaxies and clusters given possible problems with using angular velocity (line of sight/highly eccentric orbits)), conventional rotational velocity curves (analyzing for cuspiness of dark matter versus size in spiral galaxies with an eye towards central bulge/mass correlation, not radius necessarily ).~~ Proper analysis would be to analyze the data statistically from a "random" (usually edge-on galaxies, assumed to be representative of the population as a whole) assortment of spiral galaxies and see where the mean and outliers fall, attempting to see if there is a statistically significant correlation between dark matter falloff and mass in spiral galaxies. Further to this would be to analyze elliptical galaxies and see if the mass formula correlates as well (determine if some ellipticals are all bulge, no disk because of dark matter cusps).

5. The tethered galaxy problem - as detailed - assumes (or appears to assume) that a) CDM is extant and behaves the same as conventional matter b) that there is a homogeneous undifferentiated cosmological constant, or otherwise nondescript expansion of space. The

generally accepted format is that the expansion of space is a consequence, not a cause which could have an effect. This paper assumes the opposite - the expansion of space is a cause and the effect is observed as dark matter influence. This does, in a sense, answer the tethered galaxy problem in that one could actually measure the void spaces nearby and predict from that (without using hubble flow) what the relative velocities and dark matter content should be. If the systems are close enough to have a “combined” dark matter halo, then expansion between the galaxy and the tethered galaxy is minimal compared to a galaxy located across a void space and similarly tethered. In other words, it is not as much of an issue in this context because the expansion is, by the nature of its suppression by mass, varied and calculable on a local level, with a local effect (namely, dark matter).

6. The total lack of a detected dark matter component for globular clusters orbiting within or near the plane of the Milky Way. If the predictions of the model are remotely correct, either these objects have been stripped of high-velocity gas and stars through interactions which have reduced the dark matter effect on them, or they are within a larger region’s mass profile. Failing this, the model is incorrect or incomplete. An interesting side note: while postulating tidal stripping, the model cannot account for the “cool” outer profile if indeed contents were tidally stripped. In the void model, the stripping would have been consequential: spinning out of high velocity content as a result of changing dark matter profile, and might not incur the same heating as normal tidal stripping.

**10. Notes**

Description of a void (what bounds a void)

Voids are slopes in terms of how much “force” they can generate - they are anchored (bounded) by gravitational influence, and polluted by higher matter density, so the highest “slopes” at the periphery of a region of expansion occur when the void is relatively free of matter, and few if any anchoring masses within.

So, as the matter density increases, the maximum potential for an unbounded (free of atoms/mass) volume decreases.

Vacuum of higher and higher quality = greater “force” -

Okay, so the effect : masked towards the Andromeda galaxy... Let's say it's about 9/10 at that point - so, basically: 1Mpc diameter = ~ 1 x 10^11 vs 1 x 10^12 - so about a tenfold difference. If it is only dependent upon the void diameter, then the force could be calculated - so, let's say it's 1 x 10^12 Ms at 1 Mpc

For a larger diameter... 10^14 to 10^15 at 7-17 Mpc - so, for a 100 to 1000 increase the diameter increases by, say, 7 to 17 - let's just try integrating it over that range. So, an effect of 16-fold radius ( - so a difference in volume, roughly of

Radius vs Volume

1 Ms = 1.99 x 10^33 Kg

1 meter radius (2m diameter sphere) at this rate:

~ 1.426 x 10^-67 Mpc3 ~ 1 x 10^-54 Ms at one meter = 1.99 x 10^-24 Kg

.00000005 Mpc (.05pc) = 5.24 x 10-22 Mpc3 ~ 1 x 10^-9 (1/1billionth Ms)

.0000005 Mpc (.5pc) = 5.24 x 10-19 Mpc3 ~ 1 x 10^-6 (1/1000000 Ms)
(this is roughly the volume between Sol and Alpha Centauri - so one-one-millionth of a solar mass “inward” outside the radius of Sol )

.000005 Mpc (5pc) = 5.24 x 10^-16 Mpc3 ~ 1 x 10^-3 (1/1000 Ms)

.00005 Mpc (50 pc) = 5.24 x 10^-13 Mpc3 ~ 1 x 10^0 (1 Ms)

.0005 Mpc (500 pc) = 5.24 x 10^-10 Mpc3 ~ 1 x 10^3

.005 Mpc (5 kpc) = 5.24 x 10^-7 Mpc3 ~ 1 x 10^6

.05 Mpc = 5.24 x 10^-4 Mpc3 ~ 1 x 10^9

.5 Mpc = .524 Mpc3 ~ 1 x 10^12

1 Mpc = 1.8 Mpc3 ~ 2 x 10^12

2 Mpc = 33.51 Mpc3 ~ 3 x 10^13

4 Mpc = 268.08 Mpc3 ~ 2 x 10^14

8 Mpc = 2.144 x 10^3 Mpc3 ~ 2 x 10^15

16 Mpc = 1.72 x 10^4 Mpc3 ~ 2 x 10^16

*Radius vs Volume*

List of voids (wikipedia): http://en.wikipedia.org/wiki/List_of_voids
Mean void size (diameter in Mpc) (assuming these are superstructure, i.e. on cluster scales).

IRAS data of significant voids: 36
EEDTA Data: 91 (significant voids)
SSRS2 Data: 33

Discussion of “fossil” groups (single massive galaxy in more massive halo, erroneously reported as a “concentration” of dark matter, still a halo)
http://www.esa.int/esaCP/SEMCFFOFGLE_index_0.html

“End of Greatness” - universe smooth on scales > 100 Mpc

Clusters typically have the following properties.

- They contain 50 to 1,000 galaxies, hot X-ray emitting gas and large amounts of dark matter
- The distribution of these three components is approximately the same in the cluster.
- They have total masses of 10E14 to 10E15 solar masses.
- They typically have a diameter from 2 to 10 Mpc (see 1023 m for distance comparisons).
- The spread of velocities for the individual galaxies is about 800–1000 km/s.

With mean cluster diameter at ~6 Mpc, and mean void diameter at ~40 Mpc (clusters and elliptical scales)

Diagram: Conceptual "topological" diagram

APOD image of a spiral galaxy entering a massive galaxy cluster
http://antwrp.gsfc.nasa.gov/apod/ap100908.html

Terminology
*Cluster* here is in reference to large, crowded, high-mass clusters: in low-mass or “open” clusters, the behavior detailed is not too different than that for isolated galaxies. Thus, in open clusters you would not expect to see many high-mass elliptical galaxies with low to no dark matter. In large high-density (high mass) clusters, you see more high-mass ellipticals. The difference is in the mean size of adjacent voids - for an open cluster, it can still be rather large, comparatively, while within a high-density cluster mean adjacent voids become rather small.