Inhomogeneous distribution of mass-density in a static, rotating universe generates a transverse Doppler redshift that mimicks cosmological redshift and expansion.

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Abstract

One of the most effective theories for dark matter is Milgrom's Modified Newtonian Dynamics, where a modified law of gravity based on a fixed acceleration scale a_0 is postulated that provides a correct description of the gravitational fields in galaxies. However, the significance of a_0 is unknown, and the whole theory is generally viewed as a phenomenological description of the observations. Based on Newton's gravitational law as applied to a uniform continuous mass we posit a non-homogeneous distribution of mass at cosmological scales that would give rise to a constant acceleration that agrees with MOND's a_0. The implications for MOND as a viable theory of dark matter and for the problem of dark energy are discussed. In particular, a transverse Doppler redshift that scales linearly with distance occurs at short distances, and relativistic high rotational velocities at the border regions of the universe would generate highly redshifted background radiation. The model might provide an alternative explanation for the observed redshifts and expansion.

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Modified Newtonian Dymanics (MOND) is a Newtonian-derived hypothetical model of gravity proposed 40 years ago by Mordehai Milgrom to explain the multiple gravitational anomalies observed in galaxies and galaxy clusters [1-3]. They are summarized and conventionally explained through the existence Dark Matter, an elusive new form of matter that interacts only gravitationally and is not included in the Standard Model of Particle Physics. While no such particles have yet been found, the search goes on and MOND usually plays a secondary role in the list of candidate explanations for dark matter. One of the reasons is that a_0, the distinctive feature of MOND, does not correspond to any physical entity, and –it is argued- was postulated solely as a means to obtain a gravitational law that fits the observations. It is sometimes called a phenomenological explanation.

While a_0 agrees to within one order of magnitude with the acceleration calculated at the border regions of the observable universe from the simple Newtonian gravitational formula and is also found to relate to Hubble's constant and to the square root of the cosmological constant L, in both cases scaled by the speed of light *c*, no physical representation of such an acceleration has been devised, and most physicists would agree that it represents another constant of nature, whose role would be to relate fundamental gravitational phenomena in the low-acceleration regime, implying probably some modification of the laws of gravity.

The Newtonian ball model of gravity

A generally accepted assumption of all current astrophysical models is the Cosmological Principle, the idea that the universe at large scales is both homogeneous and isotropic. While it may still be isotropic and strong constraints have been set on the range of variation in matter density, the homogeneity condition has little theoretical supporting evidence. Based on original ideas of Isaac Newton, we shall argue that the universe can be modelled as a continuous distribution of mass that obeys simple dynamics embodied in the Universal Law of Gravitation. As Newton found in the late 1600s [4], when a continuous distribution of mass with constant density is allowed to evolve according to such law, an acceleration appears that is null at the center and increases outwards in linear proportion to radial distance until it reaches, for a distance equal to the radius of the ball, the exact same value as predicted by conventional Newtonian gravity.

$$F_B = G\ M\ m\ r\ /\ R^3$$

as opposed to a point-mass gravitational field:

$$F_N = G\ M\ m\ /\ R^2$$

where F_B (the force in the Newtonian ball model) and F_N (Newton's conventional point-mass gravitational force) are the force on a test particle with mass m placed at a distance r from the center of the R-ball, or at a distance R from the central point-mass M, respectively. The acceleration for the ball with mass M is then

$$Acc_B = G\ M\ r\ /\ R^3 \qquad (1)$$

and solving for G

$$G = Acc_B\ R^3\ /\ M\ r \qquad (2)$$

We now define G' as $4\pi G$ and substitute it for G above. The resulting expression is mathematically equivalent, though it may facilitate the visualization of upcoming considerations.

$$G' = (Acc_B\ 4\pi R^3)\ /\ (M\ r) \qquad [G' := 4\pi G] \qquad (3)$$

Multiplying both parts of the right-hand quotient by a factor of three,

$$G' = 3\ Acc_B\ 4/3\ \pi\ R^3\ /\ M\ r \qquad (4)$$

and since $4/3\ \pi\ R^3\ /\ M$ is the inverse of the mass density for the spherical volume ρ,

$$G' = 3\ (Acc_B\ /\ r) \cdot (1/\rho)$$

$$G' = 3\ Acc_B\ /\ (r \cdot \rho) \qquad (5)$$

where ρ is now the average, not necessarily constant matter density at radial distance r. It is well known that the Newtonian model for gravity in solid spheres is valid not only for spheres with uniform density, but for any sphere in which density depends only on radial distance, i.e, for any spherically symmetric distribution of matter.

Looking at equation (5) we see that in such a ball model of the universe, if ρ is constant, then the quotient (Acc_B / r) must be constant, which agrees with the Newtonian view but does not help us understand the existence of a constant acceleration pervading the whole universe that at the same time agrees with the Newtonian acceleration at its border regions, as MOND postulates and available evidence suggests.

We therefore let ρ vary with radial distance and assume that it is the product in the denominator of equation (5), $r\cdot\rho$ that is constant. In other words, we let density decay inversely with radial distance. We immediately see that since both G' and the product $(r\cdot\rho)$ are constant, so must be Acc_B, and this acceleration agrees with MOND's universal acceleration a_0 and with the calculated Newtonian acceleration at the border regions of the visible universe to whithin one order of magnitude, as can be easily checked. Indeed, feeding in the accepted values for the mass of the observable universe (10^{53} Kg), radial distance (10^{26} m) and G, it turns out that the acceleration in the at the external regions of a hypothetical spherical universe is about $3.4 \cdot 10^{-10}$ $m \cdot s^{-2}$, quite close to the reported value for a_0 ($1.2 \cdot 10^{-10}$). According to the Newtonian ball model and assuming $r \cdot \rho$ constant, this same aceleration would be present as a background curvature in the whole universe, explainining its local influence in all galaxies, not just as a constant of nature, but as a real acceleration that would determine the observed accelerations through some kind of averaging with the local, Newtonian-derived acceleration. In MOND, a geometrical averaging is applied.

The range of variation in mass density that would be expected depends on how far we are from the central regions, and can be approximately estimated.

From Eq (1), taking $Acc_B = a_0 = 1.2 \cdot 10^{-10}$ ms^{-2}; $R_U = 4.4 \cdot 10^{26}$ m; $G' = 8.38 \cdot 10^{-10}$ $m^3 \cdot Kg^{-1} \cdot s^{-2}$, we have

$r \cdot \rho = 0.4295$ $Kg \cdot m^{-2}$

$\rho = 0.4295 / r$

Assuming we are in a mid-radius region, $R_0 = 2.2 \cdot 10^{26}$ m and making dr = 1 Mpc = $3.1 \cdot 10^{22}$ m, it turns out that the expected decrease in density per Mpc at a radius half the universe's radius would be:

$d\rho = -0.4295 \cdot R_0^{-2} \cdot dr$

$d\rho = 6.29 \cdot 10^{-30}$ $Kg/m^3/Mpc$

This is aproximately 1% of the accepted baryonic mass density of the universe (4.6% of the critical density 10^{-26} Kg/m^3, or $4.6 \cdot 10^{-28}$ Kg/m^3). For regions closer to the center, the predicted relative variations are larger. In more external regions they would become much smaller and practically unmeasurable.

Observational evidence for the distribution of mass density in the universe is scant. The large-scale average density, known as the cosmic density parameter (Ω) depends on its composition and, according to the ΛCDM model, is very close to the critical mass density Ω_c, the one required to make the universe flat. The density of matter, including dark matter, would amount to about 28% of the global density ($\Omega_m = 0.28$), while the density of baryonic matter is thought to comprise a bare 4.6% of the total density. Distribution of average density as a function of distance is generally assumed to follow the general trend of decreasing as the radius increases, reflecting the overall dilution of matter on larger scales, but observations are dominated by a complex hierarchical structure, the so-called cosmic web, that makes a precise estimation difficult. As a result, no reliable data are currently available.

Several authors [5-9], notably Peebles, Karachentsev, Nuza and others have probed into the mass distribution in the vicinity of our Milky Way and found that, on average, its density is significantly lower than the average for the whole universe. We would thus be in a local region of low density, the Local Void, which makes the observations not representative of the whole universe. The interpretation of the results is also compounded by the influence of dark matter and structure formation, two processes of which we know little.

In two important studies [5, 6] the authors examined the distribution of the mean density of matter in spheres of various radii in our Local Universe and found that mass density up to about 50 Mpc decays with distance. The authors conclude that density is on average lower than the global density for the universe ($\Omega_{m,local} = 0.08$ vs $\Omega_m = 0.28$) and tends to an asymptotic minimum value. However, looking at the data in the figures, we speculate that they might also be consistent with a 1/r decay in that range. However, as the authors point out, larger scale distances are needed to avoid local variations, probably 100 Mpc at least. In the papers, uncertainties in the range up to 90 Mpc seem too large to draw a conclusion.
Also, as shown previously, a reliable measurement of the variations in mass density around the Milky Way could be used to gauge our proximity to the center of the universe.

Another interesting observation is the striking ressemblance of equation (5) with the Friedmann equation. The Friedman equation can be expressed as [10]

$$a''/a = - 4/3\cdot\pi\cdot G\ (\rho + 3p/c^2) + \Lambda c^2/3 \qquad (6)$$

And making a customary simplification that consists of replacing

$\rho \longrightarrow \rho - \Lambda c^2/8\pi G$

$p \longrightarrow p + \Lambda c^4/8\pi G$

we have

$$H^2 = (a'/a)^2 = 8/3\cdot\pi G\rho - \kappa c^2/a^2 \qquad (7)$$

Assuming flat space (κ=0) and substituting G' for G (G' = 4πG) results in

$$G' = 4\pi G = (3/2) \cdot H^2 / \rho \qquad (8)$$

which reminds us of Eq 5:

$$G' = 3 \cdot Acc_B / (r \cdot \rho)$$

In the last expression, since dimensions of Accel / r are $[1/T]^2$, we have

$$G' = 3\cdot (1 / t)^2 \cdot (1 / \rho) \qquad (9)$$

If we now interpret 1/t as the constant rate of expansion H, it turns out that Eq (1) can be viewed as equivalent to

$$G' = 3 \cdot H^2 / \rho \qquad (10)$$

which differs from the Friedmann equation by a factor of 2. The reason for the discrepancy we ignore, but it has happened before in astrophysics that a classical, non-relativistic approach has been later superseded by the appropriate relativistic version that differs from it by a factor of two, e.g., in the old pre-Einstein estimation of the lensing of light from Newtonian gravity by Johann Soldner in 1804.

Thus, the hypothesis of a decreasing density of matter that scales inversely with distance seems a reasonable one and, from Newtonian mechanics, this would lead to a constant background cosmic acceleration that agrees with MOND's a_0 and would account for the rotation curves in galaxies. The observed accelerations around galaxies below MOND's a_0 have been shown from observations to be the geometric average of the Newtonian acceleration and a_0. This might be understood as a real physical phenomenon related to the interaction of two competing accelerations, not only a mathematical artifact.

We cannot discuss here the other predictions of MOND related to dark matter. We would rather refer the reader to the works of the original author [1-3].

As for the CMB, it is our understanding that it has some problems that limit its ability to be used as the gold standard to adjudicate prospective fundamental theories. We'd like to draw attention to one of those problems, namely the strong anisotropy observed in the CMB, the so-called CMB multipole (dipole, quadrupole, octopole), that is generally considered as originating from the movement of our galaxy with respect to the Hubble flow. But the velocities needed for the dipole are higher than 350 Km/s [11] and the quadrupole shows a coincidence in orientation with the solar system that is hard to explain.

In summary,

1. In a modified Newtonian ball model of the universe, a continuously decreasing mass density that scales as 1/r, as opposed to the uniform distribution from the Cosmological Principle, would give rise to a constant universal physical acceleration that agrees with MOND's a_0.

2. This would provide a physical basis for MOND and support it as a viable interpretation of the dark matter problem, even if it cannot fully explain the need for a modification of the gravitational laws.

3. The resulting mass-density distribution may be hard to verify experimentally since the densities involved, as well as the variations incurred are very low. A variation in mass density around 1% per Mpc is expected.

Cosmological acceleration and redshift in relation to the universe’s expansion

We now turn our attention to the mysterious empirical relation observed between a_0 and the parameters that reflect the universe’s expansion, H_0 and Λ.

Indeed, the numerical value of MOND’s a_0 has been found to be approximately

$$a_0 \sim (c / 2\pi) \cdot H_0 \sim (c^2 / 2\pi) \cdot \mathrm{SQRT}(\Lambda/3)$$

Why is that? What is the intimate relation of a_0 to the accelerated expansion of the universe?

Motivated by the previous ideas and some inconsistencies in the current cosmological models, namely the discrepancies in the measurements of the rate of expansion -the Hubble tension-, the existence of galaxies much older than allowed by our current ideas on galaxy formation [12], and the failure to determine the magnitude and origin of the accelerated expansion, an alternative explanation is sought for the original observations that led to the idea of an expanding universe. According to the extensively confirmed Hubble Law ($v = H_0D$), Doppler redshift from stars and galaxies is linearly related to distance, suggesting increasing recessional velocities in the context of a global expansion. Despite its evident internal logic and agreement with multiple observations, we shall make here no assumptions on homogeneity, isotropy, nor expansion. Our arguments will be checked against the basic observational facts. Namely, the Hubble Law relating redshift to distance, and the existence of a pervasive background low-energy radiation in the form of the CMB. Ideally, the model should also provide an explanation for the accelerated expansion in recent epochs, as described by Riess, Perlmutter and Schmidt in 1998, as well as for the anisotropy observed in the CMB, its dipole.

In the ball model of the universe, a 1/R mass-density distribution leads to a constant background acceleration a_0, sometimes called cosmological acceleration a_Λ, that has been measured at $1.2*10^{-10}$ ms^{-2} [1-3]. Centripetal acceleration as a function or radial distance is then

$$v^2/r = a_0 = \text{constant} \qquad (11)$$

$$v = \mathrm{SQRT}(a_0 \cdot r) \qquad (12)$$

and rotational velocities would thus increase as the square root of distance.

For the estimated radius of the observable universe ($R_U = 4.4 \cdot 10^{26}$ m) we have that in a non-relativistic approximation, rotational velocities in the external shells would be

$$v = \mathrm{SQRT}(1.2\cdot10^{-10} \cdot 4.4\cdot10^{26})\ \mathrm{m/s} = 2.29 \cdot 10^8\ \mathrm{m/s} \sim c \qquad (13)$$

another striking coincidence.

If we now take the transverse Doppler redshift that would be observed from light emitted from those galaxies at the edge of the observable universe [13]

$$1 + z = 1 / SQRT(1 - (v_T^2/c^2)) \qquad (14)$$

where v_T is the velocity of the emitting galaxy in the direction perpendicular to light trajectory, relative to the observer. Redshift goes to infinity as v_T approaches c.

For shorter distances and lower velocities (v << c), the approximate formula is

$$z \sim 1/2\ (v_T/c)^2 \qquad (15)$$

For short distances, since velocity increases as the square root of distance and redshift scales as the square of velocity, redshift increases linearly with distance, which is measured from the emitting galaxy to the observer.

Light coming from distant galaxies, whether at the edge of the universer or closer to us, must then overcome the gravitational potential between its source point and us and, by so doing, it is subject to gravitational blueshift, which amounts to

$$z = \Delta U / c^2 \qquad (16)$$

For a constant acceleration a_0, the difference in gravitational potential at radial distance r is:

$$\Delta U = a_0 \cdot r \qquad (17)$$

Where ΔU is the difference in gravitational potential berween the galaxy and us and r is the distance between both. Redshift is then given by

$$z = a_0 \cdot r / c^2 \qquad (18)$$

This formula does not require correction from general relativity, since it is derived from the equivalence principle [14]. We notice that the expression for gravitational redshift has c^2 in the denominator, while the transverse Doppler redshift has the customary relativistic (1- v^2/c^2) both for the relativistic and the non-relativistic approximate formula. In consequence, the former is orders of magnitude smaller than the latter, and we can ignore gravitatonal redshift when calculating the total redshift perceived by the observer (Fig 1).

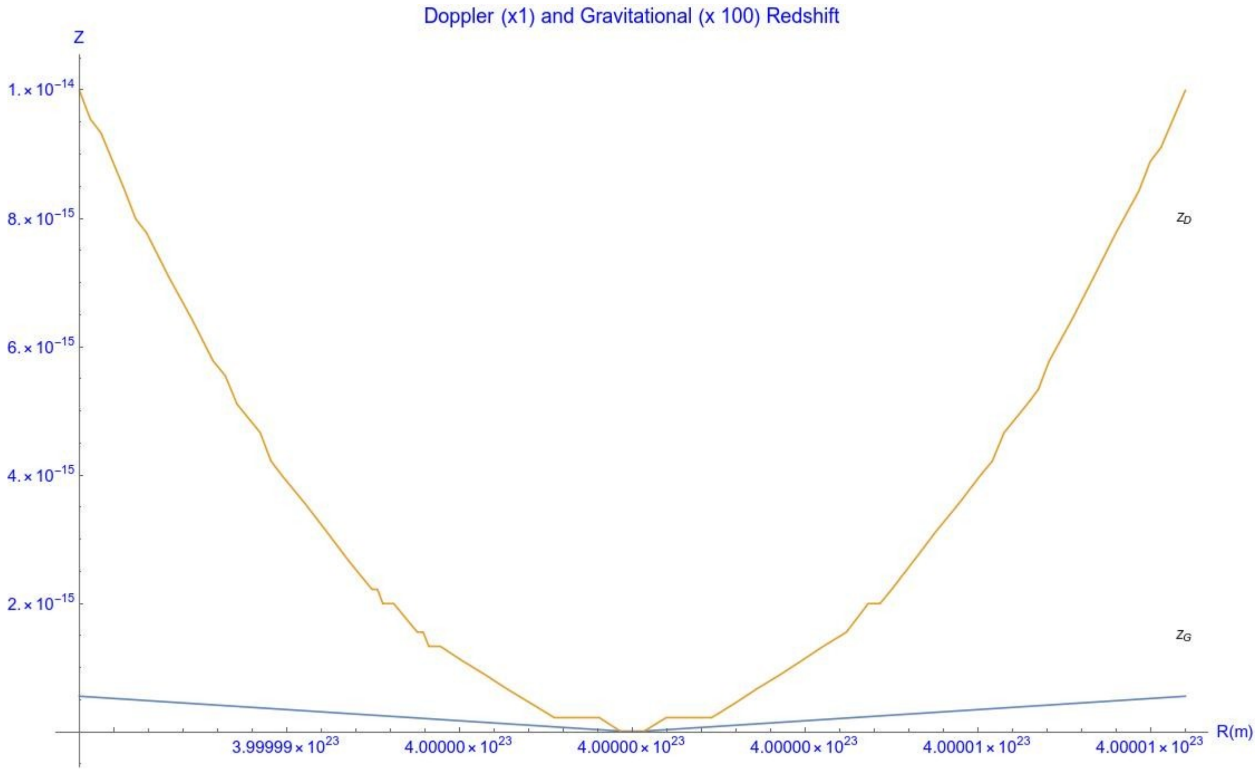


Fig 1. Gravitational (x100) and transverse Doppler redshift as a function of distance. Although gravitational redshift is calculated with the approximate non-relativistic formula, it is clear that it is orders of magnitude smaller.

Transverse Doppler redshift (TDR) is a function of relative velocity of the emitter with respect to the observer. To calculate relative velocity, we cannot take velocities from the center of universe and then subtract them vectorially. This would not comply with the relativity requirement that the universe looks the same for all observers. Instead, we define relative velocity as the velocity calculated from centripetal acceleration, taking as distance the relative radial distance between emitter and observer.

$$V_{rel}^2 / R = Accel \qquad (19)$$

$$V_{rel}(R) = SQRT(Accel \cdot (R - R_o)) \qquad (20)$$

Where R is the position of the emitter, R_o the position of the observer, and Accel is the (constant) acceleration that separates them. This is the formula that will be used to calculate relative velocities and redshift. Since acceleration remains constant at all radial distances, the expression (20) does not need to be integrated over distance.

Results

The resulting transverse Doppler redshift (TDR) calculated from (14) and (20) increases linearly with distance and picks up exponentially for large distances (Z > 0,3-0,5), mimicking an expanding universe. In Figs 1-3 we represent calculated TDR as viewed by an observer placed at 1/32 and 1/1000 of the acepted radius of the visible universe. In Fig 1 rotational velocities and TDR are plotted assuming a distribution of mass-density that decays as the inverse of radial distance,

$$\rho = 1/ R \qquad (21)$$

and compared with observed redshifts [15]. We see that TDR increases linearly for short distances, but is nowhere near the observed redshifts.

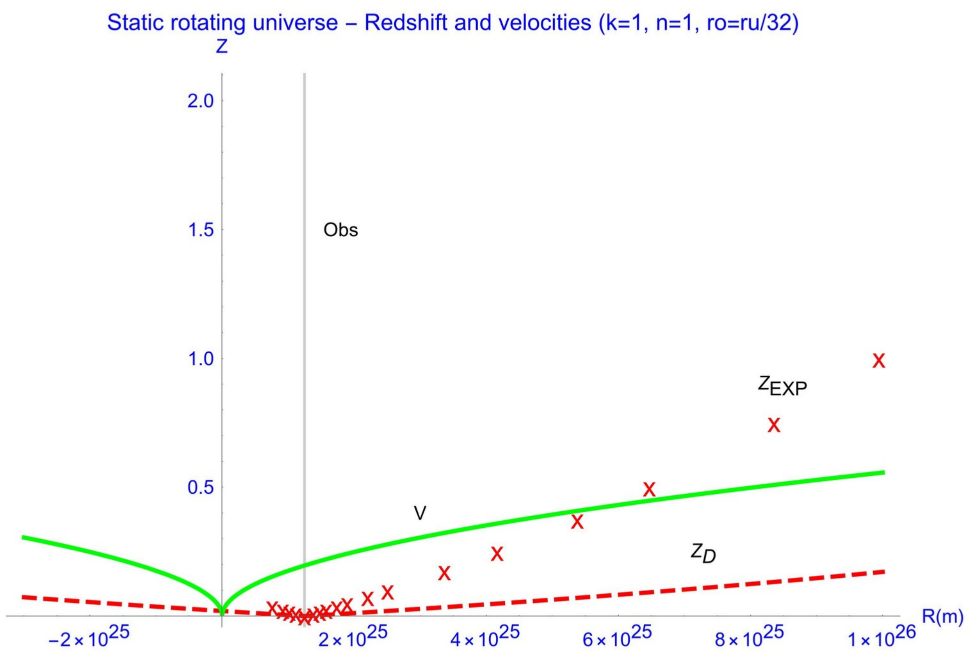
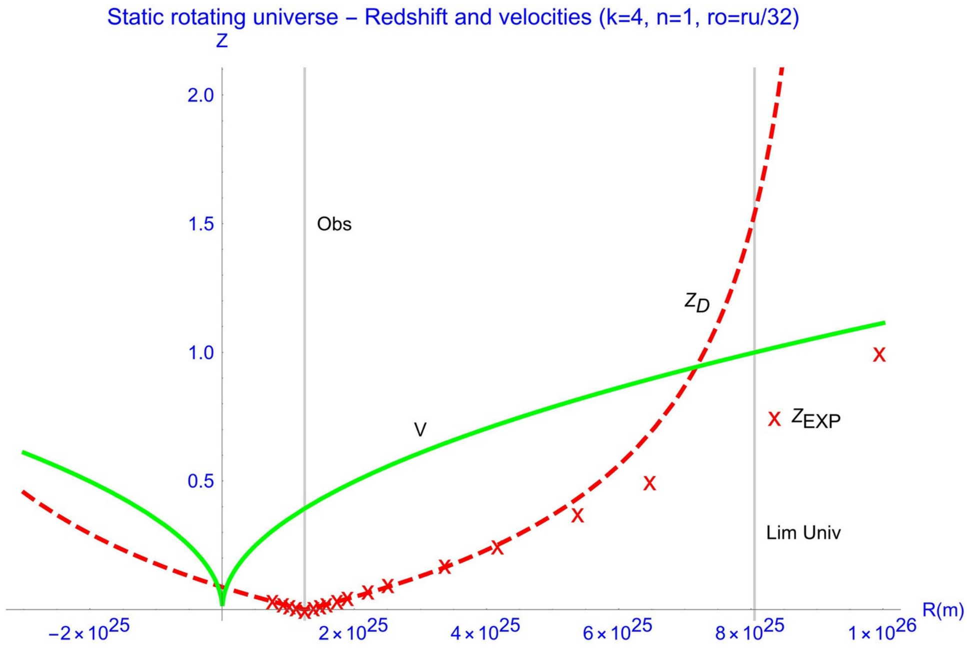


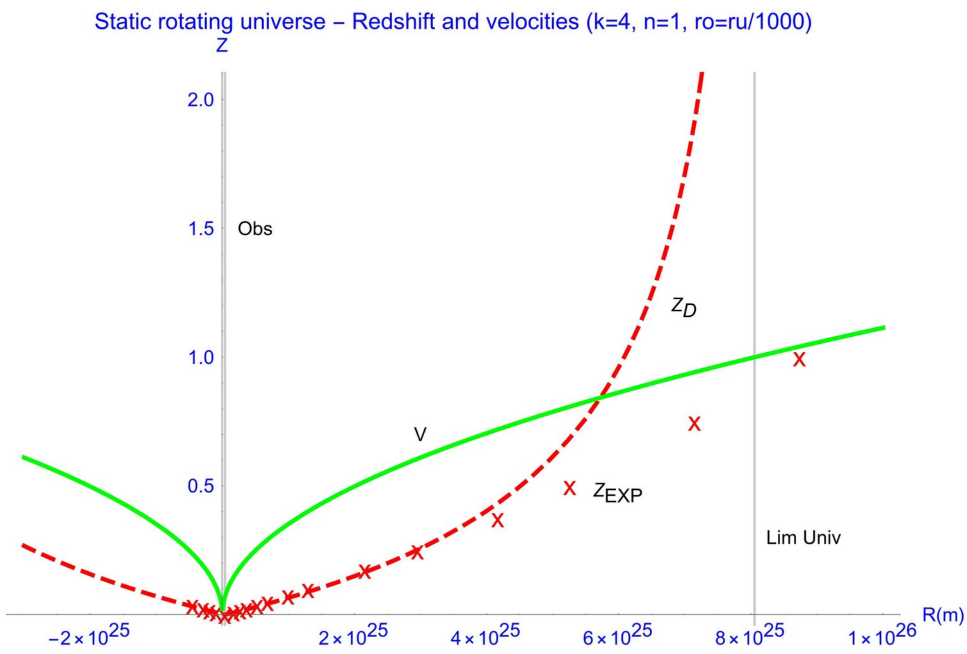
Fig 2. TDR (Z_D, dashed red line) as viewed by an observer (Obs) placed at 1/32 of the radius of universe (R_U) for a mass density that distributes as 1/R and compared with observed redshifts (red crosses). Green lines are rotational velocities (Eq 12) expresed as multiples of *c*.

In general, mass densitity will distribute as

$$\rho = k / R^n \qquad (22)$$

with k a free variable to be fitted and n very close to 1, or exactly one. We thus find the k that best fits the observed redshifts at short distances, in their linear region. An optimal value is k = 4 (Figs 3, 4).





Figs 3 and 4. Calculated transverse Doppler redshifts (Z_D, dashed red line) and rotational velocities (green line, in multiples of *c*) for a mass density distribution as in Eq 22, and k = 4. Observer (ro) is placed at 1/32 and 1/1000 of R_U, respectively. Red crosses are observed redshifts (Z_{EXP}). Vertical grey lines indicate the center of universe, the position of the observer, and the distance at which rotational velocities become larger than *c*.

Slight adjustments of the value of n in Eq 20 are possible, but we haven't seen a clear benefit in the predictive power as compared to setting its value at one and adjusting k. An example of this are shown in the appendix.

It is important to note that we have not tried here to model the velocities and redshifts that take place when the emitter is on the other side of the center of the universe (to the left in the graphics). Though essentially the same findings are expected, the calculation of gravitational accelerations, velocities and redshifts include some new phenomena that are hard to model with simple tools and might give rise to considerable asymmetries in the resulting redshifts. In this sense, only the right side of our graphics should be considered.

As we can see in the graphics, redshifts outside our local universe (approximately z = 0.3) are much higher than the currently accepted ones. This might mean the failure of the model, unless distances in such ranges (z>0.3) are overestimated by our current ΛCDM model. We will discuss this issue presently. For now, we just point out that rotational velocities larger than c make no sense. Hence the vertical line in the graphics where such velocities are achieved. The question is then whether distances could be systematically overestimated in the current Concordance Model, or is the whole idea of a static rotating universe flawed?

Discrepancies with the SN-Ia distance ladder for measuring distances.

We come thus to the striking conclusion that redshifts in this static, rotating universe are practically identical to those of an expanding universe for distances smaller than z ~ 0.3, but they strongly disagree for larger distances. Since distances in standard ΛCDM are measured from a very sophisticated and well-tested, sequential method that is ultimately anchored on optical parallax, the natural question to ask is whether there could be a problem in the last ladders or our current distance method. Could Type Ia Supernovae (SNe Ia) erroneuously measure distances outside of our local universe? Otherwise, the whole of the present model comes crumbling and must be discarded.

In the first place, we must take into acocunt that in our static rotating model of universe (SRMU), high rotational velocities are achieved that are real. For velocities > 0.3- 0.5·*c* relativistic masses must be always considered. In ΛCDM in contrast, recessional velocities are 'apparent', since in the reference frame of any particular galaxy, velocities are always sub-relativistic. Therefore in ΛCDM galaxies do not violate Special Relativity despìte recessional velocities much higher than *c.* Despite recent reports that indicate that time dilation occurs for distant galaxies and quasars, (which in itself is somewhat problematic in the context of ΛCDM) the whole ΛCDM is rooted on a mass that is relatively insensitive to recessional velocities. In SRMU instead, masses do increase relativistically in proportion to Z. This means that for all galaxies and stars out of the local universe, their effective mas is its relativistic mass m_R, which is higher, sometimes much higher than their rest mass (m_0). If the explosion of SNe-Ia takes places at a fixed mass, this -we argue- must be its relativistic mass. This would mean that they explode when they are smaller, as compared to similar galaxies at shorter distances studied with the same methods and formulas based on rest mass. The only thing that is needed then to explain a possible source of error in the SN1a method for measuring distances is that luminosity depends not on relativistic mass, but rather on rest mass. This might indeed be the case, since luminosity, the number of photons emitted per unit time, is subject to relativistic time dilation, which must be accounted for. Even though luminosity should depend also on relativistic mass, luminosity might then need to be corrected for relativistic time dilation which might result in it being essentially proportional to rest mass. The end result might be an overestimation of luminosities and distances. In the graphics, for any galaxy at radial distance R from the observer, its real luminosity at the time of its explosion might be smaller than calculated and, to acount for that, a larger distance must be assumed, that is largely approximated by the horizontal projection of the 'true' redshift represented in the dashed red lines onto the 'experimental redshift' line, represented by the red crosses. Lower-than-expected luminosities can only be made consistent with the linear relation Redshift-Distance (Hubbles's law) that holds true for all shorter distances by assuming that their location is significantly farther apart, as needed from by the inverse-square law of propagation of light. The discrepancy might increase exponentially at large distances, in parallel with the increase in rotational velocities and relativistic mass.

Second, we would point out another possible source of error in the calculation of distances. Based again on the overestimation of luminosity, it would lead to erroneously overestimated distances. This is the case for the headlight effect [16]. In an expanding universe, a headlight effect should not take place for distant galaxies, since velocities in their reference frame are sub-relativistic.

But in a rotating static universe, there is a (most likely small) headlight effect, by which an observer placed inside the orbit and near the universe's radial axis of an orbiting galaxy would detect a decreased luminosity as compared to the one predicted from its mass (whether rest o relativistic). This effect might also give rise to an erroneous estimation of distance, since the observed lower-than-predicted luminosities can only be explained by larger distances from the observer.

Both this two sources of error would go unnoticed in the lower rungs of the distance ladder (cepheids and parallax), since no relativistic corrections are needed nor used in their ranges.

Conclusions

Subject to the aforementioned limitations and the provisional semi-quantitative character of the present model, we conclude that:

1. A mass density that scales as 1/R in a static rotating universe gives rise to a constant cosmological acceleration consistent with MOND's a_0. This would generate rotational velocities that increase as the square root of radial distance from the center, reaching relativistic speeds at the outer regions.
2. Such velocities would generate a transverse Doppler redshift that scales with radial distance, mimicking recessional velocities and expansion. It is also orders of mangnitude larger than gravitational blueshift.
3. The apparent isotropy of the universe can be explained from this redshift, which would be observed from all directions.
4. Whether looking into the outward, peripheral regions of the universe or towards its center and beyond, strongly redshifted light coming from the farthest external shells is expected to predominate, possibly giving rise to images similar to those observed in the CMB.
5. Current methods based on the distance ladder and SNe-Ia might overestimate cosmological distances, and might overestimate as well the actual size of the universe. In contrast, the lifespan and stability of our universe might be grossly underestimated.

Discussion

Several authors, most notably Lombriser, Buchert, Roukema *et al* [17-19] have proposed that the expansion of the universe might be an apparent phenomenon caused by distortions in the gravitational fields at cosmic scales, but the models are incomplete, difficult to test and, in some cases they include radical unobserved features like a variation in the mass of particles.

Late American astronomer Halton Arp performed detailed observations on redshifts from quasars and galaxies around the turn of the last century, calling the attention on several inconsistencies and unexplained findings at large distances [20]. Redshift often distributes with regular patterns and periodicities that are hard to explain if expansion and the relation of redshift with distance are both correct. Morever, sometimes wide differences in redshift from close-by galaxies was recorded. For these reasons, Arp opposed to the idea of recessional velocities as the major or unique origin of cosmological redshift. Unfortunately, the alternative he postulated, i.e., that redshift is quantized and caused by intrinsic properties of galaxies and quasars, like their plasma content, has little suppport and we lack any leads to either confirm or disprove it.

On the other hand, the hypothesis that light's energy and frequency might decay across large distances, the 'tired light' hypothesis, has not gained traction mainly due to the fact that it would imply a modifications of c, contradicting Special Relativity. There have recently been some remarkable attempts [21] to make the tired light hypothesis consistent with the observation of large galaxies at early times and with ΛCDM by way of a hybrid model. However, it also necessitates modifications in the basic physical constants G, c, and Λ.

The present semi-quantitative model is based on the assumption of a mass density that decreases inversely with distance, a reasonable hypothesis that is consistent with Newtonian gravity and supported by MOND and by a handful of preliminary observations on actual mass densities in the local universe. The assumption might soon be tested by the James Webb Space Telescope and other observatories. It offers a picture of a static, rotating universe that would generate the phenomena of redshift and background low-energy radiation that we observe today and constitute the backbone of modern cosmology.

High rotational velocities are not excluded from our lack of detection of changes in the position of distant galaxies. For the same reason that the rotation of earth is not detected by us, as noted by Galileo, and rotation of the Milky Way has never been directly detected even if it amounts to hundreds of meters per second.

Unfortunately, in this model the universe could essentially no longer be expanding, nor the Big Bang could take place 14 billion years ago. On the plus side, the mass-energy composition of the universe might be better understood, and the law of conservation of energy would no longer be violated at cosmic scales. The universe would be much older and stable than previously though and, though static, it would offer an ample range of exciting features to work with and speculate.

And yet, caution is advised when contemplating these hypotheses. Our current models of the universe are self-consistent and offer a complete picture of the events up to the first nanoseconds from the origin. Even if countered by a few important discrepancies, our current cosmological models work. The present ideas are an alternative view motivated by reasonable arguments, many of them inspired by the work of other authors. They might be worth being looked into, scrunitinized and, if they end up being ruled out from disagreement with observations, the task ahead remains unchanged, which consists of seeking truth and bettering our understanding. *For us, there is only the trying. The rest is not our business* [22].

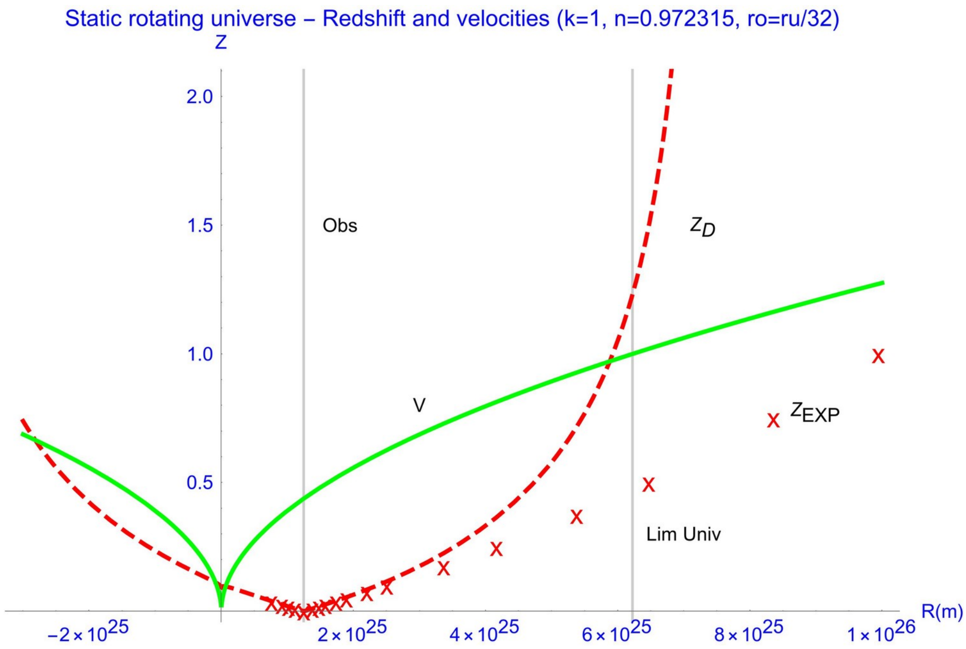
Appendix I

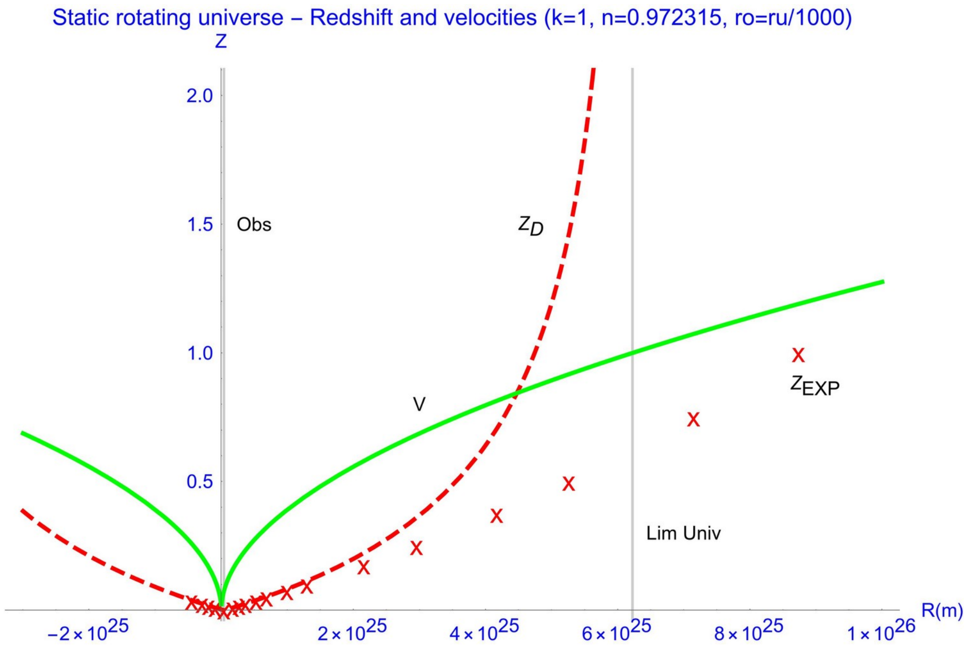
Mathematica code for the graphics

```
ro=1/8*10^26 (* Observer position *) ;

c=3*10^8 (* Speed of light *) ;

g=6.67*10^-11 (* Gravitational constant *);

k=4(* Density constant *);

n=1 (* Parameter *);

density[r_]:= k*Abs[r]^-n (* Density *);

acceleration[r_]:=1/3*4*Pi*g*density[r]*Abs[r](* Acceleration *);

v[r_]:=Sqrt[acceleration[r]*Abs[r]] (* Velocity of emitting galaxy *);

vrel[r_]:= Sqrt[acceleration[r]*Abs[r-ro]](* Relative velocity between r and observer ro *);

zd[r_]:=1/Sqrt[1-(vrel[r]/c)^2]-1(* redshift doppler *);

vplot[r_]:= Abs[v[r]]/c;

limu=r/.NSolve[vplot[r]==1&&r>0,{r}][[1]] (* Distance at which v=c *);

table={{0,0},{42.8,0.01},{74.6,0.0175},{106.2,0.025},{158.2,0.0375},{209.4,0.05},
{309.9,0.075},{407.7,0.1},{686.4,0.175},{945.2,0.25},{1338.6,0.375},{1691.9,0.5},
{2303.8,0.75},{2818.3,1},   {3644.3,1.5},{4285.9,2},{4804.1,2.5},{5234.6,3}};

dists=Take[Transpose[table][[1]]*3.0857*10^22+ro,18];

dists1=Rest[Take[2*ro-dists,5]];

ereds=Take[Transpose[table][[2]],18];

ereds1=Rest[Take[ereds,5]];

zo=ListPlot[Join[Transpose[{dists1,ereds1}],Transpose[{dists,ereds}]],PlotMarkers->
       Style["x",Red]];

rshift=Plot[{Style[zd[ll],Red,Dashed],Style[vplot[ll],Green]},{ll,-3*10^25,1*10^26}];

graph=Show[zo,rshift,PlotRange-> {{-3*10^25,1*10^26 },{0,2}},AxesOrigin-> {0,0},GridLines->
       {{ro,limu},{}},PlotLabel-> "Static rotating universe - Redshift and velocities (k=4,
n=1,   ro=ru/32)",LabelStyle->Directive[Blue,7],Epilog-> {Text[Style["V",FontColor->
       Black,FontSize-> 7],{3*10^25,0.7}],Text[Style["Subscript[Z, D]",FontColor->
Black,FontSize->     7],{7.2*10^25,1.2}],

       Text[Style["Subscript[Z, EXP]",FontColor-> Black,FontSize-> 7],{9*10^25,0.75}],

       Text[Style["Obs",FontColor-> Black,FontSize-> 7],{1.7*10^25,1.5}],

       Text[Style["Lim Univ",FontColor-> Black,FontSize-> 7],
{8.8*10^25,0.3}]}],AxesLabel->   {"R(m)","Z"}];
```

Appendix II

Additional graphics assuming n < 1 in Eq 22.





It is shown that a mass density decay that scales as k / R^n and n < 1 can also generate redshifts consistent with the observed ones. Observer at 1/32 and 1/1000 of the radius of universe. Nothing prevents in principle that mass density deviates from an exact 1/R distribution, but we would rather eschew those models since their main feature of the model is lost, i.e., a constant acceleration that pervades the whole universe. Rotational velocities also pick up quite steadily. Mixed models (with both k and n different from 1) are also possible.

Appendix III

The cosmology that would result from the Static-Rotating model of Universe (Highly speculative).

In the SRMU, size would be determined by rotational velocities being limited by the speed of light. No physical object can move at speeds higher than c, and since there is no expansion of spacetime, no exceptions are acceptable. This entails that the size of the universe is determined internally, by the fundamental laws of physics, relativity, QM and gravity. The universe shoud be much, much more stable than our current models predict. Not necessarily eternal though, since matter would be continually generated and simultaneously consumed into spacetime. In the mature and old phases of its lifetime, the universe might convert more matter into space than in reverse andf it might eventually run out of mass. At that time, which might occur 10^{50} to 10^{100} years from its origin or more, the universe would lack the necessary mass to maintain its present properties, its rotational velocities and its size, and might collpase and 'disolve' into spacetime, gas and dust, adding to the general pool in the outer 'inter-universe' space. Other 'young'universes might exist that have not yet reached its full rotational velocities size limit and are therefore capable of growing by accreting mass and spacetime. Tnhse oung universed owuld grow from the recycling of mass and spacetime in the 'interuniverse' medium, and would grow until the reached the same size as all mature universe – likely the size of our own.

The question of what lies outside of our current universe has thus no proper answer that can be validated experimentally. However, the internal logic of the model (the fact that size limits are fixed internally by the universe itself) and common sense suggest that outside of our universe there might be just spacetime governed by the same physical laws, and the same or similar things might happen, including other universes similar to our own. If other universes do actually exist, we can infer at least two of their most likely properties: 1) They shoud have about the same size and life span as our own universe, at least in their mature, adult state, and 2) The spatial and time scales involved would be similar. Judging from the scales we see in our universe, where stars are separated an average of 1 pc, and galaxies are separated and average of 1 Mpc, we should expect that other universes -if they exist- should be about 1 trillion parsecs (10^{28} m) away from each other on average, or more. Their life span would likely be immense and be measured by powers of 50s to 100s. But al this is highly speculative and not the point the present work.

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