On the variation of the energy scale 21

Predictions and Tests

by

Jo. Ke.

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www.varensca.com

Summary

The conjecture has been put forward that the energy scale can vary from location to location. This conjecture enables all astronomical situations where dark matter is invoked to be explained without any dark matter. This paper details the predictions that come from the conjecture and some additional tests of the conjecture that can be carried out. Many of these can be checked by making new observations or carrying out new experiments.

1 Introduction

1.1 JoKe1 (2015) puts forward the conjecture that the energy scale can vary from location to location. It shows that the flat rotation curves of spiral galaxies can be explained by variations in the energy scale, without the need for any dark matter.

1.2 Other papers in this series (JoKe2 to JoKe20) explain other astronomical situations where dark matter is usually invoked, including: clusters of galaxies; cluster collisions; cosmic microwave background; Friedmann equation; galaxy interactions; gravitational lensing; gravitational potential: inflation; Lagrangian mechanics; physical cosmology; primordial density perturbations; radial acceleration relation; ring and shell galaxies; solar system; structure formation.

1.3 This paper presents some predictions that follow from the conjecture. These are new ideas that can be checked by making new observations or carrying out new experiments. The paper also lists checks of the conjecture that should be possible using existing data.

1.4 Unlike previous papers in this series, all of which are "frozen", this paper will be updated as we arrive at new conjectures and tests.

2 Predictions and Tests

2.1 Predictions

1 No dark matter particles will ever be detected.
2 No dark matter objects will ever be observed.
3 Galaxies with little or no dark matter can exist.
4 Local phenomena do not need any additional matter.
5 No additional matter is required in the central regions of galaxies.
6 No additional matter is required within the solar system.
7 Galaxy clusters should disperse after collisions.
8 Galaxy rotation curves eventually decline following Newtonian gravity.
9 Galaxy rotation curves can have a faster than Newtonian decline.
10 Galaxy rotation curve can be predicted from matter distribution.
11 Pairs of galaxies should move as if they have no dark matter halos.

2.2 Tests

1 The distribution of mass within clusters of galaxies.

P1 Prediction 1
No dark matter particles will ever be detected

P1.1 It is assumed throughout this series of papers that dark matter does not exist. It follows that there are no dark matter particles to detect. So no experiment will ever detect any dark matter particles. This includes accelerators used by particle physicists, such as the Large Hadron Collider.

P1.2 The most favoured particle for dark matter is some form of WIMP (weakly interacting massive particle). This only interacts with normal matter via gravity and the weak nuclear force. Current experiments to detect WIMPs are based on the guesswork of possible particle interactions using the weak nuclear force. Needless to say but our conjecture of energy scale variations implies all such experiments will fail.

P1.3 The presumption is that dark matter does not exist. In its place we have the conjecture that the energy scale can vary from location to location. All scenarios where dark matter is invoked can be explained instead by variations in the energy scale.

P1.4 It is very hard to prove a negative. So, although we are clear that dark matter is not required to explain observations, it is not possible to demonstrate that a small amount of something that can be labelled as dark matter does not exist.

P1.5 This is not particularly useful as a prediction simply because it is very hard to prove a negative. The argument goes that if we haven't found any dark matter particles yet then perhaps we have not carried out the correct experiments or we are looking in the wrong places.

P2 Prediction 2
No dark matter objects will ever be observed

P2.1 As dark matter does not exist it follows that no dark matter objects exist. So no planets made of dark matter; no stars made of dark matter; no galaxies made of dark matter; no objects anywhere made of nothing but dark matter will ever be observed.

P2.2 In a sense this is a trivial prediction as it follows inevitably from prediction 1.

P2.3 We have plenty of objects made of normal matter that do not contain any dark matter. We only have to look at the planets and the stars. Conversely, if dark matter exists, one might expect objects made solely from dark matter to exist. But dark matter doesn't exist and neither do any dark matter objects.

P2.4 Again, as with Prediction 1, this is unhelpful as a prediction. If no dark matter object is ever found then we may have been looking in the wrong places.

P3 Prediction 3
Galaxies with little or no dark matter can exist

P3.1 The work on the rotation curves of spiral galaxies shows that the energy scale variations are not all the same and that they come in a range of sizes. In terms of the Gaussian profiles employed there are two parameters: the height of the Gaussian; the 1/e-width of the Gaussian. Both appear to vary both randomly and independently of one another.

P3.2 So, spiral galaxies with smaller than average energy scale variations are observed, as are galaxies with larger than average energy scale variations. In interpreting rotation curves in terms of dark matter this means that some galaxies appear to have very little dark matter, and others with a lot.

P3.3 The standard model of cosmology, the ΛCDM model, argues that galaxies are formed when normal matter falls into gravitation potential wells of dark matter. This means all galaxies should have a substantial dark matter halo and that galaxies with little or no dark matter should not exist.

P3.4 The variation in the Gaussian profiles for the energy scale variations means that some galaxies will show a large energy scale variation and others a much smaller one. There is no problem in explaining spiral galaxies that appear to have hardly any dark matter; these are simply galaxies with a weak energy scale variation. Similarly there is no problem in explaining galaxies that appear to have an excessively large amount of dark matter. These simply lie in a strong energy scale variation.

P3.5 This prediction cannot substantiate the existence of energy scale variations; it can only support their existence. However, it can possibly rule out alternative explanations for dark matter.

P4 Prediction 4
Local phenomena do not need any additional matter

P4.1 Our solution of energy scale variations works because the gravitational source and target are in different locations where the energy scale can have different values. By definition, where the source and target are in the same location the energy scale has the same value, and all observations should be explainable without the need for any extra gravitational force, i.e. dark matter. This applies to objects or regions close to one another, such as the solar system; binary stars; the centres of galaxies.

P4.2 The force between two masses arising from a Gaussian-shaped energy scale variation is given by

$$\boldsymbol{F(r) \ = -\frac{G\,M\,m}{r^2}\,\frac{(1+\ \beta)}{(1+\ \beta\, exp\{-r^2/\alpha^2\})}} \qquad (1)$$

where $F(r)$ is the force; M, m the two masses; r the separation; β the strength of the energy scale variation; α the 1/e-width of the energy scale variation.

When the separation becomes small, i.e. $r \ll \alpha$, this reduces normal Newtonian gravity

$$\boldsymbol{F(r) \ = -\frac{G\,M\,m}{r^2}} \qquad (2)$$

This shows that our conjecture means that at small separations there are no effects from the energy scale variation, i.e. there are no local effects.

P4.3 By local we mean that the separation between source and target is small compared to the 1/e-width of the energy scale variation. For example: the width of the energy scale variation for our galaxy is around 9 kpc (~3.5 × 10^{21} m), whereas the diameter of our solar system is around 60 AU (~9 × 10^{12} m); so a difference of at least 8 orders or magnitude. Hence it is unlikely that we could detect any changes across our solar system arising from a galactic energy scale variation.

P4.4 This is another negative prediction, so not particularly useful.

P5 Prediction 5

No additional matter is required in the central regions of galaxies

P5.1 When interpreting phenomena observed in the inner regions of galaxies, no additional mass will be required. It should be possible to understand everything that is going on in terms of the observed baryonic matter. By "inner region" we mean the central few kiloparsecs, less than 3 kpc (say).

P5.2 This stresses the point made in prediction 4 above, that no dark matter is needed in local regions.

P5.3 The ΛCDM model (Λ=cosmological constant + cold dark matter) has a problem here as it predicts a peak in the the density of the dark matter halo in the galaxy centres. This is contrary to observations. On the other hand our conjecture predicts no mass discrepancy in galaxy centres; there is no requirement for any extra mass and the observed mass should be sufficient to explain all observations there.

P5.4 This prediction gives a clear separation between dark matter and energy scale variations. The dark matter conjecture predicts a lot of extra non-baryonic mass in the centre of galaxies. The energy scale variation conjecture predicts no extra mass in the centre of galaxies.

P6 Prediction 6
No additional matter is required in the solar system

P6.1 No observations of phenomena within or across the solar system will require any additional mass, whether normal matter (baryonic) or dark matter (non-baryonic).

P6.2 This follows from prediction 4 where no additional mass is required to explain local phenomena.

P6.3 The width of the energy scale variation for our galaxy is around 9 kpc ($\sim 3.5 \times 10^{21}$ m), whereas the diameter of our solar system is around 60 AU ($\sim 9 \times 10^{12}$ m); so a difference of at least 8 orders or magnitude. Hence it is unlikely that we could detect any changes across our solar system arising from a galactic energy scale variation.

P7 Prediction 7
Galaxy clusters should disperse after collisions

P7.1 Pairs of galaxy clusters should show signs of break up after colliding with one another. The velocities of the galaxy members should be too high for the total mass present.

P7.2 Most of the normal matter in a cluster of galaxies is in the gas; the galaxies themselves are just a small fraction of the total. In collisions between galaxy clusters the gas appears to get stripped out whilst the galaxies simply pass through and carry on their way. This was discussed in JoKe5 (2015) "Collisions between clusters of galaxies".

P7.3 In the dark matter scenario the dark matter is not affected by the collision and continues with the galaxies. This means the dominating dark matter is still in place and should be strong enough to hold the galaxies together; the cluster should not disperse.

P7.4 In the energy scale variation scenario the cluster loses most of its mass when the gas is stripped out. On their own the galaxies should be insufficient to hold the clusters together.

P7.5 A virial theorem analysis of the clusters should show that they are breaking up and dispersing; i.e. that the kinetic energy in the galaxies, as derived from their velocities, should be more than twice the potential energy, as derived from weak gravitational lensing.

P7.6 We might expect this to be a relatively straightforward piece of research but I am not aware that this analysis has taken place. This would clearly discriminate between the dark matter conjecture and our energy scale variation conjecture.

P8 Prediction 8
Galaxy rotation curves eventually decline and follow Newtonian gravity

P8.1 At large distances from the galaxy centre of spiral galaxies the rotation curve should revert to the expected $\mathbf{1/\sqrt{r}}$ fall off. By large distances we mean greater than twice the 1/e-width of the Gaussian energy scale variation.

P8.2 The rotation curves should decline following Newtonian gravity with the dependence of

$$\boldsymbol{v(r) \;=\; \sqrt{G\,M\,(1+\beta)}\;\frac{1}{\sqrt{r}}} \tag{3}$$

where $\boldsymbol{v(r)}$ is the rotation speed; $\boldsymbol{M}$ the mass of the galaxy; $\boldsymbol{\beta = B/A}$ the ratio of the height to the background level of the energy scale variation; $\boldsymbol{r}$ the radial distance.

P8.3 Many of the rotation curves shown in JoKe3 (2015) "Parameters for galaxy rotation curves" do begin to show a fall off at large distances, exactly as our conjecture predicts. However, they do not extend far enough to confirm a $\mathbf{1/\sqrt{r}}$ fall off in the velocity.

P8.4 To confirm this prediction we need observations of rotation curves out to large distances from the galaxy centre. By large we mean 3 or 4 times the 1/e-width of our energy scale Gaussian. In practical terms this means a distance of at least 40 kpc. Such observations are extremely difficult to obtain, but should be possible using the latest generation of radio telescopes.

P9 Prediction 9

Galaxy rotation curves can have a faster than Newtonian decline

P9.1 It is possible for the rotation curves of spiral galaxies to have a decline that is faster than that predicted for Newtonian gravitation. This implies the "impossible" situation where the total mass interior to a point gets smaller with distance away from the galaxy centre.

P9.2 Figure 1 illustrates the expected shapes of galaxy rotation curves for a central mass. The curves are normalised so that the rotation speed is 1.0 at distance 1.0. The solid green line is the expected curve for normal Newtonian gravity; the fall off is proportional to $\mathbf{1/\sqrt{r}}$.

P9.3 If the observed rotation curve lies above the green line, beyond distance 1.0, then additional matter is required. This is illustrated by the dashed red line. This is the usual situation for spiral galaxies and the usual explanation is that the galaxy is surrounded by a large halo of dark matter, which provides the extra mass.

P9.4 Our explanation for such curves is that the galaxy lies in an energy scale variation. An energy scale variation that peaks at the galaxy centre and monotonically falls off will give rise to rotation curves in this part of the diagram.

P9.5 If the observed curve lies below the green line then less matter is required. This is illustrated by the dashed blue line. For normal matter and dark matter this situation is impossible. We cannot have galaxy with a certain total mass inside some distance but with less total mass inside a distance further out.

P9.6 Such curves can exist with energy scale variations. If, instead of continuously falling, the energy scale levels off or rises then the rotation speed will decrease faster than normal Newtonian gravity.

P9.7 Observations should be made of spiral galaxies to see if any rotation curves show a faster decrease than the expected $\mathbf{1/\sqrt{r}}$.

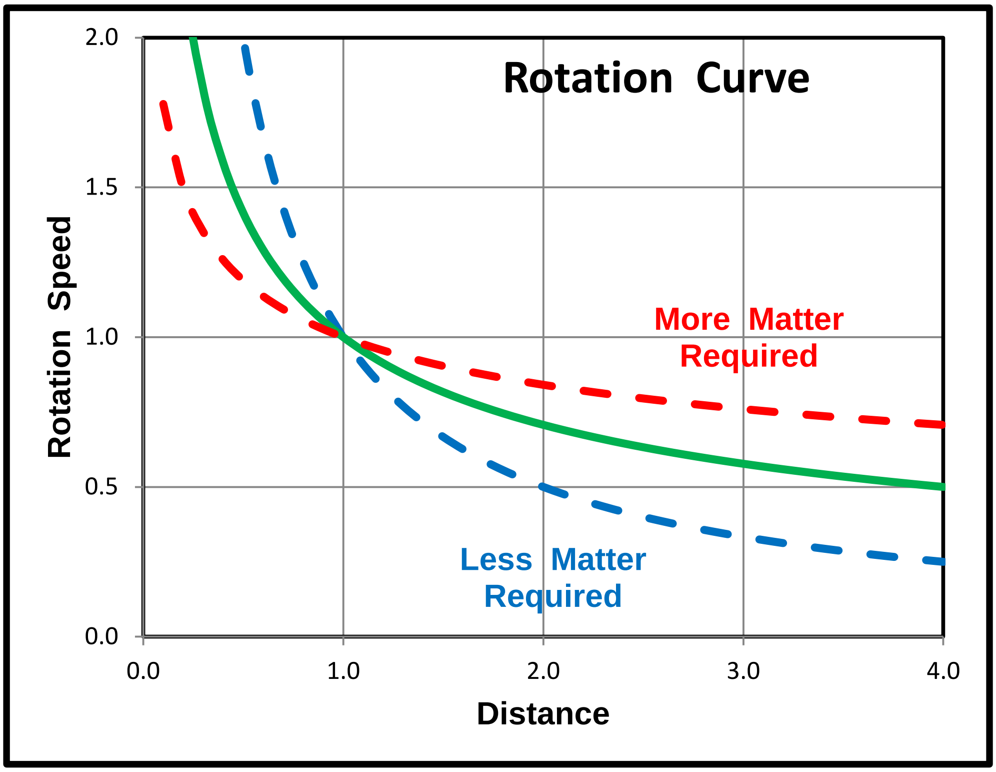

Figure 1: Illustration of galaxy rotation curves.

P10 Prediction 10
Galaxy rotation curves can be predicted from the matter distribution.

P10.1 An analysis of the disk galaxies in the SPARC catalogue (Lelli et al, 2016) led to the following expression for the rotation curve

$$\boldsymbol{v^2(r) = \frac{G}{r}\, r^{\alpha} \int_{x=0}^{r} \frac{1}{x^{\alpha}}\; dM(x) \;=\; \frac{G}{r} \int_{x=0}^{r} \left\{\frac{r}{x}\right\}^{\alpha} dM(x)} \qquad (4)$$

where $\boldsymbol{v(r)}$ is the observed rotational velocity; $\boldsymbol{dM(x)}$ the increment in baryonic mass between radial distances $\boldsymbol{x}$ and $\boldsymbol{x+dx}$. The work behind this analysis was presented in JoKe22 (2019).

P10.2 If we know the distribution of baryonic matter (i.e. the $\boldsymbol{dM(x)}$) and the rotational velocity near the galaxy centre, then we can predict the rotation curve further out using equation (4). The inner velocities are needed to fix the value of the $\boldsymbol{\alpha}$ exponent.

P10.3 Hypotheses with dark matter cannot predict the shape of the rotation curve. They can only determine the amount of dark matter required to account for the observed rotation curve from the baryonic matter distribution.

P11 Prediction 11
Pairs of galaxies should move as if they have no dark matter halos.

P11.1 Under the conjecture of energy scale variations, the gravitational acceleration is given by

$$\ddot{r} = -\frac{G\,M_A}{r^2}\,\frac{\xi(A)}{\xi(r)} \tag{5}$$

where M_A is the mass at A; $\xi(A)$ the value at A of the ξ function for the energy scale variation; $\xi(r)$ the value of the function at r.

P11.2 The baryonic mass of most disk galaxies is concentrated in the centre. So we can consider a disk galaxy as a point mass with a single high value of the ξ function. The rotation curves arise because the ξ function declines rapidly away from the centre and has much smaller values in the outer spiral arms. But by the time we get to a neighbouring galaxy centre the ξ function would have risen again.

P11.3 A second disk galaxy, B, would be expected to have a similar high values of the ξ function at its centre. This means the gravitational acceleration caused by galaxy B would be

$$\ddot{r} = -\frac{G\,M_A}{r^2}\,\frac{\xi(A)}{\xi(B)} = -\frac{G\,M_A}{r^2} \tag{6}$$

where $\xi(A) \approx \xi(B)$.

P11.4 So we expect the orbital characteristics of the two galaxies to be determined by their intrinsic baryonic masses alone. They should not behave as if their masses were enhanced by either a massive dark matter halo or any energy scale variation effects.

P11.5 For the dark matter hypothesis we predict that the rotation curves of the individual disk galaxies will require massive halos of dark matter, but that the orbits of pairs of galaxies will not require any such halos.

T1 Test 1
Matter distribution within clusters of galaxies

T1.1 The distribution of mass within a cluster of galaxies can be determined in three different ways:

(a) the velocities of individual galaxy members
(b) the X-ray emission from the intra-cluster gas
(c) the gravitational lensing of remote objects

A single energy scale variation should be capable of explaining all three sets of observations.

T1.2 This test can, of course, only be made on galaxy clusters where all three types of observation are available.

T1.3 It may well be possible to explain the observations by a suitable distribution of non-baryonic dark matter. In this case a direct comparison can be made between the two conjectures.

T1.4 The velocities of individual galaxy members
If we assume the galaxy cluster is "relaxed" then we can apply the virial theorem and derive the gravitational potential, and thus the distribution of mass. For the dark matter conjecture it is thought that the galaxies contribute just 1% of the total mass and so they act as simple test particles.

T1.5 The X-ray emission from the intra-cluster gas
The X-ray observations give a direct measurement of the mass of the intra-cluster gas. If we assume the gas is in hydrostatic equilibrium then we can get another estimate of the distribution of mass within the cluster. For the dark matter conjecture it is thought that the gas contributes around 9% of the total mass so, substantially more than the galaxies.

T1.6 The gravitational lensing of remote objects
The observed lensing, both strong and weak, and be used as an independent method to get at the distribution of mass within the galaxy cluster.

3 References

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