On the variation of the energy scale 5

Collisions between clusters of galaxies

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Summary

The hypothesis has been put forward that the energy scale can vary from location to location. This has been used to explain the rotation curves of spiral galaxies and the velocities of galaxies in clusters of galaxies. The existence of dark matter has also been invoked to explain both sets of observations. Tests are clearly needed that can distinguish between the two hypotheses.

It is suggested that the collisions between clusters of galaxies can provide a test to distinguish between the hypothesis of dark matter and the hypothesis of variations in the energy scale.

1 Introduction

1.1 The paper "On the variation of the energy scale: an alternative to dark matter" (Jo.Ke, 2015) is referred to in this paper as simply "Jo.Ke 1". This paper introduced the idea of variations of the energy scale to explain the rotation curves of spiral galaxies. It used the simple model of a galaxy point mass and a Gaussian energy scale variation.

1.2 The paper "On the variation of the energy scale 2: galaxy rotation curves" (Jo.Ke, 2015) is referred to in this paper as simply "Jo.Ke 2". This improved on Jo.Ke 1 by replacing the galaxy point mass by a disk with a Gaussian density distribution.

1.3 The paper "On the variation of the energy scale 3: parameters for galaxy rotation curves" (Jo.Ke, 2015) is referred to in this paper as simply "Jo.Ke 3". This took the model of Jo.Ke 2 and applied it to the rotation curves of a large sample of 74 spiral galaxies.

1.4 The paper "On the variation of the energy scale 4: clusters of galaxies" (Jo.Ke, 2015) is referred to in this paper as simply "Jo.Ke 4". This applied the idea of variations in the energy scale to clusters of galaxies. It showed that it could explain the high velocities of galaxies in the clusters.

1.5 The question arises as to whether or not it is possible to devise tests that can distinguish between the hypotheses of dark matter and energy scale variations.

1.6 This paper investigates collisions between clusters of galaxies as one possible way to separate the effects of dark matter from those of energy scale variations.

2 Collisions with dark matter

2.1 When clusters of galaxies collide the galaxies and dark matter pass straight through one another unscathed. The intragalactic gas is not so lucky; it appears to be stripped out of the clusters and left behind.

2.2 The position before the collision is illustrated in Figure 1 below.

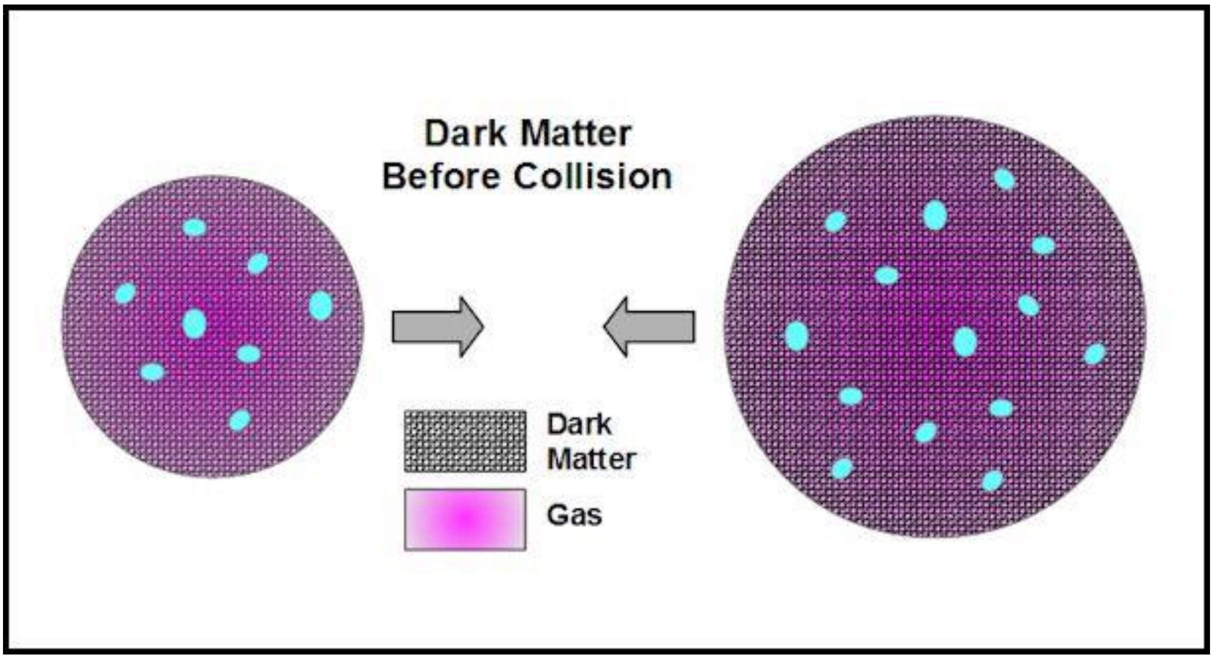

Figure 1. Two clusters of galaxies before collision. The galaxies (blue) are surrounded by hot gas (pink) and the whole embedded in dark matter (black hatching).

2.3 When the clusters collide the galaxies behave like solid particles and pass through one another. The distances between the galaxies are large compared to their size and the chance of collisions is extremely low. Dark matter, if it exists, only appears to interact gravitationally and also passes straight through.

2.4 The hot gas in the two clusters collides and interacts strongly. The gas tends to get left behind both galaxies and dark matter. So the collision results in a separation of the hot gas from the rest of the cluster.

2.5 The position after the collision is illustrated in Figure 2 below.

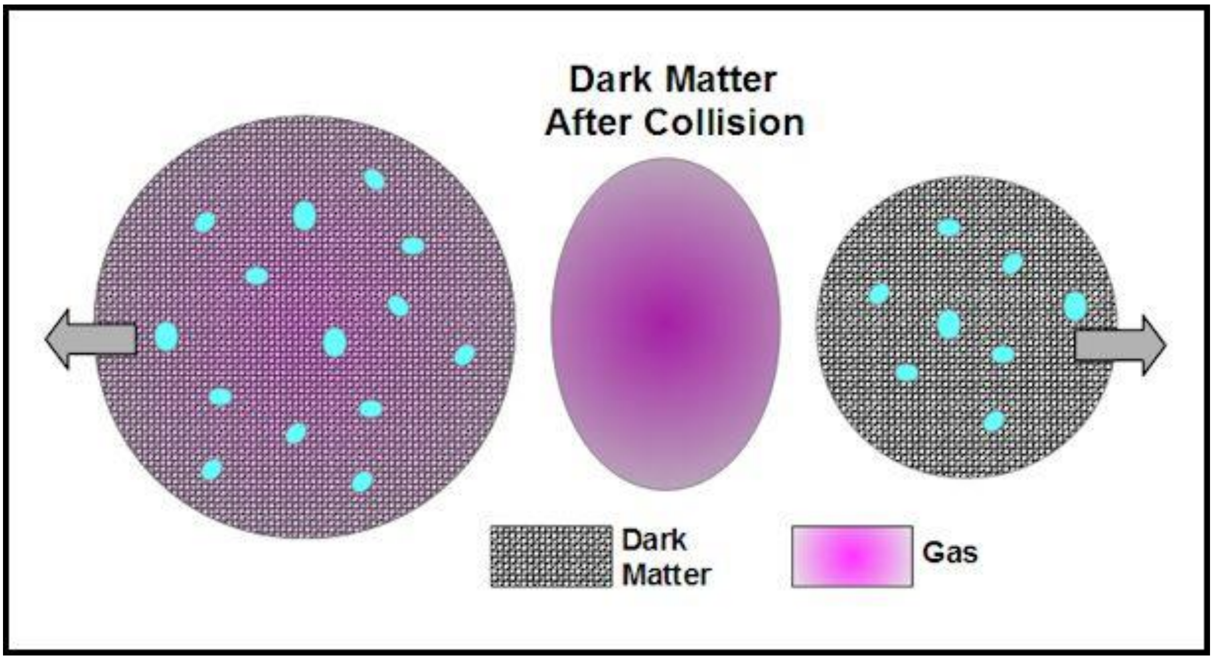

Figure 2. Two clusters of galaxies after collision. The galaxies (blue) remain embedded in dark matter (black hatching). The hot gas (pink) tends to get stripped out and left behind.

2.6 We can examine the mass of clusters before and after the collision, assuming that all the hot gas is stripped out.

2.7 Table 1

Component	Before	After
Galaxies	10%	10%
Hot Gas	10%	0%
Dark Matter	80%	80%
Total	100%	90%

2.8 It is clear that at most 10% of the cluster mass is lost during the collision. At that level we would expect the cluster to survive as it should still have sufficient mass to hold together.

3 Collisions with energy scale variations

3.1 When the clusters of galaxies collide the galaxies will pass straight through one another unscathed. It is also assumed that the energy scale variations, being waves of some kind, also passes straight through. The hot gases collide and get left behind.

3.2 The position before the collision is illustrated in Figure 3 below.

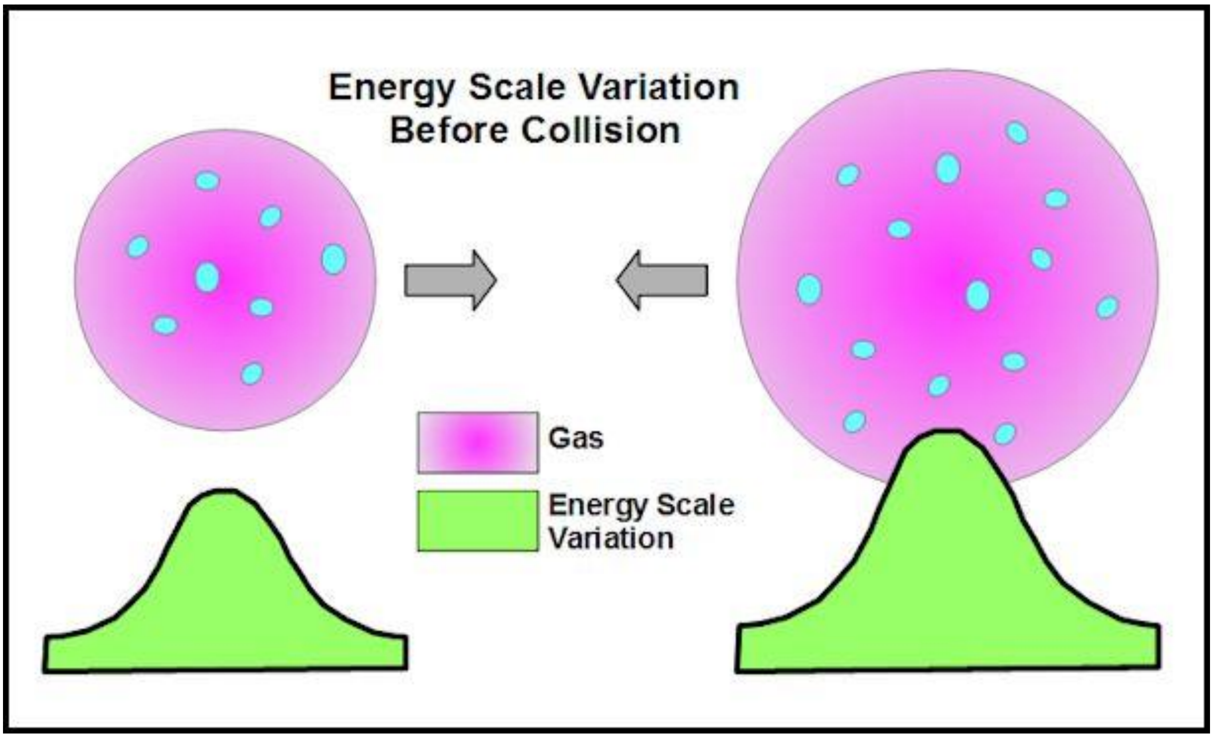

Figure 3. Two clusters of galaxies before collision. The galaxies (blue) are surrounded by hot gas (pink) and the whole embedded in energy scale variations (indicated by the green Gaussians). There is no dark matter.

3.3 When the clusters collide the galaxies behave like solid particles and pass through one another, exactly as for the collisions with dark matter. It is assumed that the energy scale variations also pass straight through.

3.4 The hot gas in the two clusters collides and interacts strongly. The gas tends to get stripped out of both galaxies and left behind. So the collision results in a separation of the hot gas from the rest of the cluster. This is the same as for collisions with dark matter.

3.5 The position after the collision is illustrated in Figure 4 below.

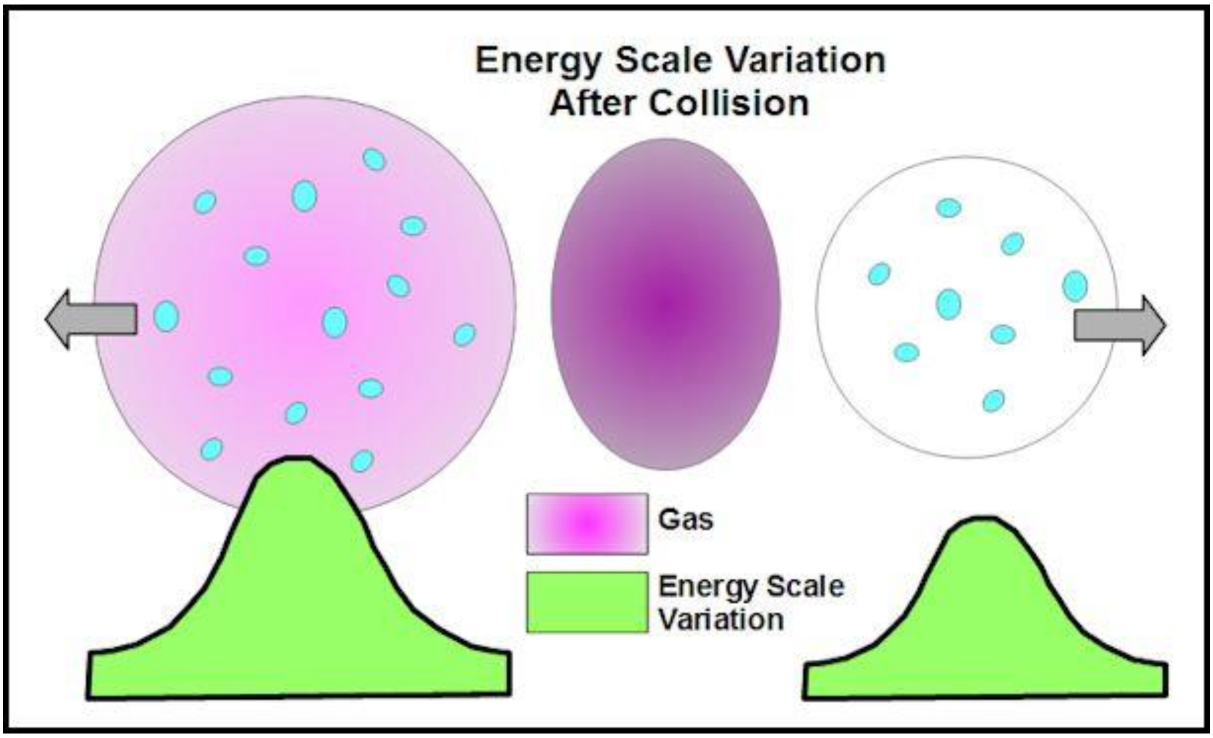

Figure 2. Two clusters of galaxies after collision. The galaxies (blue) remain embedded in the energy scale variations (indicated by the green Gaussians). The hot gas (pink) tends to get stripped out and left behind.

3.6 We can examine the mass of clusters before and after the collision, assuming that all the hot gas is stripped out. With no dark matter present the mass is divided equally between the galaxies (50%) and hot gas (50%).

3.7 Table 2

Component	Before	After
Galaxies	50%	50%
Hot Gas	50%	0%
Total	100%	50%

3.8 In this scenario it is apparent that the cluster loses half of its mass during the collision. At this level of loss it is doubtful that the cluster can survive and it should show signs of break up.

4 The Test

4.1 The mass of the cluster of galaxies can be estimated from weak gravitational lensing.

4.2 The velocity dispersion can be estimated by measuring the radial velocities of the galaxies that make up the cluster.

4.3 The virial theorem should then determine whether or not there is sufficient mass in the cluster to hold the galaxies together.

4.4 At a simplistic level the dark matter hypothesis says "yes", whereas the energy level hypothesis says "no".

4.5 We are dealing with the collision between two clusters of galaxies and expecting it to behave in a simple deterministic way. In such collisions one might expect a complete scrambling of information with little relation between the initial and final states. Nevertheless, it is important that such a test is carried out.

4.6 The obvious collision to test would be "The Bullet Cluster" (1E 0657-558). However, it might be better to work statistically with as many collisions as possible.

5 Conclusion

5.1 We apply the hypothesis of variations in the energy scale to the collisions between clusters of galaxies. It should be possible to distinguish between the hypothesis of dark matter and the hypothesis of energy scale variations..

5.2 We do not have access to any data relating to the collisions of clusters of galaxies. We must leave it to others to carry out the test.

6 References

Jo.Ke 1. (2015). "On the variation of the energy scale: an alternative to dark matter".

Jo.Ke 2. (2015). "On the variation of the energy scale 2: galaxy rotation curves".

Jo.Ke 3. (2015). "On the variation of the energy scale 3: parameters for galaxy rotation curves".

Jo.Ke 4. (2015). "On the variation of the energy scale 4: clusters of galaxies.