On the variation of the energy scale 7

Gravitational Lensing

by

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Summary

The hypothesis has been put forward that the energy scale can vary from location to location. Such energy scale variations can explain the rotation curves of spiral galaxies and the high velocities of galaxies in clusters of galaxies. This paper extends that work and shows that variations in the energy scale can explain the gravitational lensing effects usually attributed to dark matter.

1 Introduction

1.1 Gravitational lensing occurs when the light from a remote astronomical object is bent by an intervening massive object along the line of sight.

1.2 A common situation is the arcs of light observed in some clusters of galaxies. This is the so-called 'strong gravitational lensing' effect. The arcs are the distorted images of remote galaxies. The bending is usually attributed to large amounts of dark matter in the galaxy clusters. Examples of galaxy cluster showing strong lensing include: Abell 2218; SDSS J1038+4849; Abell 370; GC 0024+1654.

1.3 A second situation is where the the shapes of distant galaxies are distorted by an intervening cluster of galaxies. This is the so-called 'weak gravitational lensing' effect. There are no obvious arcs but a statistical analysis leads to an estimate of the mass of the galaxy cluster. This mass estimate is used to infer the existence of large amounts of dark matter. An example of weak lensing is the well-known 'Bullet Cluster', 1E 0657-56.

1.4 Both strong gravitational lensing and weak gravitational lensing are used to estimate the masses of clusters of galaxies. These estimates are many times greater than can be accounted for by the observed galaxies and gas. The discrepancy is currently attributed to the presence of large amounts of dark matter.

1.5 The paper "On the variation of the energy scale: an alternative to dark matter" (Jo.Ke, Sep 2015) is referred to in this paper as simply "JoKe1". It introduced the idea of variations of the energy scale to explain the rotation curves of spiral galaxies. It used the simple model of a point mass galaxy and a Gaussian energy scale variation.

1.6 The paper "On the variation of the energy scale 4: Clusters of galaxies" (Jo.Ke, Nov 2015) is referred to in this paper as simply "JoKe4". It showed that an energy scale variation encompassing a cluster of galaxies could account for the high velocities of galaxy members, without the need for any dark matter.

1.7 This paper extends the work on energy scale variations to show that they can also account for the gravitational lensing effects of clusters of galaxies.

1.8 In section 2 we show how dark matter is used to explain gravitational lensing. In section 3 we show how energy scale variations can explain exactly the same thing, but without the need to invoke the existence of any dark matter.

2 Gravitational lensing with dark matter

2.1 The effective mass of a cluster of galaxies with dark matter is illustrated in Figure 1 below.

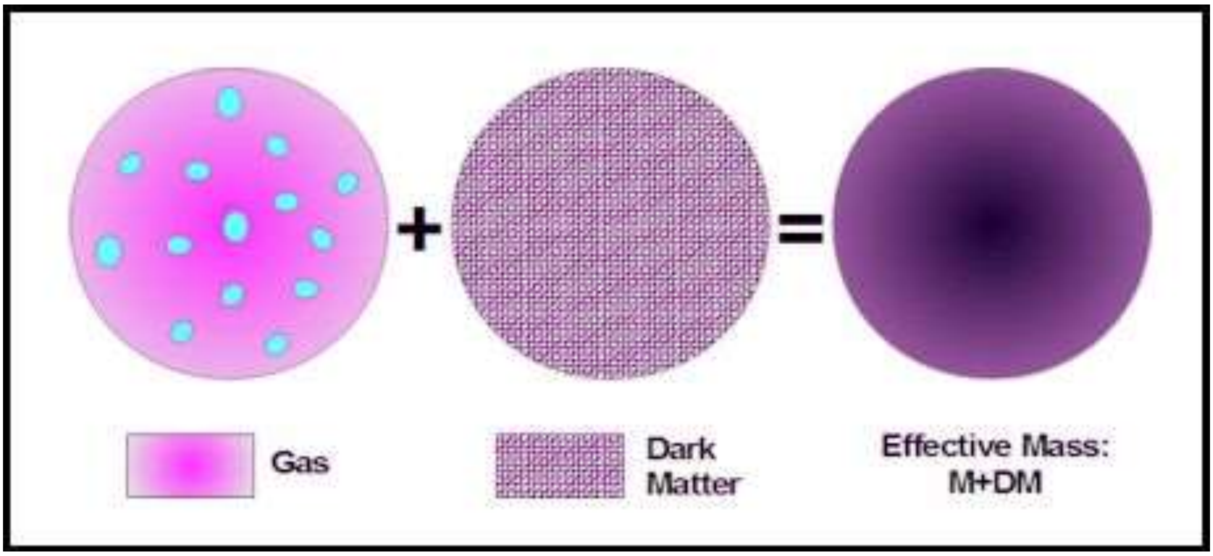

Figure 1: The effective mass of a galaxy with dark matter is the sum of the galaxies & gas and the dark matter.

2.2 The effective (total) mass of the cluster of galaxies is

$$\boldsymbol{M(total) = M + DM} \quad (1)$$

where $\boldsymbol{M}$ is the mass of the gas & galaxies; $\boldsymbol{DM}$ is the mass of the dark matter.

2.3 Current observations of clusters of galaxies suggest that the mass of the dark matter is about five times greater than the mass of gas & galaxies.

2.4 General relativity shows that a light ray from a remote galaxy is bent by the cluster of galaxies through an angle $\boldsymbol{\theta}$ given by

$$\boldsymbol{\theta = \frac{4\,G\,M(total)}{R\;c^2} = \frac{4\,G\,(M + DM)}{R\,c^2}} \quad (2)$$

where $\boldsymbol{R}$ is the impact parameter, i.e. the distance of the light ray from the centre of the cluster.

2.5 The situation is illustrated in Figure 2 below.

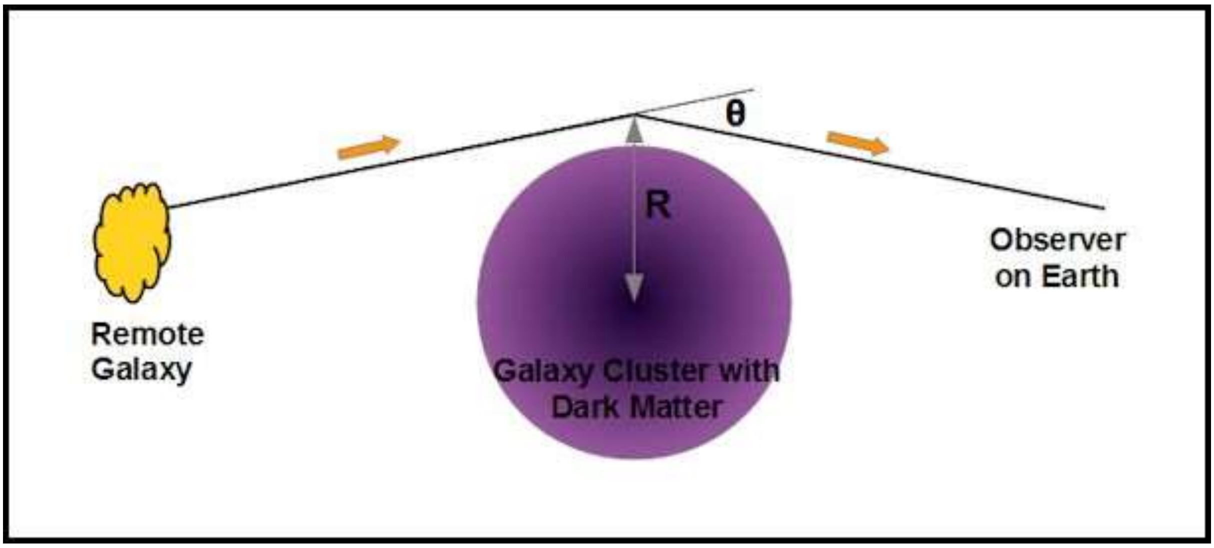

Figure 2: Illustration of the bending of light from a remote galaxy by an intervening cluster of galaxies with dark matter.

3 Gravitational lensing with energy scale variations

3.1 The effective mass of a cluster of galaxies embedded in an energy scale variation is illustrated in Figure 2 below.

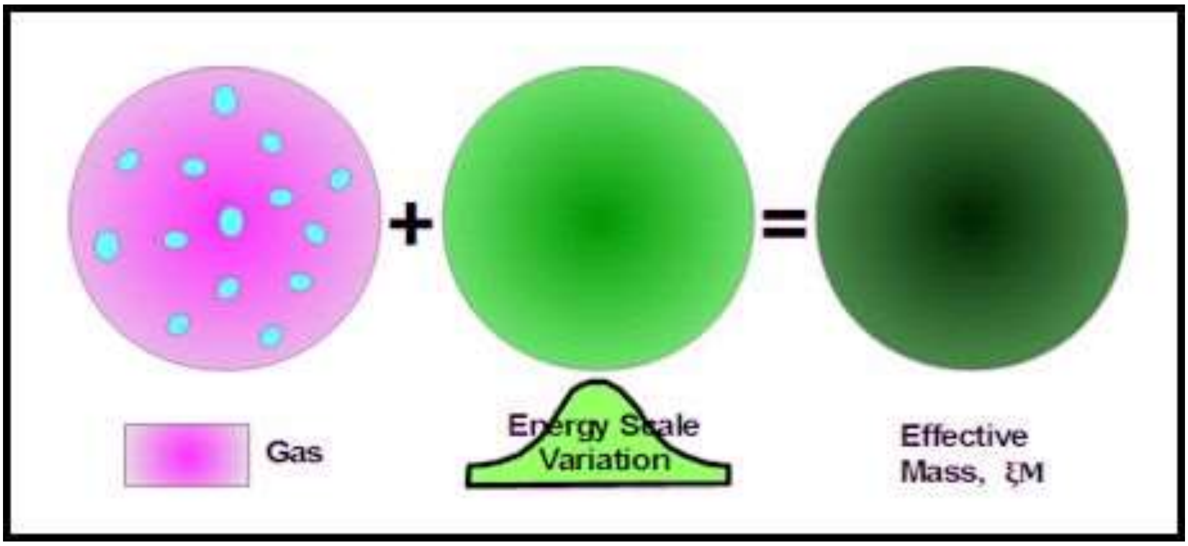

Figure 3: The effective mass of a galaxy within an energy scale variation is the product of the mass of the galaxies & gas and the ξ factor for the energy scale variation.

3.2 The effective mass, M_J, of the cluster of galaxies is

$$M_J(eff) = \xi M \tag{3}$$

where M is, as before, the mass of the gas & galaxies; ξ is the factor for the energy scale variation, as defined in JoKe1 (equation 18).

3.3 Again general relativity shows that a light ray from a remote galaxy is bent by the cluster of galaxies through an angle θ given by

$$\theta = \frac{4\, G\, M_J(eff)}{R\ c^2} = \frac{4\, G\, \xi\, M}{R\, c^2} \tag{4}$$

where R is the impact parameter, i.e. the distance of the light ray from the centre of the cluster.

3.4 The situation is illustrated in Figure 4 below.

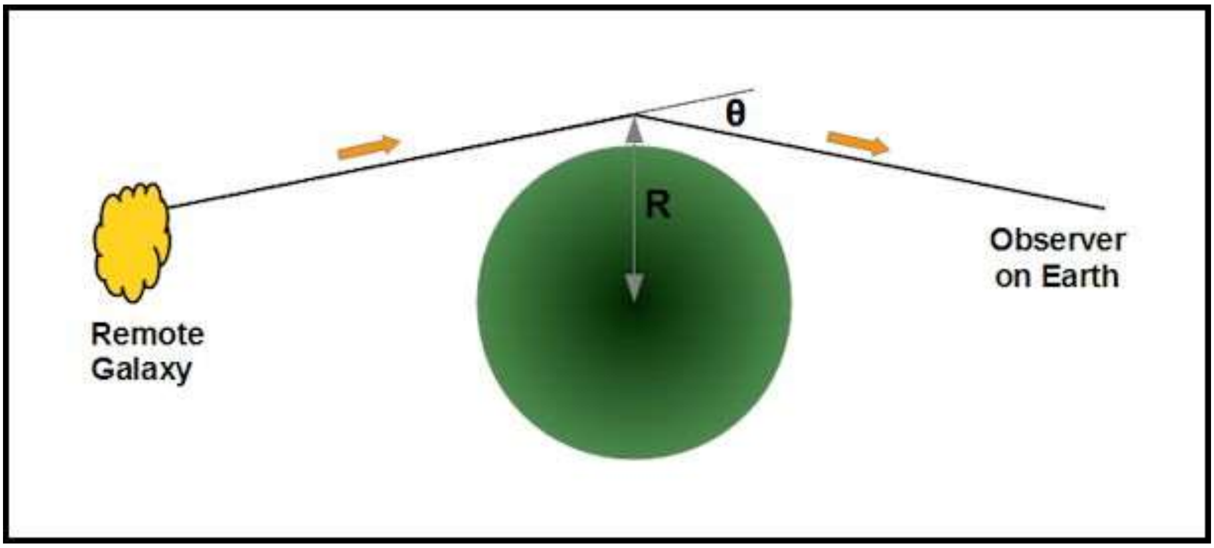

Figure 4: Illustration of the bending of light from a remote galaxy by an intervening cluster of galaxies with an energy scale variation..

4 Discussion

4.1 It is obvious that Figures 2 and 4 are essentially identical, i.e. whatever gravitational bending of light is caused by dark matter can equally well be produced by an energy scale variation.

4.2 From equations 2 and 4 it is clear that the condition for equal bending of light is simply

$$\boldsymbol{M + DM = \xi M} \tag{5}$$

which can always be satisfied.

4.3 For some clusters of galaxies it should be possible to estimate the mass in two independent ways: (a) from the peculiar velocities of the individual member galaxies and the virial theorem, and (b) from gravitational lensing. It would be interesting to compare the measurements for a dark matter solution and for an energy scale variation solution.

5 Conclusion

5.1 We apply the hypothesis of variations in the energy scale to gravitational lensing. Whenever observations of gravitation lensing are used to imply the presence of large amounts of dark matter, exactly the same observations can be used to imply the presence of an energy scale variation.

5.2 At the moment it seems that gravitational lensing is incapable of providing any tests to distinguish between the hypothesis of dark matter and the hypothesis of variations in the energy scale.

6 References

JoKe1. "On the variation of the energy scale: an alternative to dark matter". (Sep 2015). www.varensca.com

JoKe4. "On the variation of the energy scale 4: Clusters of galaxies". (Nov 2015). www.varensca.com