The nature of dark matter and a comprehensive solution

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Abstract. Dark matter has been postulated to explain the excess of gravitation in relation to Newtonian physics in the vicinity of galaxies. At present, two theories are under discussion: the assumption that undetected heavy but weakly interacting particles exist, and a modification of Newtonian gravity (MOND). Both theories are unsatisfying because they can only explain certain cases and conflict with others. Recent extended observations have now given a spectacular indication of the nature of dark matter. These observations show an identical spatial distribution of dark matter on the one hand and photons on the other hand. In the following, we will check the possibility of the solution that photons are in fact the particles that explain the phenomenon.

1. History of dark matter detection

Historically, Fritz Zwicky found in the 1930s that the galaxies in galaxy clusters are moving around each other at too high a speed in relation to their own mass. This was not compatible with Newtonian gravity. So Fritz Zwicky conjectured that there must be more matter in galaxy clusters, just that we can't see it. He called it "dunkle Materie", dark matter. This is similar for individual galaxies. The velocity of a star orbiting a galaxy depends on the total mass inside its orbit. But the stars in the outer areas of galaxies orbit the center too quickly. In addition the dependence of their speed on the distance from the galaxy does not follow Newton's law but displays a flat relationship.

Presently the physical community is discussing two theories: the assumption of heavy but weakly interacting particles or else a modification of Newtonian "dynamics" (MOND). However, both these theories only explain certain observations and are in conflict with other observations. That means that no usable theory exists in present-day physics. All existing theories for explaining this phenomenon have failed.

2. The manifestations of dark matter

2.1 Rotation of stars and galaxies

As mentioned above, this phenomenon was first observed in connection with the fast rotation of galaxies in clusters. Other well investigated cases are single stars orbiting a galaxy. The stars in the outer parts of galaxies orbit the center too quickly. In addition, the dependence of their speed on the distance from the galaxy does not follow Newton's law but displays a flat shape (see figure 1 for the galaxy NGC 3198).

This flat shape of the curve is striking. For an explanation we have to conclude, if we follow Newton's law of gravity, that the dark matter causing this behavior has a spatial distribution of $1/r^2$ in the outer region of the galaxy (where r is the distance to the center of the galaxy). And this observed motion has led physicists to conclude that there is a huge amount of invisible matter. So our physical knowledge can only account for a small portion of the matter in the universe, while the rest is completely unknown up to now.

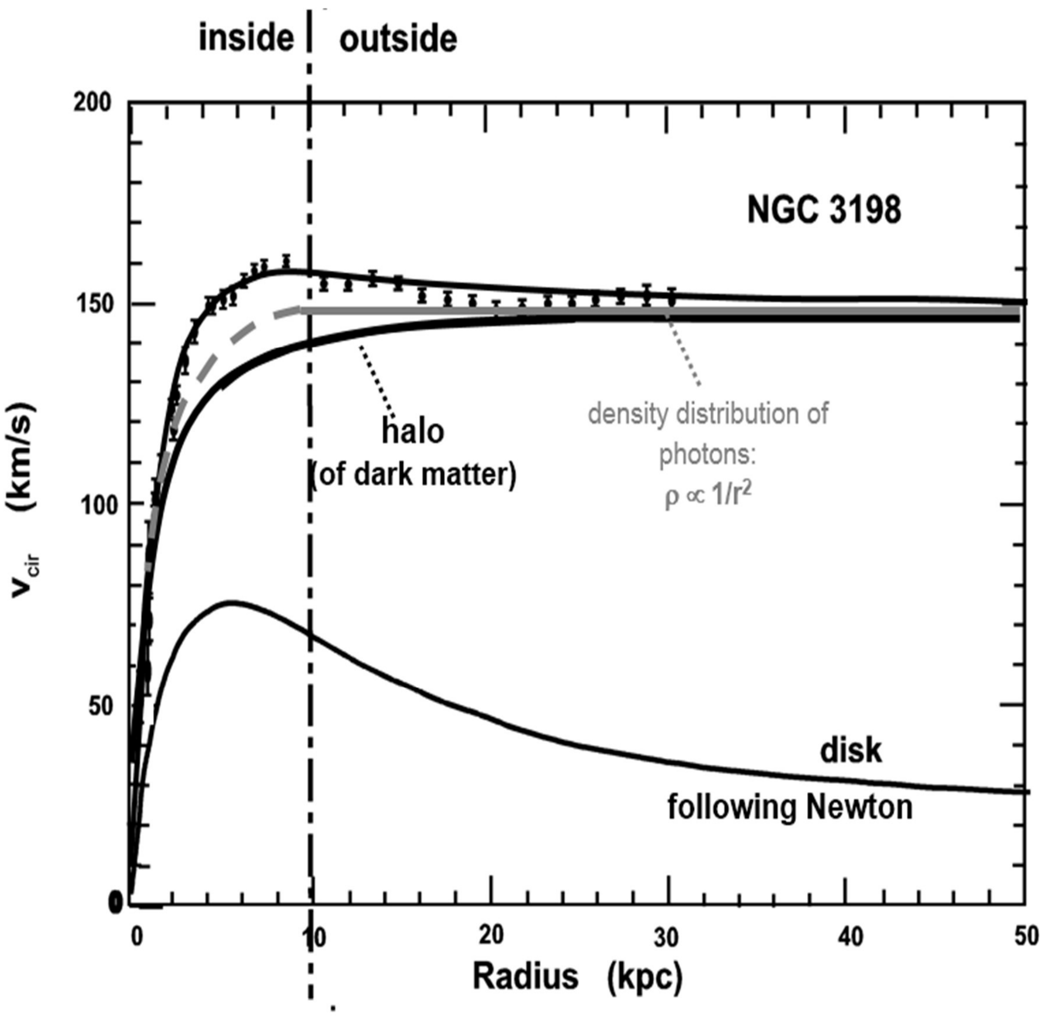

Figure 1. Rotation curve of galaxy NGC 3198

2.2 Gravitational lensing in Abell 2261

Gravitational lensing is also stronger than be explained by the masses of the lensing objects, which in general are also galaxies.

The huge galaxy cluster "Abell" A2261 has been thoroughly investigated with regard to gravitational lensing [1]. The results not only indicate a stronger gravitational field compared to the Newton prediction, but also some details of the distribution of dark matter. Figure 2 shows that at the far end, which is free of baryonic matter, the distribution of dark matter also follows the slope $1/r^2$.

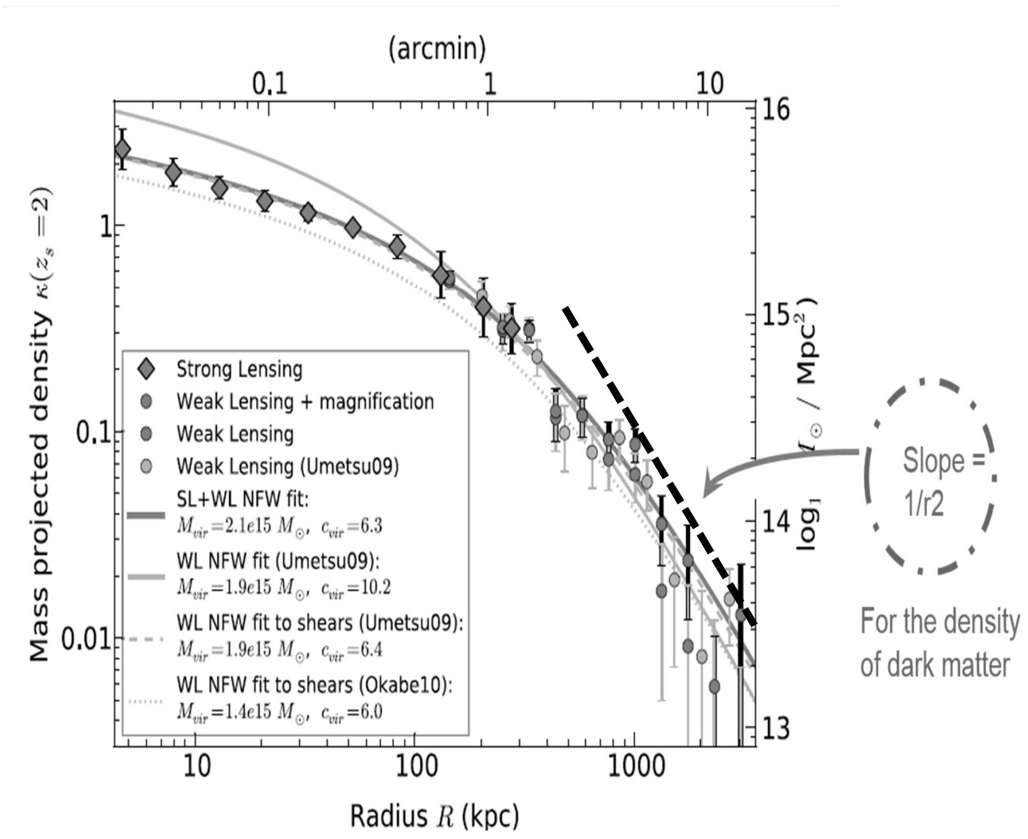

Figure 2. Gravitation graph of galaxy cluster A2261

2.3 The bullet cluster

In this situation, two galaxies have passed each other. Their distribution after the passage shows the dark matter moving in front of both clusters (figure 3). This is surprising since the assumed heavy dark matter particles should not move faster than normal baryonic matter.

2.4 Renzo's rule

Renzo's rule refers to the observation that those parts of a galaxy having a reduced luminosity display a reduced gravitational field. This can be detected in orbiting stars whose path is modified when passing along such a region.

This conflicts with the general physical understanding that dark matter should remove any correlation between the luminosity and the rotation curves.

2.5 Formation building
In the cosmological development of the universe, the growth of clusters forming stars and galaxies has been faster that can be explained by baryonic matter. Again, the conclusion is that there must have been more gravitational than visible matter around to cause this rate of growth.

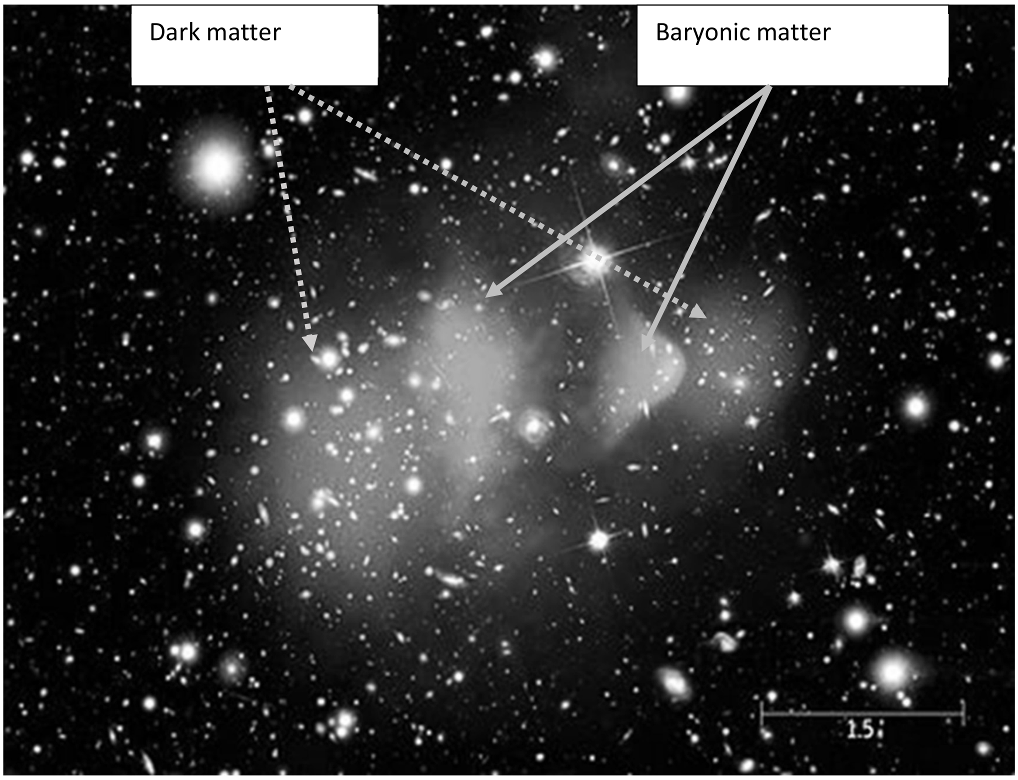

Figure 3. The bullet cluster.

3. Present Theories
There are two theories currently under discussion to explain this behavior, the assumption of specific particles and the "Modified Newton Dynamics" (MOND)

3.1 Dark matter particles
3.1.1 The assumed nature of dark particles
This approach assumes that dark matter is made up of a type of particle which does not interact with known matter except through gravity. From the observed gravitational phenomena it is concluded that these particles make up 80% of the matter in our universe. This means that our physical knowledge covers only 20% of the matter in our world.

3.1.2 Observations explained by dark matter particles
The existence of such particles could explain the rotation processes. They can in principle also explain the rapid building of structure if an appropriate distribution of these particle is assumed.

3.1.3 The problems with dark matter particles
The assumption of such particles is in conflict with certain observations.

The present model of dark matter assumes that the particles are generated in the center of a galaxy. Their density should therefore be highest in the center. However, observations indicate a flat distribution there.

Another problem is the bullet cluster. As stated above, it is not understandable that the dark matter portion leaves the cluster ahead of the baryonic matter.

Also Renzo's rule, which describes the dependency of the gravitational field on the luminosity of a region of a galaxy, is unexplained and incompatible with the assumption of specific particles.

A specific problem with this approach is the flat shape of the rotation curves. Their shape calls for a spatial distribution of $1/r^2$ around a galaxy, for which no argument is presently available.

And a serious objection to such particles is the fact that they have not been detected. During the last two decades a lot of effort has been invested into detecting them. According to our present understanding, they should belong to the class of supersymmetric particles. So there was some hope that signs of them would be found at the LHC accelerator at CERN. However, despite every effort, not the faintest hint of the existence of such particles has been seen. Also the search for them by investigating cosmic particles has been without any result.

3.2 Modified Newtonian dynamics (MOND)
The approach of modified Newtonian dynamics assumes that Newton's law of gravity is altered in a specific way.

3.2.1 The basic idea of MOND
The main goal of this approach is to explain the height and the flat shape of the rotation curves. The assumption is that the $1/r^2$ rule of Newtonian gravity changes at a certain distance to a 1/r rule. The flat shape of the rotation curve can be explained if the transition from $1/r^2$ to 1/r occurs at the rim of the galaxy. This point of transition is a necessary adaption, which is however not based on a specific physical argument.

3.2.2 The problems with MOND
One problem is that this will not work precisely for galaxies of different radii as the assumed transition is associated with a specific distance. And so it also fails for the mutual rotation of galaxies in a cluster. Furthermore it cannot easily explain structure building where a large range of distances exists between objects. Another problem is the increased gravitational lensing, which is also observed for a large range of distances.

4. The photon solution
4.1 The approach
The similarity between the distribution of dark matter and that of photons is an obvious and striking fact. And more than that: for the flat shape of these curves, the similarity between the distributions applies with a precision of a few percent. So, what can we conclude?

At first glance, one might suspect that there is a strict pairing between dark matter particles and photons. This could work statically. On the other hand, though, there is a strong conflict between the fact that photons always move at c whereas massive particles cannot.

The ultimate implication is that photons are in fact the very particles in question. This follows logically if every particle contributes equally to the gravitational field. And this is more than simply an assumption. If we follow Lorentz's approach rather than that of Einstein in explaining gravity, this result is plausible (see below).

The assumption that photons themselves are the particles required is on the one hand a huge step for present-day physics, since it contradicts our long-time understanding of gravity. On the other hand, the extent to which this assumption solves all the questions in this area that have been unanswered is fascinating.

4.2 A historical view of gravity
Why do we think that mass is the origin of gravity? Let's look back in history.

For Newton it was obvious that gravity depends on some kind of quantity of matter. What quantity was conceivable for him? The volume of an object could not be the cause; this was easily understandable. And the existence of elementary particles was far outside the reach of Newton's knowledge, so there was no point in him relating gravity to them. Mass was therefore the only available way of quantifying matter as the origin of gravity for a physicist in his time.

There was also no better background for Einstein when he took mass as the origin of gravity. So, when Einstein developed general relativity, he adopted this assumption made by Newton.

Why did Einstein not look for an independent view? It seems that Einstein initially attempted to do so. In 1911, he published a paper [2] in which he started to draw conclusions from the fact that the speed of light is reduced in a gravitational field. He deduced this reduction by considering the energetic state of a light-like particle moving in a field. That seemed plausible; however it was not correct. It seems that Einstein noticed that he had achieved results that were not physically plausible, and therefore stopped pursuing this path and returned to the view of Newton, relating gravity to mass – or in terms of his special relativity – to energy.

It is possible to continue the path pursued by Einstein. His error with respect to the dependency of the speed of light on gravity has to be avoided, and our present understanding of particle physics needs to be included. We know that the reduction in c depends on the direction of a light-like particle with respect to the source of gravity. This allows a functional model to be deduced, which treats gravity as a universal feature of an elementary particle that does not depend on mass or energy. This leads to the conclusion about the similarity of dark matter and photons.

4.3 Quantitative results
We have seen that the spatial distribution of the gravitational field caused by dark matter is identical to the distribution of photons in the regions investigated. This we have taken as an indication that photons are in fact dark matter particles.

There is an even stronger argument than this: a quantitative determination of the rotation curve of a galaxy is an example. We will here check the hypothesis that every elementary particle contributes in to the gravitational field to the same extend independently of its mass. For this we use the insight that the proton and the neutron are composed of 3 elementary particles and that the electron is 1 elementary particle. The photon is taken here also as 1 elementary particle. (Historically Louis de Broglie once suspected that it might be appropriate to view it as composed of 2. This is not used in this calculation.)

According to this viewpoint and to the published data, the galaxy NGC 3198 contains $3*10^{67}$ elementary particles. On the other hand it contains $4.4*10^{67}$ photons as can be concluded from its luminosity. Both numbers are comparable in terms of the available accuracy. If we look at the graphical presentation (figure 1) we see that both particle types contribute equally to the gravitational field at the rim of the galaxy, whereas outside the galaxy photons dominate strongly as the cause of the gravitational field.

The conclusion is that until the border of the galaxy the numbers of baryonic particles and of photons are comparable. So, if gravity is taken as being caused not by mass but similarly by every elementary particle, both will generate a comparable gravitational field at this distance, in this case at the rim of the galaxy. This conforms to the figure 1. From this point, beyond the baryonic body of the galaxy, the photonic field dominates over the baryonic one as shown by the flat shape of the rotation curves.

This looks like an obvious proof that the assumption of photons as dark matter particles is supported by the rotation curve.

5. Summary

We have seen strong arguments that the mysterious phenomenon of dark matter is caused by photons. The background is that gravity is not caused by mass or energy, but by elementary particles (fermions and photons), which contribute equally to the gravitational field.

This assumption yields quantitative results that prove this photonic dark matter and is – on the basis of the discussed assumptions – in agreement with all observations.

References

[1] CLASH 2012 Precise new constraints on the mass profile of the galaxy cluster A2261 *The Astrophysical Journal* 757 **1** 22
[2] Einstein A 1911 Über den einfluss der schwerkraft auf die ausbreitung des lichtes (On the influence of gravitation on the propagation of light); *Annalen der Physik* 35 898-908