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On the Nature of Dark Matter

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Abstract.

Dark matter is observed enveloping massive black holes and leading to a uniform rotation of the galaxy around the black hole over most of the galaxy cross-section. It is stipulated that dark matter originates from the central massive black hole. By the fact that the speed of light is close to infinity this dark matter through the Heisenberg Uncertainty relation appear outside the black hole as virtual particles leading to the correct radial distribution of the density to cause the uniform rotation observed for the galaxies.

Keywords: Dark Matter, Heisenberg Uncertainty, black hole, virtual particles.

Introduction

There are two competing mechanisms in deciding the size of the objects around us: one is the speed of light: fundamental particles are proportional in size to the speed of light and the second is the scale length of the universe determined by the so-called expansion of the universe. It was shown in [1, 2] that the speed of light is not a constant. And that although it will always have for any observer a constant value, it may well vary in time. This is possible because any measurement of the speed of light is basically flawed due to quantum-mechanical properties of matter (the fine-structure constant). Also it was shown [3] that an acceleration of the expansion is an artefact of the measurements due to a slowing down of all clocks in sync with the spatial expansion.

All those effects above are assumed at present by most people not to occur: the speed of light is taken to be a constant and the standard clocks are assumed to be constant too. (How do we know?).

Also in [3] it was shown that a changing speed of light in sync (this is $\gamma=-½$ in [3]) with the expansion of space-time leads to an expansion that is consistent with observation on the sizes of distant galaxies [4].

This then leads to the following postulation: The speed of light is simply proportional to the density of space-time. This then helps to understand what happens when matter falls into black-holes [5] and therefore liberates space-time to relax or expand into.

Inside black-holes the speed of light is close to infinity and maybe a function of the mass of the black-hole. Also in the beginning of time the speed of light is also close to infinity and diminishing over time with the “expansion” of the initially very dense universe. This is for our clock only around 14 billion years ago. So there must be similar conditions in these very different times and places.

Black Holes and Galaxies

Both in the black-holes now and at the start of the universe all fundamental particles are very big and extend over most of space. They are virtually everywhere, leading to a very uniform space. Such an uniformity has been observed in the Cosmic Microwave background radiation and could not be explained in the case of a constant speed of light unless a very rapid inflation took place. But it can be explained by a speed of light being close to infinity.

A similar "uniformity" should exist around black-holes, since the source of the "virtual matter" is a point source. There should exist a spherical symmetry of this matter. So if Dark Matter is related to this "virtual matter" it should have a spherical symmetry. In quite a few galaxies it has been observed that the fraction of Dark Matter is a large portion of the total matter [6], [7], [8]. The density of the matter can be deduced from the measured rotational velocities of the stars of each galaxy. This is subjected to the actual configuration of the galaxy whether is spherical, elliptical or a disk configuration. Of course using Newton's law of gravitation the total mass of each galaxy is fixed by its velocity radial profile. Following Sofue, there are five components assumed to be important in this balance [8]:

- the central bulge matter: stars and planets
- the matter in the disk: stars and planets
- the halo matter: a blanket of neutral gasses and dust surrounding each galaxy
- the unknown "Dark Matter", that forms a the most important part of the total matter [6,8]
- a central "super-massive" Black Hole.

The mass of the central black hole is usually determined by the rotation of stars close to the centre of the galaxies and are often allocated a mass of several million solar masses. This of course is very wrong when dark matter can be attributed to the central black hole: the central black hole will then have a mass of several trillion solar masses. However the stars that rotate around the black hole close to the centre only see a very small fraction of the total mass of the black hole.

The Andromeda Galaxy M31.

This galaxy has been studied by many over quite a time [6],[11]. Because of its proximity to earth a wealth of data has been produced. Fig.1 shows the measured velocity radial profile over most of its radial extend of 120 light years.

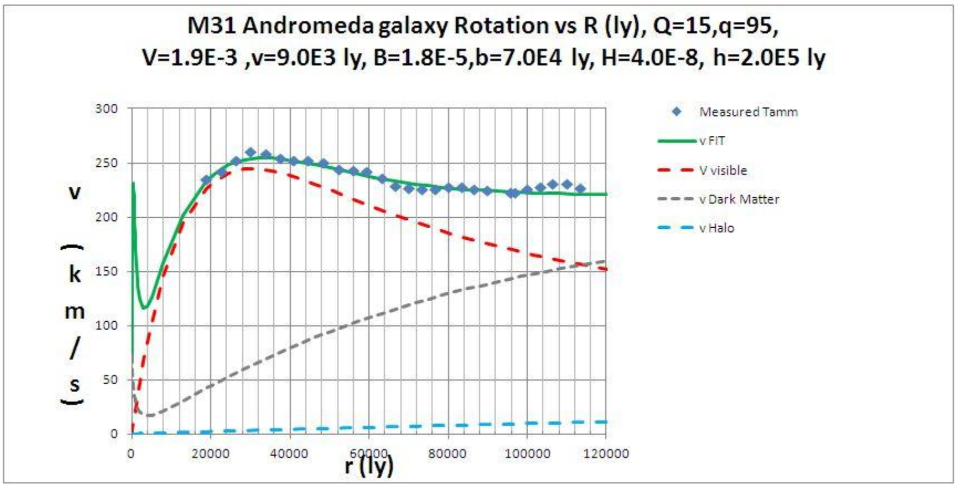

Fig.1 The error bars on the measured velocities are around 10% or less, especially in the central region [6]. A density function with four pair of parameters :(Q,q), (V,v), (B,b) and (H,h) have been applied. The central bulge data is not visible here.

The density function is : $\rho(r) = Qe^{-r/q} + Ve^{-r/v} + Be^{-r/b} + He^{-r/h}$ (1)

The first pair the central bulge pair is chosen to match the bulge parameters (see further on for data at radii less than 3000 ly). The visible matter in the disk related (V, v) pair is required to get the match with the velocities at the central disk part of the galaxy. The value of v is chosen to match the peak in the rotation curve at 30000 ly. The third pair : the dark matter related pair (B, b) is chosen in order to get the correct rotation speed in the middle section (between 50000 and 80000 ly) and the fourth halo related pair (H, h) is required to set the speed at the very large radii (between 100000 ly and 1000000 ly).

It is clear that there is a fairly large degree of freedom to choose the different parameters, however that changes if one wants to match the complete radial profile of the rotation of the stars and the estimates of halo mass and the like.

For this example given in this paper, one gets the following gross features:

The total mass is: 2.2 10^{42} kg, the mass of the visible matter is: 3.9 10^{41} kg, the dark matter is: 1.8 10^{42} kg and the halo matter: 9.1 10^{40} kg. This puts the ratio of the dark matter to the sum of visible and dark matter close to the published 80%. The halo matter is only important outside the radius of 300000 ly.

It is not the intention here to make another detailed study of the Andromeda galaxy but actually to analyse the behaviour of the dark matter and it possible relation to the central black hole. It is then important to get these mass ratios roughly correct.

For a spherical symmetric galaxy one can get the densities of the various components as function of radius [8]. So if the dark matter is spherically symmetric one obtains the correct density. For the visible matter that is not the case however it is possible to correct for the mapping of spherical geometry to disk/cylindrical symmetry. It is interesting that a density profile in spherical symmetry that scales as $1/r^2$ becomes a profile that scales as 1/r for radii greater than half the height of the disk.

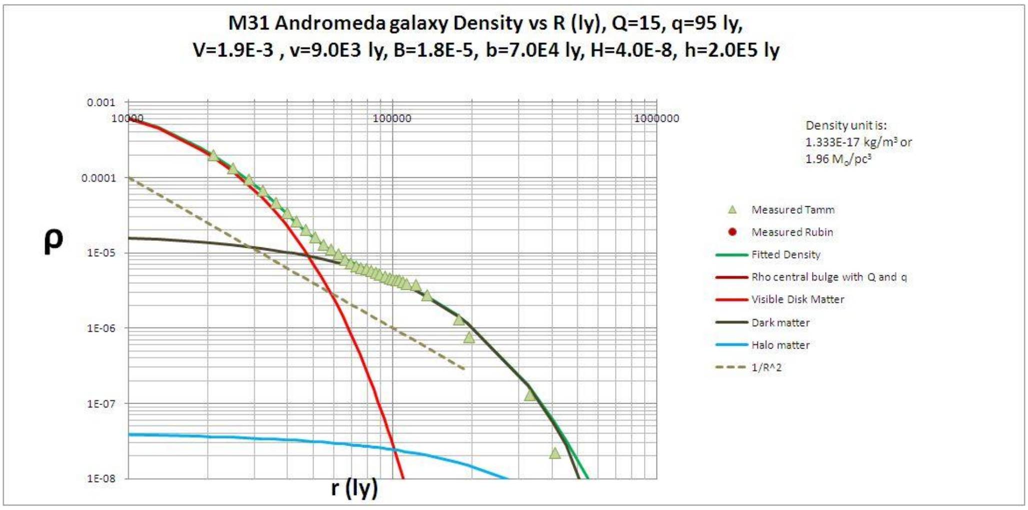

Fig.2. This figure shows the measured and fitted density as a function of radius. The fitted density is used to calculate the fitted velocity radial profile of fig.1. This velocity is an incomplete Gamma function [9] of the density for spherical geometry.

$$rv^2 = \left(Qq^3 f(r/q) + Vv^3 f(r/v) + Bb^3 f\left(r/b\right) + Hh^3 f(r/h)\right) \quad (2)$$

with $$f(x) = 2 - (2 + x(2 + x))e^{-x} \quad (3)$$

In the part where the dark matter is dominant at radii greater than 40000 ly, one can notice that the density scales close to $1/r^2$, perhaps not surprising, since the rotation velocity is close to being constant. However that is also the scaling expected from the Heisenberg uncertainty principle with the speed of light close to infinity as will be shown further on.

The actual size of a Black Hole

Each Black hole has a radius where for particles and light reaching that position there will be no escape, this is the event horizon [10]. It is called the Schwarzschild radius: $R=2GM/c^2$. Since the gravitational constant scales with c^3 [2], it means that the Schwarzschild radius scales with 1/c and so decreases with increasing speed of light.

Less room for the particles to squeeze into were it not for the Heisenberg Uncertainty Principle which allows particles to be outside of their confined location for a finite amount of time. The lighter particle will go further than the heavier particle. This determines the density radial profile around the black hole: the dark matter will have a much greater density close to the black hole.

The Heisenberg Uncertainty Principle is: $$\Delta E.\Delta t = h \quad (4)$$

with *h* the Planck constant. A fairly good idea of the "size" of elementary particles can be obtained by replacing Δt with r/c and ΔE with $m.c^2$, in which *m* the rest mass of the particle in question and *c* is the value of the speed of light here today. For instance for an electron, one obtains the Compton wavelength and for a proton, an approximate size of $1.3x10^{-15}$ m in this part of the universe.

However, when the speed of light increases to close to infinity, those sizes become huge and comparable to dimensions in the galaxies. The Dark matter parameter b of 70000 ly implies that the speed of light inside the central black hole of the Andromeda galaxy should be:

$$c = \frac{\Delta E}{h.b} \quad (5)$$

For the electron mass this yields c = $9x10^{23}$ m/s, which is considerable more than the present speed of light value in our part of the universe. And it implies that the e-folding radius of the proton or neutron is at r = 38 ly, that of the helium nucleus or 4 neutrons and protons at r = 9.5 ly and finally that of the plutonium or a 289 neutrons and protons nucleus at r = 0.13 ly. It should be pointed out that the dark matter density of the various elements adds up so that a considerable density near the centre of the galaxy, which is in agreement with the observations in our galaxy the Milky Way [8,12]. The strong nuclear force is capable to glue protons and neutrons together and must be the main component in making a neutron star, where it glues the neutrons together. It is believed that this is also the case inside black holes. Electrons and positrons do not possess this property and therefore will not bunch together to build up towards the black hole. But it is thought that neutrons or their building blocks the quarks can bunch up as virtual particles and determine the density radial profile of the dark matter.

So there will be two branches of dark matter: one branch related to light particles like electrons and positrons and a second branch towards the core of the galaxy the heavy particle branch related to neutrons and quarks, which will cause a build up of the density towards the core.

The total dark matter density will be then:

$$\rho(r) = B_e\, e^{\frac{-r}{b}} + B_n \sum_{i=1}^{N} i\, e^{\frac{i m_p r}{m_e b}} \quad (6)$$

In good approximation the sum for the dark matter density can be written as an integral in particular for smaller values of r/b and one gets an incomplete gamma function that works out to be for large N:

$$\rho(r) = B_e e^{\frac{-r}{b}} + B_n \left(\frac{m_e}{m_p}\right)^2 \frac{b^2}{r^2} \left(1 + \frac{m_p r}{m_e b}\right) e^{\frac{-m_p r}{m_e b}} \tag{7}$$

It is believed that the electron mass represents the light virtual particles and the proton mass the glued together virtual neutrons or quarks. The ratio of the central densities B_e and B_n will be depend on the quantities of light particles: electrons and positrons and the number of heavy particles: neutrons or quarks present in the black hole.

It is very interesting to notice that the heavy particle branch has a built in $1/r^2$ dependence leading to a constant rotation velocity for stars on circular orbits.

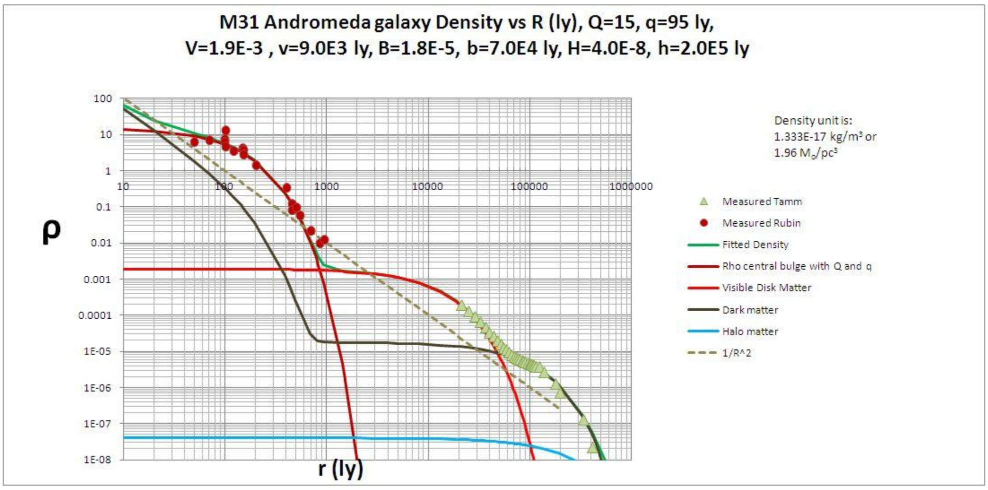

Fig.3. The density radial profile based on the observed rotation and obtained from the model with its 4 components: bulge, visible-disk, dark and halo matter as equation (1). The dark matter has now two components as equation (7).

The measured data are derived from the measured velocities [6, 11] using the derivative of the fitted velocity to derive the density. This is correct for spherical symmetry and if the derivative is close to zero. Densities obtained in this way are for spherical symmetry, but can be corrected for disk geometry.

One can expect the observed rotation in fig. 4 to go to zero when passing through the centre to match with the opposing rotation on the other side because these measurements have a finite spatial resolution (a resolution of 0.001'' corresponds to ~100 ly). Overall a good fit is obtained with all the data.

The following observations can be made:

- It can be seen that at r= 100 ly the density has a value of 0.6 $M_\odot/pc^3$ (0.3 in the local units in the figure). This leads to a value of $4x10^9$ $M_\odot/pc^3$ at a radius of 0.035 pc. (1 pc = 3.26 ly, one solar mass: 1 $M_\odot$ = $1.98847x10^{30}$ kg). In our galaxy the density of the dark matter at that radius has been estimated to be $6.5x10^9$ $M_\odot/pc^3$ [12],[13]. So the heavy particle branch of the dark matter can easily yields high densities in the core of the galaxy. The Milky Way has roughly the same size as the Andromeda nebula.
- If there is a constant rotation velocity in the central bulk , it can be explained by the particular density profile created by the heavy particle branch of the dark matter.

- The dip in the rotation around a few thousand light-years followed by a rise is made possible by the transition of the heavy particle branch to the light particle branch of the dark matter originating from the massive central black hole.
- Further studies on the distribution of dark matter will be required. For example : a Gaussian distribution instead of the exponential decay one or another type of Einasto profile [6]. The exponential and Gaussian profiles in any case are part of Einasto class of profiles. But the exponential profiles have been used successfully by Sofue [8] for the rotation curve for the Milky Way.
- To get a reasonable match to the data, the mass ratio of heavy particle over the light particle is close to 918. This is the ratio over the weight of a neutron over a positron/electron pair. The ratio of B_n/B_e is 50000. This suggests that neutrons are the dominant species inside the black hole. Of course this has to be taken with some extreme caution.
- Finally the density profiles shown are again resulting in the correct masses and agree closely to the values in the literature. Total matter $M_{tot} = 2.2x10^{42}$ kg, total visible matter $M_{vis} = 3.9x10^{41}$ kg, dark matter $M_{DM} = 1.8x10^{42}$ kg and halo matter $M_{Halo} = 9.1x10^{40}$ kg. Dark matter is close to 80% of the total matter.

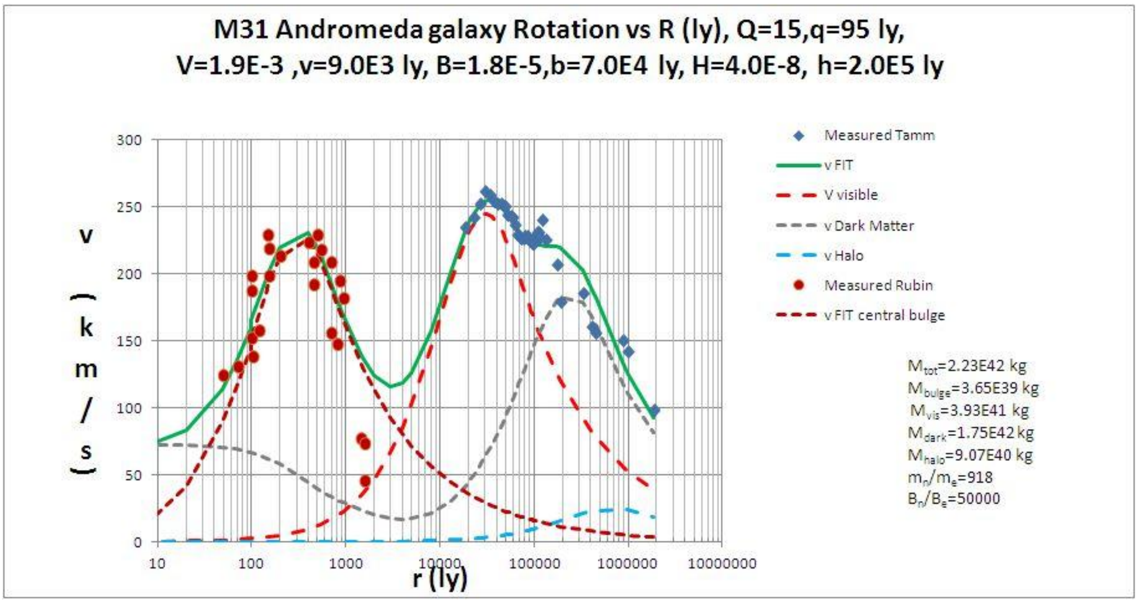

Fig.4. The rotation curve on semi-log scale over most of the Andromeda cross-section. The error bars of the measurements are small (< 10%) from 10000 to 100000 ly but for larger radii are substantial.

It can be concluded that dark matter originates from the central black hole and that this black hole is super massive and contains $8.6x10^{11}$ solar masses. That means there are as many solar masses in the central black hole as there are stars in the Andromeda galaxy.

It was suggested previously that the speed of light might be dependent on the size of the black hole. Is there actually any evidence for that? It seems there is. Our galaxy the Milky Way was analysed and gave similar results as the Andromeda galaxy, however there is also good observational data of a neighbouring dwarf galaxy M33, a much smaller galaxy.

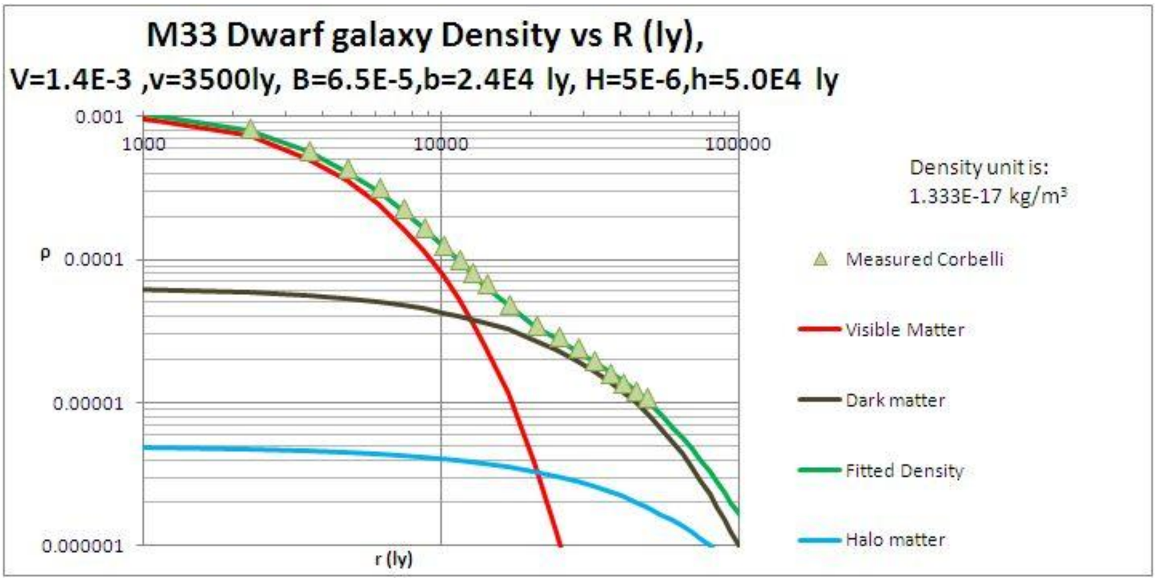

Fig.5. Density profiles derived from the rotation radial profile of the M33 Dwarf Galaxy

The rotation data is from Corbelli et al. [7]. There are remarkable differences with the rotation profile of the M31 galaxy: the Andromeda nebula. The first one is that the heavy particle branch of the dark matter, which played an important role in the M31 galaxy is hardly present here in the M33 galaxy. The second one is that all e-folding lengths: v, b and h are about 30% of the values in the M31 galaxy. That should mean that the speed of light in the central black hole is also 30% of the value in the M31 central black hole galaxy. Further studies are required to determine the detailed dependence of the speed of light on the mass of black hole. Please note that the dark matter in M33 is about 15% of that of the M31 galaxy. Please note that the central bulge (Q,q) has been omitted in this analysis.

Discussion

There are still many issues to be solved before a full understanding of dark matter can be obtained.

It is not the intention of this paper to deal with these issues, but to make a first step away from the dogmatic physics assumption that the speed of light is constant. The restrictions that that assumption has made on our understanding of the world around us are enormous. We cannot understand dark matter for instance or the uniformity of the Microwave background radiation at the beginning of time if we keep the speed of light a constant. The assumption that the speed of light is a constant was based on the excellent measurements by Michelson, however he could not have known at that time that a fine-structure constant exists, which invalidates his measurements in a fundamental way.

It is overdue that we as a physics community realise this and accept the real world and not hang on an assumption of the constancy of the speed of light that is clearly wrong.

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