A Dark Matter halo for every elementary particle in a Zwicky de Broglie synthesis

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Abstract

In this paper I introduce a new Dark matter hypothesis. I assume that every elementary particle has a Dark Matter halo. Given a rest mass m_0 at $r = 0$, it will have an additional spherical Dark Matter halo containing an extra mass in the sphere with radius r as $m_{DM} = \frac{r}{R_{DM}} m_0$ with the constant Dark Matter radius R_{DM} having a measured value somewhere in between 10 kpc and 20 kpc, so approximately once or twice the radius of an average luminous galaxy. The total rest mass of an elementary particle contained within a sphere with radius r will then be given by $m = m_0 + \frac{r}{R_{DM}} m_0$. Inside a sphere of radius $R_{DM} \approx 15kpc$, the total mass of an elementary particle at rest wil be twice the original rest mass at $r = 0$. The correlated mass density is $\rho_{DM} = \frac{m_0}{4\pi r^2 R_{DM}}$. The new Newtonian gravitational energy will be $U_g = -\frac{GM_0 m_0}{r} - \frac{GM_0 m_0}{R_{DM}}$ resulting in an unchanged Newtonian force of gravity but with a correct galaxy velocity rotation curve, due to the still applicable virial energy theorem. The axiom is theory of gravity neutral because it is a statement about mass and mass density distribution only. But it implies that WIMP's and the like aren't necessary to explain Dark Matter; my proposal isn't WIMP neutral. Beyond the scale of galaxy clusters the model becomes problematic due to an extra halo halo interaction term becoming active at that scale.

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I. PRINCIPLES OF THE DE BROGLIE MATTER WAVES OF REST MASSES

Modern post-orbital or post-"Bohr-Sommerfeld" wave quantum mechanics began with de Broglie's hypothesis of the existence of matter waves connected to particles with inertial mass [1]. De Broglie started with the assumption that every quantum of energy U should be connected to a frequency ν according to $U = h\nu$ with h as Planck's constant [2],[3]. Because he assumed every quantum of energy to have an inertial mass m_o and an inertial energy $U_0 = m_0c^2$ in its rest-system, he postulated $h\nu_0 = m_0c^2$. De Broglie didn't restrict himself to one particular particle but considered a material moving object in general [2]. This object could be a photon (an atom of light), an electron, an atom or any other quantum of inertial energy. If this particle moved, the inertial energy and the associated frequency increased as $\nu_i = \gamma\nu_0$. De Broglie assumed the inertial energy of the moving particle to behave as a wave-like phenomenon, so the inertial wave associated with a moving particle not only had a frequency ν_i but also a wave-length λ_i, analogous to the fact that any inertial energy U_i of a moving particle had a momentum p_i associated to it according to the relation $p = h/\lambda$. De Broglie never could specify what exactly oscillated in relation to m_0 with frequency ν and wavelength λ, but using these relations physicists could make major progress in theory and experiments. De Broglie's ideas regarding matter waves surrounding moving masses proved useful in the further development of quantum mechanics and the success of such chimeras is what finally counts in science, regardless of the ontological status of postulated ideas. Discussions regarding experimental reality of the frequency of rest masses is ongoing [4], [5], [6] .

II. THE PROBLEMS FOR WHICH THE DARK MATTER HALO OF GALAXIES WAS A SOLUTION

In 1933 Dark Matter was mentioned as "dunkle Materie" in a paper by Zwicky. Fritz Zwicky was studying the Coma Cluster of galaxies and found that his calculations for orbital acceleration and stellar mass within it was off by a large factor. He concluded that there should be a much greater density of dark matter within the cluster than there was luminous matter. Zwicky concluded that this constituted an unsolved problem [7]. In 1937 Zwicky regarded his study on the Coma Cluster a test of Newton's law of gravity on the largest

cosmological scale possible, by applying the virial theorem on a cluster of galaxies. He also mentioned in his 1937 paper the possibility to test the virial theorem by applying it to the rotational velocities of the individual stars in the separate galaxies. But he concluded that this was technologically out of reach [8].

The breakthrough research of Rubin and Ford around 1970-1975 established beyond doubt the outer rotational velocity curves of individual galaxies, which turned out to be flat [9]. This was in conflict with velocity curves that resulted from the application of the virial theorem to the luminous mass of these galaxies. Rubin and Ford cited colleagues who suggested the existence of a large galactic halo of dark matter. In a 1980 paper presenting further research they concluded that the form of the rotation curves implied that significant non-luminous mass should be located at large distances beyond the optical galaxy. The total mass of a galaxy should, for large distances, increase at least as fast as the distance from the center [9].

The third major evidence for Dark Matter is the gravitational lensing effect of clusters of galaxies. The mass of stars and hot gas in clusters who collectively act as a gravitational lens is too small to bend the light from the background galaxies so much. A large density of dark matter in the center of these cluster is needed to explain the strength of the observed lensing effects.

For our paper, the galaxy rotation curve results are most relevant. All three mentioned astrophysical observations use the hypothesis of a galactic Dark Matter halo that extends far beyond the luminous part of the galaxies in order to explain the results of measurements. But where the first two effects relate to Newtonian gravity, gravitational lensing directly involves Einstein's General Relativity. Our hypothesis will focus on the Newtonian virial theorem.

III. THE DARK MATTER HALO AS A PROBLEM THAT HAS TO BE SOLVED

Many solutions to the Dark Matter observations have been proposed. All these solutions create their own problems and scientific consensus is no where in sight.

The major problem with the Dark Matter elementary particle hypothesis is that they cannot be found. The search for the elementary particle constituting Dark Matter is in process to mimic the search for the ether around 1900. Some researchers even mention

looking for a Dark Matter wind, that should vary with the seasons.

A smaller problem is that the Dark Matter density around the sun should be considerable and have possible tiny effects on the orbits of our planets. However, no deviations from Newtonian gravity have been found.

Interesting is the fact that a link has been established between the amount of luminous matter in a galaxy and the density of the Dark Matter in the halo. And the density of Dark Matter that could cause a flat rotation velocity curve has to fall of as the inverse of the square of the radius. The inverse square law indicates that the central luminous galaxy might function as a source of the Dark Matter.

Some solutions have tried to explain the astronomical observations by correcting the relevant theories of gravity instead of postulating Dark Matter. These solutions have problems of their own. MOND is a non-relativistic ad-hoc correction of Newtons force of gravity, whereas gravitational lensing is a GR phenomenon. GR in turn is specifically designed to correspond to Newtons theory in the low field domain and that is exactly the galaxy and galaxy cluster virial theorem area. The theorem that is in trouble.

From a recent paper by Koopmans et.al. we quote:

> In both spiral and elliptical galaxies with prominent baryonic components, there appears to be a conspiracy between dark-matter and baryons, leading to a nearly universal total mass distribution out to the largest measured radii that is very close to isothermal (i.e. $\rho \sim r^{-2}$), with only a small intrinsic scatter between systems. [11]

This is a key motivation for our proposed axiom as it is presented in the next section. The observation in the quote indicates towards some kind of a source like connection between baryons and their Dark Matter halo.

IV. THE DARK MATTER HALO AS AN AXIOM OF ELEMENTARY PARTICLE COSMOLOGY

We will try to transform the unsolved problem regarding the constitution of the Dark Matter halo into an axiom. So instead of us working on the problem we try to let the problem work for us. In the following we present our proposed model.

Given a rest mass m_0 at $r = 0$, it will have an additional spherical Dark Matter halo containing an extra mass in the sphere with radius r as

$$m_{DM} = \frac{r}{R_{DM}} m_0 \tag{1}$$

with the constant Dark Matter radius R_{DM} having a constant value somewhere in between 10 kpc and 20 kpc, so approximately once or twice the radius of an average luminous galaxy. The total rest mass of an elementary particle contained within a sphere with radius r will then be given by

$$m = m_0 + m_{DM} = m_0 + \frac{r}{R_{DM}} m_0 = m_0 \left(1 + \frac{r}{R_{DM}}\right). \tag{2}$$

The total mass of an elementary particle at rest inside a sphere of radius R_{DM} wil be twice the original rest mass at $r = 0$. Disturbances in the elementary Dark Matter halo due to changes in position and momentum at $r = 0$ will travel with matter wave velocity through the halo, with

$$v_{wave} = \frac{c^2}{v_{particle}} \tag{3}$$

If the elementary particle has velocity zero, the disturbances at the source can travel instantaneously through the entire halo. The DM halo functions as a medium for the de Broglie matter waves, it is the halo that vibrates when matter waves packages pass by. This directly implies that the halo has local Born-interpretation probability-density properties.

Particles that will be kicked out of an original $r = 0, p = 0$ position and momentum and acquire a velocity approaching c will have a matter wave velocity approaching c from above and there will be a considerable delay regarding the Dark Matter halo adjustment to the new situation of the source particle. Considerable has to be interpreted as on galactic travel and time scales with $R_{DM} \approx 50.000ly$. In such circumstances, large retardation effects should be expected, diluting the conspiracy between dark-matter and baryons on cosmic scales. The identification of the Dark Matter halo with the de Broglie matter wave medium is necessary in order to assures our proposal to be in full accordance with Special Relativity and pre-spin Wave Quantum Mechanics. Our theory is a Relativistic Quantum Gravity without spin.

The elementary particle Dark Matter halo mass content has been derived from a mass density that is inversely proportional to $4\pi r^2$. So the mass density of the halo drops of or dilutes at the surface of an ever larger sphere in the same way that all classical central

sources do. We define a Dark Matter halo mass density as

$$\rho_{DM} = \frac{m_0}{4\pi r^2 R_{DM}} \tag{4}$$

and then the spherically symmetric Dark Matter halo mass inside a sphere of radius r is given by

$$m = \int_V \rho_{DM} dV = \int_r \rho_{DM} 4\pi r^2 dr = \int_r \frac{m_0}{R_{DM}} dr = \frac{m_0}{R_{DM}} r + m_0 \tag{5}$$

with the last factor as the obvious constant of integration, given the starting point of our model that we have $m = m_0$ at $r = 0$.

The density and mass functions of the elementary particle's halo are chosen to match the values necessary to arrive at the constant velocity rotation curve of galaxies. It is the astrophysical experimental input, especially the $\rho \sim r^{-2}$ Dark Matter density distribution observation, see [11], that is turned into axiomatic definitions regarding the properties of elementary rest masses.

V. THE CHECK WITH FACTS REGARDING THE VIRIAL THEOREM

Given the definition of the gravitational potential as

$$\phi = -\frac{GM}{r} \tag{6}$$

and the mass M as

$$M = \frac{M_0}{R_{DM}} r + M_0 \tag{7}$$

we get a gravitational potential at r as

$$\phi = -\frac{GM_0}{r} - \frac{GM_0}{R_{DM}} \tag{8}$$

For the resulting force of gravity on a classical mass m we get the Newtonian result

$$\boldsymbol{F} = -m\nabla\phi = \frac{GM_0 m}{r^2}\hat{r}. \tag{9}$$

This is due to the fact that the new factor varies linear over r and thus results in a additional potential term that is constant. Our Dark Matter halo acts as a gauge term in the source that produces a constant term in the potential and thus has zero effect on the force.

But the extra term is effecting the gravitational energy of a satellite mass m in the field of a source mass M. This gravitational energy is given by

$$U_g = m_0\phi = -\frac{GM_0m_0}{r} - \frac{GM_0m_0}{R_{DM}}. \tag{10}$$

Now we assume that the virial theorem is still valid, actually we assume that it is more fundamental than the force relation from which it has been originally derived, giving $2U_k = -U_g$, so $v^2 = -\phi$ for orbiting satellites and

$$v^2 = -\phi = \frac{GM_0}{r} + \frac{GM_0}{R_{DM}}. \tag{11}$$

If we let $r \to \infty$ then

$$v^2 = \frac{GM_0}{R_{DM}}, \tag{12}$$

which is a constant.

This result allows us to give an estimate of R_{DM} by applying this to an average galaxy. We get

$$R_{DM} = \frac{GM_0}{v^2} \approx \frac{6,7.10^{-11}.3,5.10^{41}}{(2,5.10^5)^2} = 3,8.10^{20}m = 12kpc. \tag{13}$$

Actual galaxy velocity rotation curves vary considerably from our model with its point like mass distribution. Real galaxies have disk like or spherical like mass distributions which cause deviations from our single particle model. But given the luminous mass distribution, the associated galaxy Dark Matter halo as a summation over all the elementary particle Dark Matter halo's should be computable. Every galaxy has it's own specific luminous mass distribution and then also a particular Dark Matter halo. These calculations should eventually lead to a determination of the value of the specific Dark Matter radius R_{DM}, the Dark Matter constant of my proposal.

As for galaxy clusters as for example the Coma cluster studied by Zwicky, the same approach should be used, assuming that all the luminous matter content of the cluster will form one single halo. Given the fact that a typical cluster can have an extension radius of a 250 kpc and the galaxy rotation curve, and thus the galaxy Dark Matter halo, can stretch out as far as 50 kpc, to treat the cluster in an identical way as a spherical galaxy should be justifiable.

VI. ABOUT QUANTUM MECHANICS AND GENERAL RELATIVITY

The problem with cold elementary Dark Matter particles like WIMP's is that they cannot be found or detected. Our proposal means that the Dark Matter halo isn't composed of separate elementary particles, so to the extend that we are correct, WIMP's and the like will not be found. In our proposal, the Dark Matter halo is a stochastic quantum "ether", the de Broglie matter wave substratum with Born-interpretation statistical properties. The indirect quantum effects of this substratum have been amply detected, but the underlying substance itself is still eluding all detection. Our proposition means that we assume that this local quantum stochastic substratum, according to de Broglie endowed with intrinsic thermodynamic properties, is cosmologically showing gravitational mass properties. From our quantum mechanic perspective, trying to detect this halo locally is the same endeavour as trying to prove the de Broglie-Bohm pilot wave theory correct by directly measuring the piloting substance.

The original problem with MOND or modified Newtonian gravity was that it wasn't relativistic. In the double sense of not in accordance with Special Relativity and neither with General Relativity. Our proposal is embedded in SR from the beginning because of the de Broglie connection. It is also easily incorporated in General Relativity due to the fact that our proposal is about the source of GR effects, the density distribution of matter. Our axiom only affects the source of every theory of gravity, the amount and distribution of matter and matter density in the area under consideration. Our axiom is theory of gravity neutral because it is a statement about mass itself only.

VII. RUNNING INTO TROUBLE WITH HALO-HALO INTERACTION AT THE SCALE OF THE UNIVERSE

The gravitational energy of a classical satellite in a Dark Matter halo was determined using a simple m_0. But if we investigate the gravitational energy of two elementary particles with each a Dark Matter halo, at the distance between two separate galaxy cluster from

each other, say r, we get

$$U_g = \left(m_0 + \frac{m_0 r}{R_{DM}}\right)\left(-\frac{GM_0}{r} - \frac{GM_0}{R_{DM}}\right) \tag{14}$$

$$= -\frac{GM_0 m_0}{r} - \frac{2GM_0 m_0}{R_{DM}} - \frac{GM_0 m_0 r}{R_{DM}^2}. \tag{15}$$

This gives us a classical term, a double constant term and a new Dark Matter halo Dark Matter halo interaction term that increases with r.

If we then determine the force using $\boldsymbol{F} = -\nabla U_g$ we get

$$\boldsymbol{F} = -\nabla U_g = -\frac{GM_0 m_0}{r^2}\hat{r} + \frac{GM_0 m_0}{R_{DM}^2}\hat{r} \tag{16}$$

in which the first term is the Newtonian classical force of gravity and the second term is the halo-halo force of gravity. That last term has the inverse sign and is a constant. Then in between galactic clusters with $r \gg R_{DM}$, the galaxy clusters will tend to repel each other with a constant force, supposing R_{DM} to be constant in time.

Let's safely assume that we have reached the limit of applicability of our proposal. At these distances, the expansion of the Universe interferes with gravity and Dark Energy and Inflation come into play. Dark Matter effects will be overruled by Dark Energy, the dominant factor at that length-scale.

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