A NEW DARK MATTER DENSITY PROFILE AS POWER OF GRAVITATIONAL FIELD FOR COMA CLUSTER

Author: Manuel Abarca Hernández mabarcaher1@gmail.com

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1. ABSTRACT

For last two years I have published eight papers about DM on galaxies. Data have been taken from recent papers written by prestigious researches. The main target of papers have been to calculate DM density through an original profile called Bernoulli profile and check its results with other standard DM profiles such as NFW, Burket or Pseudo-Isothemal. Results on every galaxy checked have been successful.

The importance these works is that Bernoulli profile is supported by an original hypothesis about Dark matter nature. This hypothesis stated that dark matter is generated locally by gravitational field, E, according an unknown quantum mechanism. Formula which relates DM density and gravitational field is DM density = A·E^B. Where A & B are parameters.

Now , in this paper Dark matter density in Coma cluster will be studied with the same method.

Briefly is going to be explained the structure of this paper.

Firstly are presented data Coma Cluster, which come from recent papers published in 2016. They are two couples of radius and mass enclosed by its sphere. Radius considered are R_{500} = 1.314 Mpc and Virial radius = 3.1 Mpc

With only two couple of data is fitted NFW profile for Dark matter density in Coma cluster within an interval radius 1.314 Mpc to 3.1 Mpc. NFW profile is an intermediate processes to get A & B parameters of formula DM density = A·E^B. Finally it is got a Bernoulli differential equation for E whose solution gives DM density Bernoulli profile and whose dominion extend up to 14 Mpc.

As it is known DM through NFW profile gives an excessive amount of DM within halo up to 14 Mpc. This is the reason why I have tried with Bernoulli profile.

According Chernin,A. 2013. At cluster scale is needed to consider dark energy, gravitating mass and matter mass. This formula relates three masses. M_G (R) = M_M (R) + M_{DE} (R) .Dark energy is a negative quantity. So gravitating mass, which is the mass measured by observation is lower than mass matter which is baryonic mass plus dark matter.

Result got as gravitating mass within cluster halo up to 14 Mpc through DM calculated with Bernoulli profile is 2.25· 10 ^15 Solar masses and differ only 6% regarding gravitating mass got by Geller M.J. & Diaferio A. 1999 whereas gravitating mass got with NFW differ more than 600%.

2. INTRODUCTION

For last two years I have published eight papers about DM on galaxies. Data have been taken from recent papers written by prestigious researches. The main target of papers have been to calculate DM density through an original profile called Bernoulli profile and check its results with other standard DM profiles such as NFW, Burket or Pseudo-Isothemal. Results on every galaxy checked have been successful.

The importance these works is that Bernoulli profile is supported by an original hypothesis about Dark matter nature.

In my first paper [1] Abarca, M.2014.called *Dark matter model by quatum vacuum*,were introduced the main hypothesis the model which is that DM is generated locally by gravitational field according an unknown quantum mechanism.

Now , in this paper Dark matter density in Coma cluster will be studied with the same method.

Briefly is going to be explained the structure of this paper.

Firstly are presented data Coma Cluster, which come from recent paper published in 2016. They are two couples of radius and mass enclosed by its sphere. R1= R_{500} and R2 = Virial radius.

1.314 Mpc = R1	$6\cdot 10^{14}$ M_{Θ} = M1
3.1 ± 0.7 Mpc = R2	$2.9\cdot 10^{15}$ M_{Θ} = M2

Secondly has been fitted a NFW profile to get DM density at R1 and R2.

R1 =1.314 Mpc	DM 1 = $2.67\cdot 10^{-24}$ kg/m^3
R2 = 3.1 Mpc	DM 2 = $9.2\cdot 10^{-25}$ kg/m^3

In galaxies are used dozens of data to get its NFW profile. However we have got NFW profile for Coma cluster with the minimum, two couples of data. In addition error data are important because of huge distance to Coma cluster, 95 Mpc.

Therefore it is clear that calculus have errors not very well quantified.

The following step is to fit data of NFW DM density profile as power of gravitational field, E. Particularly formula found is $\varphi_{DM}(E) = A\cdot E^B$ Where A and B are parameter to calculate with previous data.

Before calculate A& B is needed to know gravitational field at R1 & R2.

Data of Dark matter density and gravitational field at R1 and R2 radius.		
R1=1.314 Mpc	E1= $4.83\cdot 10^{-11}$ m/s^2	D1 = $2.67\cdot 10^{-24}$ kg/m^3
R2= 3.1 Mpc	E2= $4.19\cdot 10^{-11}$ m/s^2	D2 = $9.2\cdot 10^{-25}$ kg/m^3

Taking second and third column it is calculated easily parameters A& B of $\varphi_{DM}(E) = A\cdot E^B$

DM Density as power of gravitational field $D = AE^B$	
A International System	$5.563 \cdot 10^{53}$
B A dimensional	7.495

In chapter 6 it is got a Bernoulli differential equation for E depending on radius within halo dominion from 3.1 Mpc to 14 Mpc and thanks its solution it is possible to calculate Bernoulli profile which is

DM Density Bernoulli profile for Coma Cluster halo 3.1 < radius < 14 Mpc
$E_{BER}(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = $3.5155 \cdot 10^{-233}$ D = $2,52698 \cdot 10^{44}$ α = 12.99 β = -0,15396459
Density $_{\text{D.M. BERNOULLI}}$ (r) = $D_{DM\,B}$(r) = $A \cdot E^B$ Where A= $5.563 \cdot 10^{53}$ and B= 7.495 unit kg/m^3

In chapter seven is tabulated Bernoulli and NFW profiles at 0,1 Mpc step. It is clearly showed that NFW is a great deal bigger density that Bernoulli profile. In chapter eight and nine are calculated total mass enclosed within halo cluster up to 14 Mpc.

Quoting to [12] Chernin, A.D. 2013. In chapter ten are introduced concepts of Gravitating mass, Anti gravitating mass or Dark energy and Matter mass. According this author at scale halo cluster it is needed to consider dark energy to calculate gravitating mass, which is kind of matter measured by astrophysics.

Therefore $M_G (R) = M_M (R) + M_{DE} (R)$ where $M_{DE} (R)$ is a negative quantity.

According [12] Chernin, A.D. 2013 M_{DE} (14 Mpc) = $- 2.4 \cdot 10^{15}$ M_Θ.

According numerical calculus of total dark matter through Bernoulli profile M_M (14 Mpc) = $4.6 \cdot 10^{15}$ M_Θ and therefore $M_G = 2.2 \cdot 10^{15}$ M_Θ which match perfectly with gravitating mass found by [13] Diaferio & Geller 1997 with a value $M_G = 2.4 \cdot 10^{15}$ M_Θ. However with NFW profile M_M (14 Mpc)= $3.05 \cdot 10^{16}$ M_Θ which is a quantity 6 times bigger than $4.6 \cdot 10^{15}$ M_Θ therefore it is clear that NFW profile does not work at halo cluster scale.

The agreement between $M_G = 2.4 \cdot 10^{15}$ M_Θ got by Diaferio & Geller, 1997 and $M_G = 2.2 \cdot 10^{15}$ M_Θ got through Bernoulli profile is the main result this paper.

3. COMA CLUSTER DATA

According [10] De Martino, Plank Collaboration project [12] determined that the angular size subtended by R_{500} is $\theta_{500} = 48 \pm 1 arc\min$ corresponding to R_{500} = 1.314 Mpc and the mass associated is $M_{500} \approx 6 \cdot 10^{14} M_{\Theta}$.

As it is known R_{500} is the radius a sphere where the average density is 500 times bigger than critical density of Universe which is $\rho_{CRITICAL} = \frac{3 \cdot H_0^{\ 2}}{8\pi G}$ where H_0 is Hubble constant. Currently Ho = 67.8 Km/s/Mpc. so

$$\rho_{CRITICAL} = \frac{3 \cdot H_0^{\ 2}}{8\pi G} = 8.64 \cdot 10^{-27}\ \text{kg/m}^3 \text{ and } M_{500} \approx 6 \cdot 10^{14} M_{\Theta}$$

According [9] Fuller, C.2016. Virial Radius has been estimated as the mean Virial radius published by four authors Kubo et al. 2007.Geller et al. 1999. Hughes, 1989.The &White 1986. $R_{VIRIAL} = 3.1 \pm 0.7$ Mpc

[9] Fuller, C.2016 has published this graphs and data which allows to calculate velocity dispersion $\sigma = 905\ Km/s$

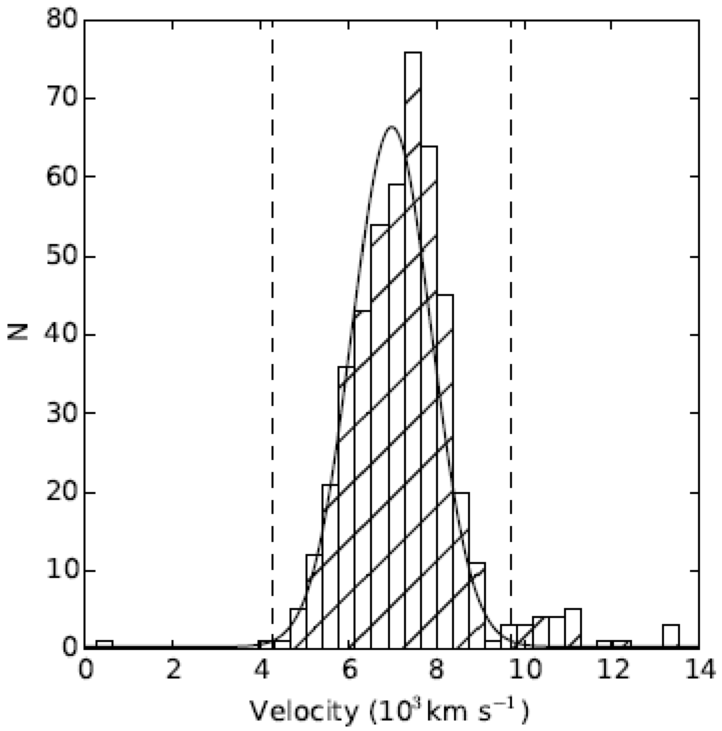


Figure 1. The velocity distribution of the CCC galaxies, showing a clearly relaxed system. The vertical dashed lines represent the 3σ velocity dispersion of the fitted Gaussian function (solid line).

Table 1. Derived parameters of the Coma cluster.

Virial Radius	3.1 Mpc
Velocity Dispersion, σ	905 km s^{-1}
Mean Cluster velocity, μ	6984 km s^{-1}
Minimum velocity limit, $\mu - 3\sigma$	4268 km s^{-1}
Maximum velocity limit, $\mu + 3\sigma$	9700 km s^{-1}

[9] Fuller, C.2016 has published table below where is shown baryonic mass and Virial Mass or dynamical mass at 3.1 Mpc radius.

It is remarkable the quotient $M_{VIRIAL} / M_{BARYONIC} = 104$. As reader knows the same proportion of masses, in average, 10 times lower in galaxies.

Table 11. Mass parameters for the Coma Cluster derived from optically selected galaxies

Component	Mass ($M_\odot$)
Total Stellar Mass	2.8×10^{13}
Total Gas Mass	1.6×10^{11}
Total Dust Mass	2.5×10^{9}
Total Baryonic (Excluding X-ray gas)	2.8×10^{13}
Virial Mass	2.9×10^{15}

the cluster, we can measure the Virial mass of the cluster using:

$$M_{Virial} = \frac{5R_{virial}\sigma^2}{G} \quad (6)$$

Below are summarised Coma Cluster data needed in this paper.

DISTANCES VS MASSES IN	COMA CLUSTER
1.314 Mpc	$6\cdot10^{14}\ M_\Theta$
3.1 ±0.7 Mpc	$2.9\cdot10^{15}\ M_\Theta$

Another important data used to contrast calculus got in this paper are the following one:
According [12] Chernin, A.D. 2013 and [13] Diaferio,A., Geller M.J.,1997. Gravitating mass of Coma cluster halo up to 14 Mpc is $2.4\cdot10^{15}\ M_\Theta$. In chapter 10 will be explained gravitating mass concept.

4. FITTING PARAMETERS OF NFW PROFILE

As Baryonic matter is under 1% of total mass. This kind of matter is neglected, so it can be considered previous data as Dark matter entirely.

Through previous data it is possible to fit a NFW profile for DM density.

As it is known $D_{NFW}(R) = \frac{4D_S}{x\cdot(1+x)^2}$ where $x = R/R_S$. R_S is called radius scale and D_S is density at $x=1$ or $R=R_S$

As reader knows, Total DM enclosed by a sphere of radius R is $M(<R) = 16\pi R^3{}_S\cdot D_S\cdot\left[\ln(1+x) - \frac{x}{1+x}\right]$

Calling $f(x) = \left[\ln(1+x) - \frac{x}{1+x} \right] = \ln(1+r/Rs) - \frac{r}{r+Rs}$ and $K = 16\pi R^3{}_S \cdot D_S$ then M(R)= K·f(x)

Having NFW profile two parameters Rs and Ds, it is needed a couple of data to calculate these parameters.

Below is explained method followed.

Naming these data, it is right to explain better calculus

DISTANCES VS MASSES IN	COMA CLUSTER
1.314 Mpc = R_1	$6 \cdot 10^{14}$ M_Θ = M_1
3.1 Mpc = R_2	$2.9 \cdot 10^{15}$ M_Θ = M_2

Using total mass formula at two radius we have.

$M(R_2)=K \cdot f(X_2)$ where $X_2 = R_2 /R_S$ and $M(R_1)=K \cdot f(X_1)$ where $X_1 = R_1 /R_S$

$M(R_2)/ M(R_1) = f(X_2) / f(X_1) = 4.83333$

Are defined these auxiliary functions $g(r) = \left[\ln(1+3.1/r) - \frac{3.1}{3.1+r} \right]$ and $j(r) = \left[\ln(1+1.314/r) - \frac{1.314}{1.314+r} \right]$

Tabulating both functions by a computer it is right to get that for r= 14.9 quotient g(14.9)/j(14.9) = 4.834

Therefore parameter radius scale R_S= 14.9 Mpc.

Knowing R_S= 14.9 Mpc it is right to calculate $f(X_2)$ = 0.016788322 y $f(X_1)$ = 0.00347278

From formula $M(R_2)=K \cdot f(X_2)$ or formula $M(R_1)=K \cdot f(X_1)$ it is got Ds = $6.98 \cdot 10^{-26}$ kg/m^3 thanks data masses.

PARAMETER NFW PROFILE FOR	COMA CLUSTER
Rs	14.9 Mpc
Ds	$6.98 \cdot 10^{-26}$ kg/m^3

Finally it is possible to calculate DM density at radius R1 and R2

Dark matter density for NFW profile at R1 and R2 radius.		
R1=1.314 Mpc	X1= 0.0882	D1 = $2.67 \cdot 10^{-24}$ kg/m^3
R2= 3.1 Mpc	X2= 0.208	D2 = $9.2 \cdot 10^{-25}$ kg/m^3

5. FITING PARAMETER OF DARK MATTER DENSITY AS POWER OF GRAVITATIONAL FIELD

Density DM = A· E^B. Having this function two parameters, are needed two couple of data to calculate it.

Dark matter density for NFW profile at R1 and R2 radius and total mass enclosed by its spheres		
R1=1.314 Mpc	M1= $6 \cdot 10^{14}\ M_\Theta$	D1 = $2.67 \cdot 10^{-24}$ kg/m^3
R2= 3.1 Mpc	M2= $2.9 \cdot 10^{15}\ M_\Theta$	D2 = $9.2 \cdot 10^{-25}$ kg/m^3

Through these data it is possible to calculate firstly gravitational field at radius R1 and radius R2.

$$E = \frac{GM}{R^2}$$

Data of Dark matter density and gravitational field at R1 and R2 radius.		
R1=1.314 Mpc	E1= $4.83 \cdot 10^{-11}$ m/s^2	D1 = $2.67 \cdot 10^{-24}$ kg/m^3
R2= 3.1 Mpc	E2= $4.19 \cdot 10^{-11}$ m/s^2	D2 = $9.2 \cdot 10^{-25}$ kg/m^3

Summarising data

E1= $4.83 \cdot 10^{-11}$ m/s^2	D1 = $2.67 \cdot 10^{-24}$ kg/m^3
E2= $4.19 \cdot 10^{-11}$ m/s^2	D2 = $9.2 \cdot 10^{-25}$ kg/m^3

Writing symbolically previous data D1 = A·$E1^B$ and D2= A· $E2^B$ it is right to get that $B = \dfrac{\ln 2.902}{\ln 1.151}$ =7.495

because D1/D2= 2.902 and E1/E2= 1.153

Calculus of A may be made using (E1,D1) and (E2,D2) data. Both of them led to A= $5.563 \cdot 10^{53}$,probably the bigger parameter never got ¡

Calculus of A and B are a great deal easier than calculus made for NFW parameters.

DM Density as power of gravitational field D = AE^B	
A International System	$5.563 \cdot 10^{53}$
B Adimensional	7.495

In the following chapter it will be show that both DM profiles (NFW and power of E) give essentially the same results when radius is inside the interval 1.314Mpc – 3.1 Mpc. However DM as power of E is a great deal lower than NFW profile when radius is R > 3.1 Mpc.

5.1 DARK MATTER DENSITY THROUGH DM DENSITY AS POWER OF E FOR GALAXIES

According [2] Abarca, M.2015 and [8] Abarca,M.2016. Formula below is a good approximation for dark matter density whatever giant galaxy.

Dark matter density function as Universal law for big galaxies
$Density_{DM} = 2{,}526 \cdot 10^{-5} \cdot E^{B}$ where B= 1,74
Where Unit for $Density_{D.M.}$ is Kg / m^3 and Unit for E is m/s^2

Now it will be checked with data we have for Coma cluster.

Data within Coma cluster for gravit. Field and DM density	
$E1= 4.83 \cdot 10^{-11}$ m/s^2	$D1 = 2.67 \cdot 10^{-24}$ kg/m^3
$E2= 4.19 \cdot 10^{-11}$ m/s^2	$D2 = 9.2 \cdot 10^{-25}$ kg/m^3

DM density through DM density as power of E for giant galaxies	
$E1= 4.83 \cdot 10^{-11}$ m/s^2	$D1_{GALAXIES} = 2.8 \cdot 10^{-23}$ kg/m^3
$E2= 4.19 \cdot 10^{-11}$ m/s^2	$D2_{GALAXIES} = 2.2 \cdot 10^{-23}$ kg/m^3

Reader can check that DM density got with formula for galaxies is more than ten times bigger than DM density formula fitted to Coma cluster data.

6. BERNOULLI DIFFERENTIAL EQUATION FOR GRAVITATIONAL FIELD IN COMA CLUSTER HALO

It will be considered the region 3.1 < Radius < 14 Mpc where density of baryonic matter is negligible versus baryonic density. So for radius bigger than 3.1 Mpc it will be considered that derivative of M(r) depend on dark matter density only.

As it is known in this formula $E = G\dfrac{M(r)}{r^2}$, M(r) represents mass enclosed by a sphere with radius r. If it is considered radius > 3.1 Mpc then the derivative of M(r) depend on dark matter density essentially and therefore $M'(r) = 4\pi r^2 \varphi_{DM}(r)$.

As $\varphi_{DM}(r) = A{\cdot}E^{B}(r)$ Where $A= 5.563 \cdot 10^{53}$ and B= 7.495 then $M'(r) = 4\pi r^2 \cdot A{\cdot}E^{B}$

If $E = G\dfrac{M(r)}{r^2}$ is differentiated it is got $E'(r) = G\dfrac{M'(r)\cdot r^2 - 2rM(r)}{r^4}$

If $M'(r) = 4\pi r^2 \varphi_{DM}(r)$ is replaced above it is got $E'(r) = 4\pi G\varphi_{DM}(r) - 2G\dfrac{M(r)}{r3}$ As $\varphi_{DM}(r) = A\cdot E^B(r)$ it is right to get $E'(r) = 4\pi\cdot G\cdot A\cdot E^B(r) - 2\dfrac{E(r)}{r}$ which is a Bernoulli differential equation.

$E'(r) = K\cdot E^B(r) - 2\dfrac{E(r)}{r}$ being $K = 4\pi\cdot G\cdot A$ then K=4,66488631594·10^{44} into I.S. of units.

Calling ***y*** to E, the differential equation is written this way $y\grave{} = K\cdot y^B - \dfrac{2\cdot y}{r}$

Bernoulli family equations $y\grave{} = K\cdot y^B - \dfrac{2\cdot y}{r}$ may be converted into a differential linear equation with this variable change $u = y^{1-B}$.

General solution is $E(r) = \left(Cr^{2B-2} + \dfrac{Kr(1-B)}{3-2B}\right)^{\frac{1}{1-B}}$ $with\ B \neq 1\ and\ B \neq 3/2$ where C is the parameter of initial condition of gravitational field at a specific radius.

Calling $\alpha = 2B-2$ $\beta = \dfrac{1}{1-B}$ and $D = \left(\dfrac{K(1-B)}{3-2B}\right)$ formula may be written as

$E(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ Where specifically values for these parameters are the following ones:

$\alpha = 2B-2$ = 12,99

$\beta = \dfrac{1}{1-B}$ = -0,15396459

$D = \left(\dfrac{K(1-B)}{3-2B}\right)$ = 2,52698·10^{44}

Initial condition for parameter C calculus

Suppose $R_0\ and\ E_0$ are specific initial conditions for radius and gravitational field then $C = \dfrac{E_0^{\ 1/\beta} - D\cdot R_0}{R_0^{\ \alpha}}$

As dominion radius begin at R= 3.1 Mpc = $9.57 \cdot 10^{22}$ m. it is right to consider as initial condition Ro = 3.1 Mpc = $9.57 \cdot 10^{22}$ m. and Eo = $4.19 \cdot 10^{-11}$ m/s^2 being C= $3.5155 \cdot 10^{-233}$

Probably the lower parameter never calculated ¡

Initial condition values Ro & Eo	
Ro =	3.1 Mpc
Eo =	$4.19 \cdot 10^{-11}$ m/s^2
C =	$3.5155 \cdot 10^{-233}$ units I.S.

Finally it is possible to write formula for DM density profile got through Bernoulli method.

Bernoulli Solution for Gravitational field inside halo 3.1 Mpc < Radius < 14 Mpc
$E_{BER}(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = $3.5155 \cdot 10^{-233}$ D = $2,52698 \cdot 10^{44}$ α = 12.99 β = -0,15396459

7. BERNOULLI PROFILE OF DARK MATTER DENSITY FOR COMA CLUSTER HALO

Thanks Bernoulli solution for gravitational field is right to get DM density through power of E formula.

DM Density Bernoulli profile for Coma Cluster halo 3.1 < radius < 14 Mpc
$E_{BER}(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = $3.5155 \cdot 10^{-233}$ D = $2,52698 \cdot 10^{44}$ α = 12.99 β = -0,15396459
Density $_{D.M.\ BERNOULLI}$ (r) = $D_{DM\,B}$(r) = $A \cdot E^B$ Where A= $5.563 \cdot 10^{53}$ and B= 7.495 unit kg/m^3

Thanks these formulas it is right to tabulate gravitational field and DM as power of E. The last column shows DM density of NFW profile. Both density are essentially the same at 3.1 Mpc. However DM density Bernoulli decrease more quickly than density NFW. Therefore total mass of DM in halo will be different for both densities profiles.

In next chapter will be calculated total mass, and surprisingly mass provided through Bernoulli density matches with DM calculated by observational methods whereas total mass through NFW profiles is far from it.

Radius	Gravt. field	DM Bernoulli	DM NFW profile
Mpc	m/s^2	Kg/m^3	kg/m^3
3,1	4,19E-11	9,20E-25	9,19E-25
3,2	4,15608E-11	8,66E-25	8,81E-25
3,3	4,11806E-11	8,08E-25	8,45E-25
3,4	4,07464E-11	7,46E-25	8,11E-25
3,5	4,02448E-11	6,80E-25	7,79E-25
3,6	3,9663E-11	6,10E-25	7,50E-25
3,7	3,8991E-11	5,37E-25	7,21E-25
3,8	3,82234E-11	4,62E-25	6,95E-25
3,9	3,73609E-11	3,90E-25	6,70E-25
4	3,64111E-11	3,21E-25	6,46E-25
4,1	3,53873E-11	2,59E-25	6,24E-25
4,2	3,43073E-11	2,06E-25	6,03E-25
4,3	3,31905E-11	1,60E-25	5,83E-25
4,4	3,20562E-11	1,24E-25	5,63E-25
4,5	3,09214E-11	9,44E-26	5,45E-25
4,6	2,98001E-11	7,15E-26	5,28E-25
4,7	2,87034E-11	5,40E-26	5,11E-25
4,8	2,7639E-11	4,07E-26	4,96E-25
4,9	2,66121E-11	3,06E-26	4,81E-25
5	2,56259E-11	2,31E-26	4,66E-25
5,1	2,46818E-11	1,74E-26	4,53E-25
5,2	2,37801E-11	1,32E-26	4,40E-25
5,3	2,29205E-11	1,00E-26	4,27E-25
5,4	2,21016E-11	7,62E-27	4,15E-25
5,5	2,13222E-11	5,82E-27	4,03E-25
5,6	2,05805E-11	4,46E-27	3,92E-25
5,7	1,98746E-11	3,44E-27	3,82E-25
5,8	1,92029E-11	2,66E-27	3,72E-25
5,9	1,85634E-11	2,06E-27	3,62E-25
6	1,79545E-11	1,60E-27	3,52E-25
6,1	1,73742E-11	1,25E-27	3,43E-25
6,2	1,68211E-11	9,84E-28	3,35E-25
6,3	1,62936E-11	7,75E-28	3,26E-25
6,4	1,57901E-11	6,13E-28	3,18E-25
6,5	1,53094E-11	4,86E-28	3,10E-25
6,6	1,48501E-11	3,87E-28	3,03E-25
6,7	1,4411E-11	3,09E-28	2,95E-25
6,8	1,3991E-11	2,47E-28	2,88E-25
6,9	1,3589E-11	1,99E-28	2,82E-25

7	1,32039E-11	1,60E-28	2,75E-25
7,1	1,2835E-11	1,30E-28	2,69E-25
7,2	1,24812E-11	1,05E-28	2,63E-25
7,3	1,21419E-11	8,55E-29	2,57E-25
7,4	1,18161E-11	6,97E-29	2,51E-25
7,5	1,15033E-11	5,70E-29	2,45E-25
7,6	1,12027E-11	4,68E-29	2,40E-25
7,7	1,09137E-11	3,85E-29	2,35E-25
7,8	1,06358E-11	3,17E-29	2,30E-25
7,9	1,03683E-11	2,62E-29	2,25E-25
8	1,01107E-11	2,17E-29	2,20E-25
8,1	9,86269E-12	1,80E-29	2,16E-25
8,2	9,62364E-12	1,50E-29	2,11E-25
8,3	9,39318E-12	1,25E-29	2,07E-25
8,4	9,17089E-12	1,04E-29	2,03E-25
8,5	8,9564E-12	8,74E-30	1,98E-25
8,6	8,74935E-12	7,34E-30	1,94E-25
8,7	8,54938E-12	6,17E-30	1,91E-25
8,8	8,3562E-12	5,20E-30	1,87E-25
8,9	8,16949E-12	4,39E-30	1,83E-25
9	7,98896E-12	3,71E-30	1,80E-25
9,1	7,81435E-12	3,14E-30	1,76E-25
9,2	7,64541E-12	2,67E-30	1,73E-25
9,3	7,48188E-12	2,27E-30	1,70E-25
9,4	7,32354E-12	1,93E-30	1,66E-25
9,5	7,17018E-12	1,65E-30	1,63E-25
9,6	7,02158E-12	1,41E-30	1,60E-25
9,7	6,87756E-12	1,21E-30	1,57E-25
9,8	6,73792E-12	1,04E-30	1,54E-25
9,9	6,60249E-12	8,89E-31	1,52E-25
10	6,4711E-12	7,65E-31	1,49E-25
10,1	6,3436E-12	6,59E-31	1,46E-25
10,2	6,21982E-12	5,68E-31	1,44E-25
10,3	6,09964E-12	4,91E-31	1,41E-25
10,4	5,9829E-12	4,25E-31	1,39E-25
10,5	5,86949E-12	3,68E-31	1,36E-25
10,6	5,75926E-12	3,19E-31	1,34E-25
10,7	5,65212E-12	2,77E-31	1,32E-25
10,8	5,54793E-12	2,41E-31	1,29E-25
10,9	5,4466E-12	2,10E-31	1,27E-25
11	5,34803E-12	1,83E-31	1,25E-25
11,1	5,2521E-12	1,60E-31	1,23E-25
11,2	5,15873E-12	1,40E-31	1,21E-25
11,3	5,06783E-12	1,22E-31	1,19E-25
11,4	4,97931E-12	1,07E-31	1,17E-25
11,5	4,89309E-12	9,41E-32	1,15E-25

11,6	4,80909E-12	8,27E-32	1,13E-25
11,7	4,72724E-12	7,27E-32	1,12E-25
11,8	4,64745E-12	6,40E-32	1,10E-25
11,9	4,56967E-12	5,64E-32	1,08E-25
12	4,49383E-12	4,97E-32	1,06E-25
12,1	4,41986E-12	4,39E-32	1,05E-25
12,2	4,3477E-12	3,88E-32	1,03E-25
12,3	4,27729E-12	3,43E-32	1,01E-25
12,4	4,20858E-12	3,04E-32	9,99E-26
12,5	4,14151E-12	2,70E-32	9,84E-26
12,6	4,07604E-12	2,39E-32	9,69E-26
12,7	4,0121E-12	2,13E-32	9,55E-26
12,8	3,94966E-12	1,89E-32	9,40E-26
12,9	3,88866E-12	1,68E-32	9,26E-26
13	3,82906E-12	1,50E-32	9,13E-26
13,1	3,77083E-12	1,34E-32	8,99E-26
13,2	3,71391E-12	1,19E-32	8,86E-26
13,3	3,65827E-12	1,06E-32	8,73E-26
13,4	3,60387E-12	9,51E-33	8,60E-26
13,5	3,55068E-12	8,51E-33	8,48E-26
13,6	3,49866E-12	7,62E-33	8,36E-26
13,7	3,44777E-12	6,83E-33	8,24E-26
13,8	3,39798E-12	6,12E-33	8,12E-26
13,9	3,34927E-12	5,49E-33	8,01E-26
14	3,30159E-12	4,93E-33	7,90E-26

8. CALCULUS OF DARK MATTER IN COMA CLUSTER HALO UP TO 14 MPC WITH NFW PROFILE

Total DM for NFW profiles is $M(<R) = 16\pi R^3{}_S \cdot D_S \cdot \left[\ln(1+x) - \dfrac{x}{1+x} \right]$.

In chapter four were calculated NFW parameters.

PARAMETER NFW PROFILE FOR	COMA CLUSTER
Rs	14.9 Mpc
Ds	$6.98 \cdot 10^{-26}$ kg/m^3

For R = 14 Mpc x = 0.9396 M(14 Mpc) = K· f(0.9396) = 0.17805· K and K= $1.71 \cdot 10^{17}$ M_Θ

So M(14 Mpc)= $3.05 \cdot 10^{16}$ M_Θ which is more than 6 times bigger than dark matter calculated by other methods which includes observational techniques.

9. CALCULUS OF DARK MATTER IN COMA CLUSTER HALO UP TO 14 MPC WITH BERNOULLI PROFILE

In chapter seven there is the exact DM density Bernoulli profile:

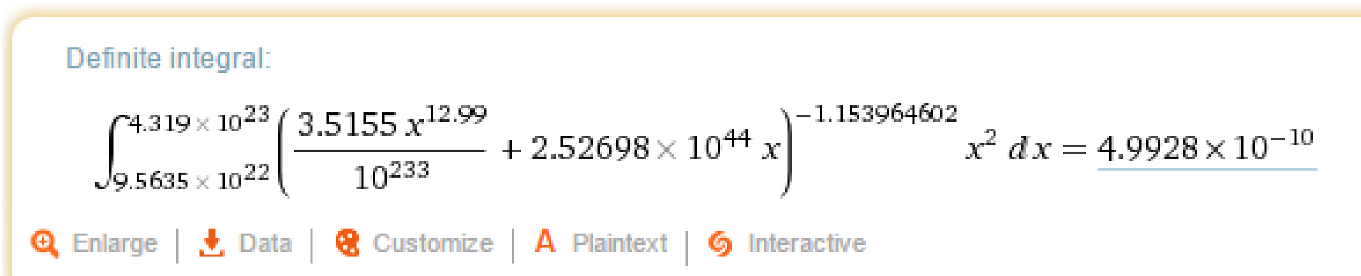
DM Density Bernoulli profile for Coma Cluster halo 3.1 < radius < 14 Mpc
$E_{BER}(r) = \left(Cr^\alpha + Dr\right)^\beta$ C = $3.5155 \cdot 10^{-233}$ D = $2,52698 \cdot 10^{44}$ α = 12.99 β = -0,15396459
Density $_{\text{D.M. BERNOULLI}}$ (r) = $D_{DM\,B}$(r) = A· E^B Where A= $5.563 \cdot 10^{53}$ and B= 7.495 unit kg/m^3

By a definite integration it is possible to calculate total DM between R1 = 3.1 Mpc and R2= 14 Mpc.

Integration is very complex as reader can check.

$$M_{DM} = \int_{R1}^{R2} 4\pi r^2 \cdot \rho(r) dr = \int_{R1}^{R2} 4\pi r^2 A E^B dr = 4\pi A \int_{R1}^{R2} r^2 \left[\left(Cr^\alpha + Dr\right)^\beta \right]^B dr = 4\pi A \cdot I$$

Thanks remarkable web site *Wolfram alpha* it is possible to calculate definite integral needed to know total dark matter from 3.1 Mp to 14 Mpc. Below is showed result.



So $M_{DARK\ MATTER\ HALO}$= 4 · Pi· A· I . Where I = $4.9928 \cdot 10^{-10}$ and A= $5.563 \cdot 10^{53}$

Therefore $M_{DARK\ MATTER\ HALO}$ (3.1 < R < 14 Mpc) = $1.754 \cdot 10^{15}$ M_{Θ}

Adding this value to $2.9 \cdot 10^{15}$ M_{Θ} ,which is mass within radius 3.1 Mpc, results a total mass for Coma cluster M_M (14 Mpc) = $4.654 \cdot 10^{15}$ M_{Θ}

Author [12] Chernin, A.D. 2013, mentioned that [13] Geller & Diaferio 1999 using the caustic technique got a mass up to 14 Mpc of $2.4 \cdot 10^{15}$ M_{Θ}.

Apparently results got do not agree at all with observational results got by Diaferio. However if it is considered Dark Energy enclosed within halo, results match perfectly as it will be seen at following chapter.

10. GRAVITATIONAL MASS IN COMA CLUSTER UP TO 14 MPC

According [12] Chernin, A.D. 2013. At cluster scale is necessary consider three class of mass, because at this scale dark energy effect may be considerate as anti gravitating mass or negative mass. Therefore effective gravitating mass is calculated adding to total mass, dark energy as a negative quantity.

M_G (R) = M_M (R) + M_{DE} (R)

According [12] Chernin, A.D. 2013. Mass of dark energy within a given clustrocentric radius R is

$M_{DE} = \frac{-8\pi \cdot \rho_{DE} \cdot R^3}{3}$ Where ρ_{DE} =$7.1 \cdot 10^{-27}$ kg/m^3 is density of dark energy, which is Universal. It is remarkable that DE density should be multiplied by two times volume of sphere to calculate mass anti gravitating effect.

So M_{DE} (14 Mpc) = - $2.4 \cdot 10^{15}$ M_{Θ}.

Therefore M_G (14 Mpc) = M_M (14 Mpc) + M_{DE} (14 Mpc) = $4.654 \cdot 10^{15}$ M_{Θ} - $2.4 \cdot 10^{15}$ M_{Θ} = $2.254 \cdot 10^{15}$ M_{Θ} which is a very close value to total gravitating mass found by [13] Geller & Diaferio 1999 with a value M_G = $2.4 \cdot 10^{15}$ M_{Θ}. Relative difference between both values is 6%.

11. CONCLUSION

It is known that NFW profile works perfectly at galactic scale. However at cluster halo scale has given a very high value for total dark matter which is not supported by observational method. More exactly DM calculated by NFW profile within cluster halo up to 14 Mpc is 6 times bigger over the expected value estimated with other methods.

The original view this work has been to calculate a new DM profile called Bernoulli taking as data NFW profile at radius 1.314 Mpc and 3.1 Mpc. and extend successfully its dominion up to 14 Mpc.

In the first version this paper DM was got by numerical integration. Total gravitating mass of Coma cluster up to 14 Mpc was $M_G = 2.2 \cdot 10^{15}$ M_Θ which regarding gravitating mass got by [13] Geller & Diaferio 1999 differ 8 %.

In this version calculus of DM within cluster halo has been made through Wolfram alpha web site and final gravitating mass is now $M_G = 2.254 \cdot 10^{15}$ M_Θ which differ 6 % regarding gravitating mass found by [13] Geller & Diaferio 1999 with a value $M_G = 2.4 \cdot 10^{15}$ M_Θ.

During last two year I have published several papers about DM in galaxies through Bernoulli profile with successful results which always are very similar to got with NFW profile. However it is well known that NFW profile does not work at cluster halo scale.

The importance Bernoulli profile is that is supported by hypothesis of dark matter generated by gravitational field..

I think is not casual that total matter calculated, under this hypothesis, within Coma cluster halo agree perfectly with total matter calculated by observational methods by prestigious researchers.

In my opinion results got in this paper support strongly that DM is generated locally by gravitational field according a universal mechanism that works at galaxy halo scale and cluster halo scale as well. Therefore I think it is worth to check widely this law in different galaxies and clusters.

In addition, as I published in [1] Abarca, M.2014. the ultimate theory of DM will be a quantum gravity theory.

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