A NEW DARK MATTER DENSITY PROFILE FOR NGC 3198 GALAXY TO DEMONSTRATE THAT DARK MATTER IS GENERATED BY GRAVITATIONAL FIELD

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1. ABSTRACT

The main target this paper is to check a theory about dark matter nature, which was published by the author in previous papers. It was postulated and supported, with several experimental evidences, that dark matter density is a function which depend on E, gravitational field, according to an Universal law for big galaxies.

Current paper studies the same law for NGC 3198, which is an intermediate galaxy belong to Ursa Major cluster, 14 Mpc away.

In this work has been fitted a new function for DM density as power of E.

Reader could think, why disturb me with another DM density profile whose values have relative differences with NFW ones below 5%?

The reason is clear. This DM profile has been got starting from hypothesis that DM is generated by the own gravitational field. Ttherefore if DM Bernoulli profile fits perfectly to observational data of DM and NFW profile as well then it is possible conclude that observational data supports author´s hypothesis about DM nature.

To find reasons that author has to do so daring statement reader can consult [1] Abarca,M.2014. *Dark matter model by quantum vacuum* and [2] Abarca,M.2015. *Dark matter density function depending on gravitational field as Universal law*

Briefly will be explained method followed to develop this paper. Firstly are presented rotation curve and table with data about DM density inside halo of NGC 3198 galaxy. These data come from [3] E.V. Karukes, 2015. Despite the fact that data begin at radius of 2 kpc, in this paper it has been considered radius bigger than 18 Kpc, because it is the halo region where density of baryonic matter is negligible in comparison with DM density.

In fourth epigraph, starting from speed data it is right to calculate gravitational field E, so from Karukes data, it is possible to tabulate gravitational field and density of dark matter from 18 kpc to 48 kpc.

In fifth epigraph has been fitted data of DM density as power of gravitational field, E, with a correlation coefficient bigger than 0,99. Particularly formula found is $\varphi_{DM}(r) = A \cdot E^B \ \ where\ A = 2{,}8 \cdot 10^{-5} \ \ and\ \ B = 1{,}69$

In sixth epigraph it has been compared DM density data, DM density as power of E and DM density NFW profile. Tables and plots show clearly that DM density power of E adjust better to density data than NFW profile.

In seventh epigraph it is considered derivative of gravitational in halo region where density of baryonic matter is negligible. As consequence $M'(r) = 4\pi r^2 \varphi_{DM}(r)$ and considering that $\varphi_{DM}(r) = A \cdot E^{1,69}(r)$ where A = 2,8 · 10^{-5} then $M'(r) = 4\pi r^2 \cdot A \cdot E^{1,69}$. If M´(r) is replaced on derivative of E (r) then it is got a Bernoulli differential equation whose solution is a new DM density profile.
To integrate differential equation has been taken four different values for gravitational field at four different radius to check accuracy of integration parameter.

In eighth epigraph power of E, Bernoulli and NFW DM profiles have been tabulated and plotted to show clearly that power of E agree very well with Bernoulli but both are a bit different of NFW profile.

In ninth epigraph Bernoulli and NFW DM profiles has been compared with DM density data. Tables and plots show clearly that Bernoulli profile fits better observational data DM density data than NFW profile.

2. INTRODUCTION

The main target this paper is to check a theory about dark matter nature, which was published by the author in previous papers. In the previous work was postulated and supported, with several experimental evidences, that dark matter density is a function which depend on E, gravitational field, according to an Universal law for big galaxies. A galaxy is considered big if its flat area in rotation curve is higher than 200 Km/s. The main formula found in that paper was:

Density $_{DM}$ = 2,526 · 10^{-5} · E^B where B = 1,74 Units are Kg /m^3 for density and m/s^2 for E.

This paper has focussed on NGC 3198 dark matter halo. As flat area of its rotation curve is about 150 km/s NGC 3198 may be considered an intermediate galaxy.

In his previous paper the author explained the reason why inside halo intermediate or dwarf galaxies DM density may be bigger than DM density inside halo of big ones.

This is the reason why in this work has been fitted a new function for DM density as power of E but through different coefficients. Specifically has been found this formula:

Density $_{DM}$ = 2,8 · 10^{-5} · E^B where B= 1,69 Units are Kg/m^3 for density and m/s^2 for E.

Observational data has been taken from [3] E.V. Karukes, 2015. Through these data has been calculated a fitted function to DM density depending on E with a correlation coefficient bigger than 0,99.

Having this DM density function has been easy to get a Bernoulli differential equation whose general solution is a new DM density profile called in paper Bernoulli profile.

As NFW is a DM density profile well known by astrophysics researchers is a good test to compare the new density profile with NFW profile. Chapters 8 and 9 are dedicated to this assignment with very successful results.

3. OBSERVATIONAL DATA FROM KARUKES.2015 PAPER

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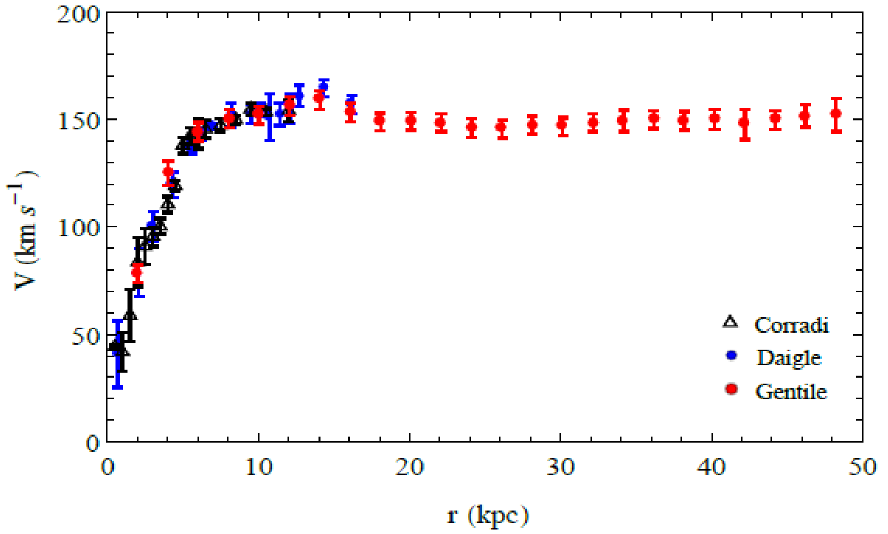


Fig. 1. Comparison between Hα and HI RCs black open triangles with error bars from Corradi et al. (1991), blue circles with error bars are from Daigle et al. (2006), and red circles with error bars are from Gentile et al. (2013).

Table 1. Stellar disk contribution V_d (km s^{-1}) (de Blok et al. 2008) and the circular velocity V (km s^{-1}) mainly from Gentile et al. (2013), but also from Corradi et al. (1991) and Daigle et al. (2006), of the NGC 3198 with errors dV (km s^{-1}). The DM density profile $\rho \times 10^{-25}$ (g cm^{-3}) (see Sect. 5 for details).

R (kpc)	V_d (km s^{-1})	V (km s^{-1})	dV (km s^{-1})	$\rho \times 10^{-25}$ (g cm^{-3})
2.0	86.2	79.0	7.0	—
3.0	85.4	97.8	5.0	—
4.0	93.6	118.0	5.6	—
5.5	115.7	139.4	4.3	2.34
6.0	120.8	144.2	4.3	2.33
7.0	125.4	143.3	4.5	2.20
8.0	125.5	150.3	4.3	2.01
9.0	123.5	149.9	4.3	1.83
10.1	120.1	152.1	4.3	1.64
11.0	116.6	151.1	4.5	1.48
12.1	112.6	156.2	4.3	1.32
14.1	105.2	161.0	4.3	1.06
16.1	98.6	155.3	4.3	0.86
18.1	92.7	148.7	4.3	0.70
20.1	87.5	149.1	4.3	0.58
22.1	82.8	148.4	4.3	0.48
24.1	78.7	146.2	4.3	0.42
26.1	75.1	145.5	4.3	0.36
28.1	71.9	147.3	4.3	0.33
30.2	68.9	146.5	4.3	0.30
32.2	66.3	148.4	4.3	0.27
34.2	63.9	149.3	5.0	0.25
36.2	61.8	149.9	4.3	0.23
38.2	59.8	149.3	4.3	0.21
40.2	58.0	150.0	4.6	0.20
42.1	56.4	147.6	7.0	0.18
44.2	54.9	149.8	4.3	0.16
46.2	53.5	151.5	4.3	0.13
48.2	52.2	151.9	7.7	0.11

Graphic and table come from [3] E.V. Karukes, 2015.

4. GRAVITATIONAL FIELD AND D.M. DENSITY DEPENDING ON RADIUS

In order to guarantee that baryonic gas density is neglible it has been chosen a large radius to begin table. By the end of table radius 48,2 kpc has been omitted because of its large observational error.

In order to simplify calculus velocity has been approximate to 150 Km/s because this measure is inside error interval each observational data. Target this paper no need bigger accuracy.

As it is known total gravitational field may be calculated through the formula $E = v^2/R$ whose I.S. unit is m/s^2. In fourth column is shown results of E. Reader can check these data taking into account that 1 Kpc = $3{,}0857 \cdot 10^{19}$ m.

In the last column it is tabulated D.M. density according Mr. Karukes data into International System (I.S.)

Radius	Radius	Velocity	Gravt. field	D.M. density Data Karukes
kpc	m	m/s	m/s^2	Kg/m^3
18,1	5,59E+20	1,50E+05	4,03E-11	7,00E-23
20,1	6,20E+20	1,50E+05	3,63E-11	5,80E-23
22,1	6,82E+20	1,50E+05	3,30E-11	4,80E-23
24,1	7,44E+20	1,50E+05	3,03E-11	4,20E-23
26,1	8,05E+20	1,50E+05	2,79E-11	3,60E-23
28,1	8,67E+20	1,50E+05	2,59E-11	3,30E-23
30,2	9,32E+20	1,50E+05	2,41E-11	3,00E-23
32,2	9,94E+20	1,50E+05	2,26E-11	2,70E-23
34,2	1,06E+21	1,50E+05	2,13E-11	2,50E-23
36,2	1,12E+21	1,50E+05	2,01E-11	2,30E-23
38,2	1,18E+21	1,50E+05	1,91E-11	2,10E-23
40,2	1,24E+21	1,50E+05	1,81E-11	2,00E-23
42,2	1,30E+21	1,50E+05	1,73E-11	1,80E-23
44,2	1,36E+21	1,50E+05	1,65E-11	1,60E-23
46,2	1,43E+21	1,50E+05	1,58E-11	1,30E-23
48,2	1,49E+21	1,50E+05	1,51E-11	1,10E-23

5. D.M. DENSITY FUNCTION AS POWER OF GRAVITATIONAL FIELD E

Gravt. field m/s^2	D.M. density Kg/m^3
4,03E-11	7,00E-23
3,63E-11	5,80E-23
3,30E-11	4,80E-23
3,03E-11	4,20E-23
2,79E-11	3,60E-23
2,59E-11	3,30E-23
2,41E-11	3,00E-23
2,26E-11	2,70E-23
2,13E-11	2,50E-23
2,01E-11	2,30E-23
1,91E-11	2,10E-23
1,81E-11	2,00E-23
1,73E-11	1,80E-23
1,65E-11	1,60E-23
1,58E-11	1,30E-23
1,51E-11	1,10E-23

Reason why the author has decided to fit this kind of function is explained in [2] Abarca,M.2015.

It is right to fit a power function to these data according this formula

Density $_{\text{DARK MATTER}} = A\cdot E^B$

Where $A = 2{,}80080937\cdot 10^{-5}$ and B= 1,693308 being correlation coefficient r= 0,99046

So DM density power function fitted will be

$$\varphi_{DM}(r) = A\cdot E^B \ \ where \ A = 2{,}80080937\cdot 10^{-5} \ \ and \ \ B = 1{,}693308$$

As It was said in abstract, NGC 3198 is an intermediate galaxy, in a previous paper author has calculated similar DM density function as power of E for big galaxies. Although coefficients are not exactly the same they have close values.

Reader can consult paper, although briefly I will say that these coefficient has been got as a result of a statistical study of rotation curves of six big galaxies placed in different galaxy clusters. Galaxies are NGC 2841 NGC7331 NGC 3992 NGC 3031 M31 and Milky Way.

The main aim that paper was to look for evidences that DM density depend on gravitational field according a Universal law in big galaxies. Below is the formula.

Dark matter density function as Universal law for big galaxies – International System of Units						
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						
E gravt. I.S.	$3{,}24\cdot 10^{-12}$	$1{,}62\cdot 10^{-11}$	$4{,}86\cdot 10^{-11}$	$9{,}72\cdot 10^{-11}$	$1{,}458\cdot 10^{-10}$	$2{,}106\cdot 10^{-10}$
Density$_{DM}$ I.S.	$2{,}58\cdot 10^{-25}$	$4{,}24\cdot 10^{-24}$	$2{,}86\cdot 10^{-23}$	$9{,}57\cdot 10^{-23}$	$1{,}94\cdot 10^{-22}$	$3{,}67\cdot 10^{-22}$
Dominion $3{,}24\cdot 10^{-12} < E < 2{,}11\cdot 10^{-10}$						

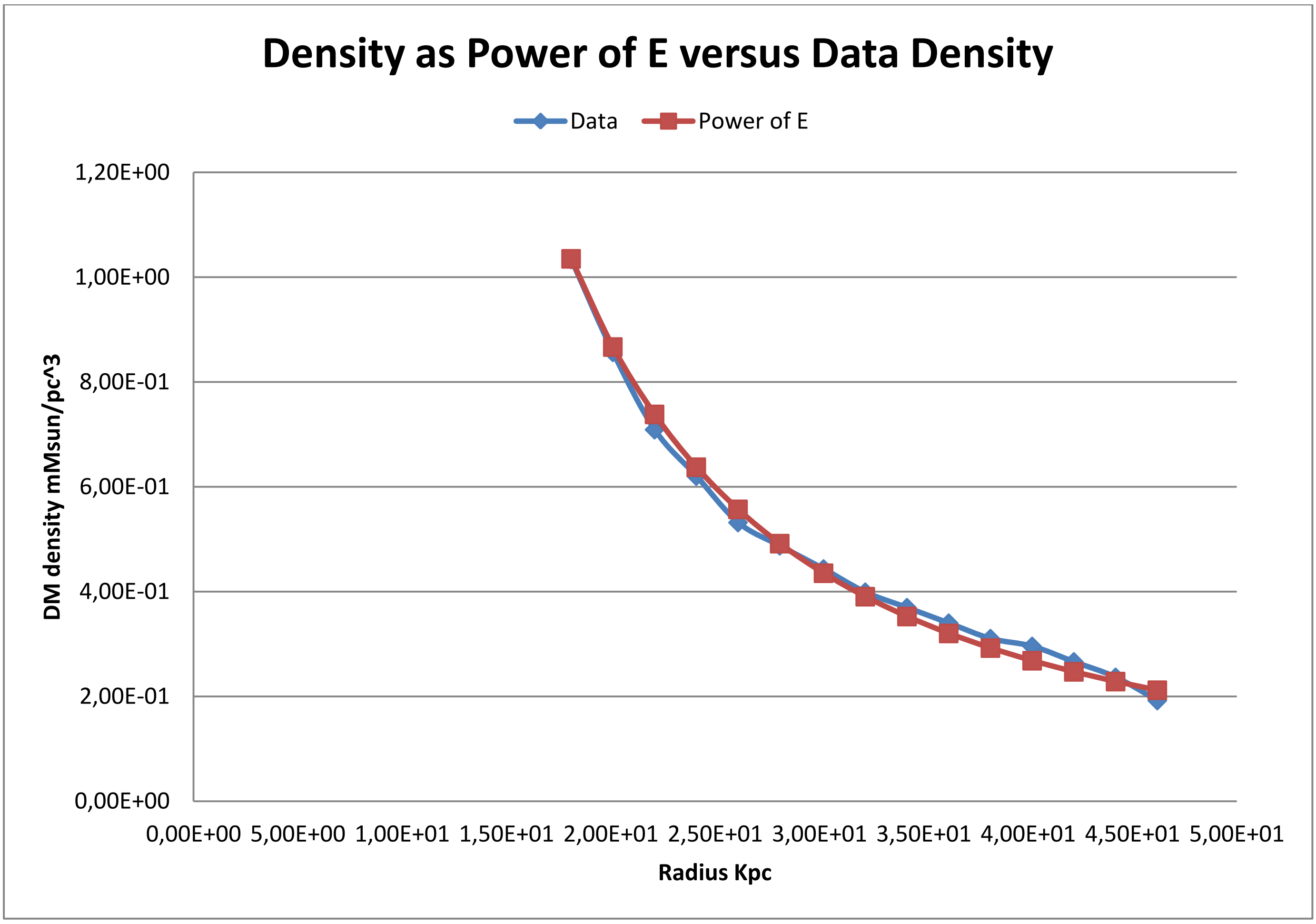
Table above come from [2] Abarca,M.2015

It is remarkable the fact that coefficient A for NGC 3198 is only 12 % bigger than one for big galaxies. It is logic a little difference by reason explained in previous paper. Briefly I will explain that intermediate galaxy near big galaxies could appropriate a part of DM density generated by gravitational field of galactic neighbours.

Table below shows results of dark matter density power function fitted to data and the relative difference in comparison with Mr. Karukes data. It is remarkable that relative differences are under 6% mainly, despite the fact velocity has been approximate to 150 Km/s in the whole dominion 18 Kpc < radius < 46 Kpc.

Radius Kpc	Data density mMsun/pc^3	Dens. Power of E mMsun/pc^3	Rel diff. %
1,81E+01	1,03E+00	1,04E+00	-1,16E-01
2,01E+01	8,57E-01	8,67E-01	-1,18E+00
2,21E+01	7,09E-01	7,38E-01	-4,12E+00
2,41E+01	6,20E-01	6,37E-01	-2,76E+00

2,61E+01	5,32E-01	5,57E-01	-4,74E+00
2,81E+01	4,87E-01	4,92E-01	-8,37E-01
3,02E+01	4,43E-01	4,35E-01	1,82E+00
3,22E+01	3,99E-01	3,90E-01	2,14E+00
3,42E+01	3,69E-01	3,52E-01	4,56E+00
3,62E+01	3,40E-01	3,20E-01	5,78E+00
3,82E+01	3,10E-01	2,92E-01	5,79E+00
4,02E+01	2,95E-01	2,68E-01	9,27E+00
4,22E+01	2,66E-01	2,47E-01	7,14E+00
4,42E+01	2,36E-01	2,28E-01	3,41E+00
4,62E+01	1,92E-01	2,12E-01	-1,03E+01



6. COMPARISON BETWEEN DM DENSITY DATA - DM DENSITY AS POWER OF E AND NFW DENSITY

According [3] E.V. Karukes, 2015. Parameters of NFW profile for NGC 3198 are

Dark matter density function profile NFW
Rs = 37,2 ± 11 Kpc
Do = (8 ± 4)·10^{-23} Kg/m^3
Do = 1,17 · 10^{-3} Msolar/pc^3 = 1,17 mMsolar/pc^3

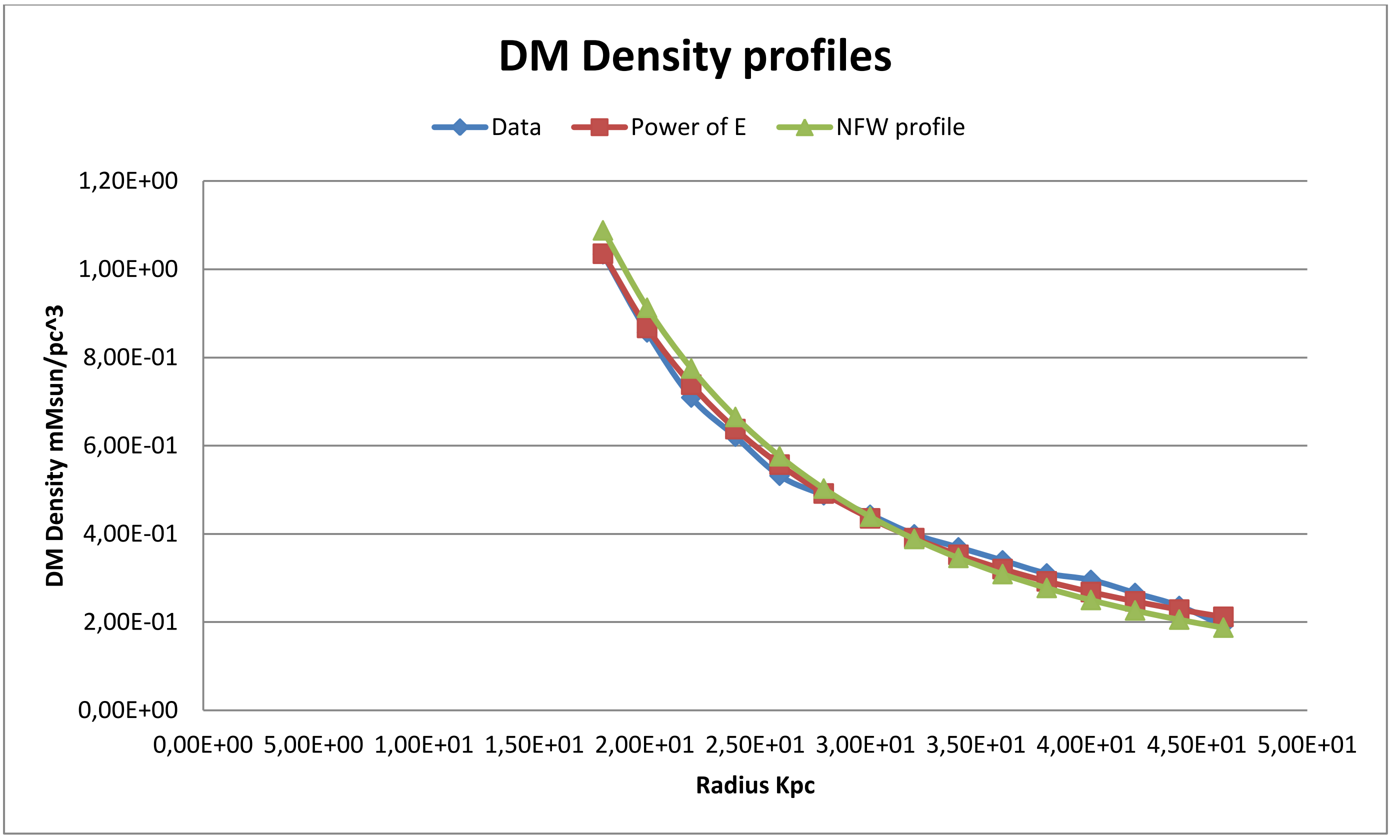
Knowing that mMsolar/pc^3 = 6,768 · 10^{-23} Kg /m^3

Unit of Do has been changed into mMsolar/pc^3 which is a very common unit for galactic densities.

$$D_{NFW}(R) = \frac{D_0}{x \cdot (1+x)^2}$$ Where x= radius/ Rs Rs is called length scale and Do is density scale.

NFW density is one of the most well known profile to study DM density, so it is advisable to compare new results about DM density with NFW density profile.

Radius	Data density	Dens. Power of E	Den. NFW	Data-power E	Data - NFW
Kpc	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	Relt. Diff. %	Relt. Diff. %
1,81E+01	1,03E+00	1,04E+00	1,09E+00	1,16E-01	4,98E+00
2,01E+01	8,57E-01	8,67E-01	9,13E-01	1,17E+00	6,13E+00
2,21E+01	7,09E-01	7,38E-01	7,75E-01	3,96E+00	8,52E+00
2,41E+01	6,20E-01	6,37E-01	6,65E-01	2,68E+00	6,72E+00
2,61E+01	5,32E-01	5,57E-01	5,76E-01	4,53E+00	7,67E+00
2,81E+01	4,87E-01	4,92E-01	5,03E-01	8,30E-01	3,03E+00
3,02E+01	4,43E-01	4,35E-01	4,39E-01	1,86E+00	9,36E-01
3,22E+01	3,99E-01	3,90E-01	3,88E-01	2,19E+00	2,69E+00
3,42E+01	3,69E-01	3,52E-01	3,45E-01	4,78E+00	6,90E+00
3,62E+01	3,40E-01	3,20E-01	3,09E-01	6,14E+00	1,00E+01
3,82E+01	3,10E-01	2,92E-01	2,77E-01	6,15E+00	1,18E+01
4,02E+01	2,95E-01	2,68E-01	2,50E-01	1,02E+01	1,81E+01
4,22E+01	2,66E-01	2,47E-01	2,26E-01	7,69E+00	1,74E+01
4,42E+01	2,36E-01	2,28E-01	2,06E-01	3,54E+00	1,49E+01
4,62E+01	1,92E-01	2,12E-01	1,87E-01	9,33E+00	2,45E+00
		Total sum of	Differences→	6,52E+01	1,22E+02

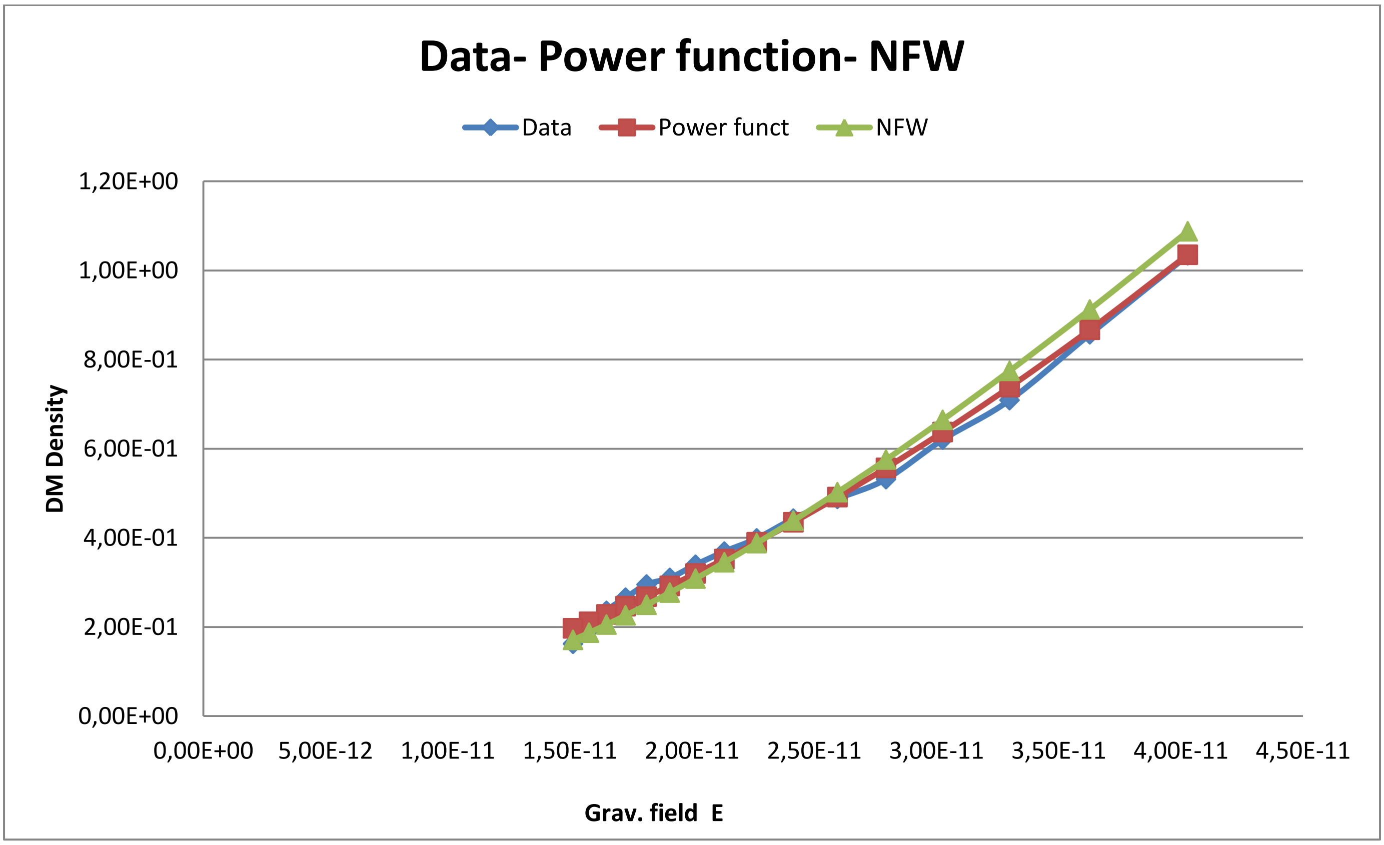


It is shown clearly that Power of E function fits better than NFW profile data of DM density.

6.1 DM DENSITY PROFILES DEPENDING ON GRAVITATIONAL FIELD. TABLES & GRAPHS

Below are tabulated and plotted three DM profiles depending on E. In last column has been tabulated radius as reference. The most remarkable property is that function are increasing whereas in previous epigraph are decreasing with radius. Likely it is clearly shown that Power of E profile fits better data than NFW one.

Gravt. Field	Data density	Dens. Power of E	Den. NFW	Data-pow E	Data - NFW	Radius
m/s^2	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	Relt. Diff. %	Relt. Diff. %	Kpc
4,03E-11	1,03E+00	1,04E+00	1,09E+00	1,16E-01	4,98E+00	1,81E+01
3,63E-11	8,57E-01	8,67E-01	9,13E-01	1,17E+00	6,13E+00	2,01E+01
3,30E-11	7,09E-01	7,38E-01	7,75E-01	3,96E+00	8,52E+00	2,21E+01
3,03E-11	6,20E-01	6,37E-01	6,65E-01	2,68E+00	6,72E+00	2,41E+01
2,79E-11	5,32E-01	5,57E-01	5,76E-01	4,53E+00	7,67E+00	2,61E+01
2,59E-11	4,87E-01	4,92E-01	5,03E-01	8,30E-01	3,03E+00	2,81E+01
2,41E-11	4,43E-01	4,35E-01	4,39E-01	1,86E+00	9,36E-01	3,02E+01
2,26E-11	3,99E-01	3,90E-01	3,88E-01	2,19E+00	2,69E+00	3,22E+01
2,13E-11	3,69E-01	3,52E-01	3,45E-01	4,78E+00	6,90E+00	3,42E+01
2,01E-11	3,40E-01	3,20E-01	3,09E-01	6,14E+00	1,00E+01	3,62E+01
1,91E-11	3,10E-01	2,92E-01	2,77E-01	6,15E+00	1,18E+01	3,82E+01
1,81E-11	2,95E-01	2,68E-01	2,50E-01	1,02E+01	1,81E+01	4,02E+01
1,73E-11	2,66E-01	2,47E-01	2,26E-01	7,69E+00	1,74E+01	4,22E+01
1,65E-11	2,36E-01	2,28E-01	2,06E-01	3,54E+00	1,49E+01	4,42E+01
1,58E-11	1,92E-01	2,12E-01	1,87E-01	9,33E+00	2,45E+00	4,62E+01
		Total sum of	differences	6,52E+01	1,22E+02	



7. BERNOULLI DIFFERENTIAL EQUATION FOR GRAVITATIONAL FIELD IN NGC 3198 HALO

It will be considered the region 18 Kpc < Radius < 46 Kpc where density of baryonic matter is negligible. So for radius bigger than 18 Kpc, Dark matter is the only kind of matter which exits in a significant amount.
Althoug in epigraph 5 has been got this formula for DM density $\varphi_{DM}(r) = A \cdot E^B \;\; where\; A = 2{,}80080937 \cdot 10^{-5} \;\; and \;\; B = 1{,}693308$ in order to simplfy calculus in the rest of paper it will consider the formula a bit approximate $\varphi_{DM}(r) = A \cdot E^B \;\; where\; A = 2{,}8 \cdot 10^{-5} \;\; and \;\; B = 1{,}69$. This level of accuracy is enough for purpose of this paper.

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 > 18 Kpc then the derivative of M(r) depend on dark matter density only and therefore
$M'(r) = 4\pi r^2 \varphi_{DM}(r)$ As $\varphi_{DM}(r) = A \cdot E^{1,69}(r)$ where A = 2,8 · 10^{-5} then $M'(r) = 4\pi r^2 \cdot A \cdot E^{1,69}$
Now it will differentiated E(r) when r > 18 Kpc

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 $\varphi_{DM}(r) = A \cdot E^{1,69}(r)$

it is right to get $E'(r) = 4\pi \cdot G \cdot A \cdot E^{1,69}(r) - 2\dfrac{E(r)}{r}$ which is a Bernoulli differential equation.

As parameter $A = 2{,}8 \cdot 10^{-5} \; .I.S.$ parameter $K = 4\pi \cdot G \cdot A = 2{,}34681 \cdot 10^{-14} \; I.S.$

Calling ***y*** to E, the differential equation is written this way $y` = K \cdot y^{1,74} - \dfrac{2 \cdot y}{x}$

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

This is the general solution $$E(r) = \left(Cr^{2n-2} + \frac{Kr(1-n)}{3-2n} \right)^{\frac{1}{1-n}} \;\; with\; n \neq 1 \; and\, n \neq 3/2$$

Where C may be calculated by initial condition of gravitational field at a specific radius.

For n = 1,69 1/(1-n) = - 1, 45

2n-2 = 1,38 (1-n)/(3-2n) = 1,8158

For n= 1,69 formula above is reduced to

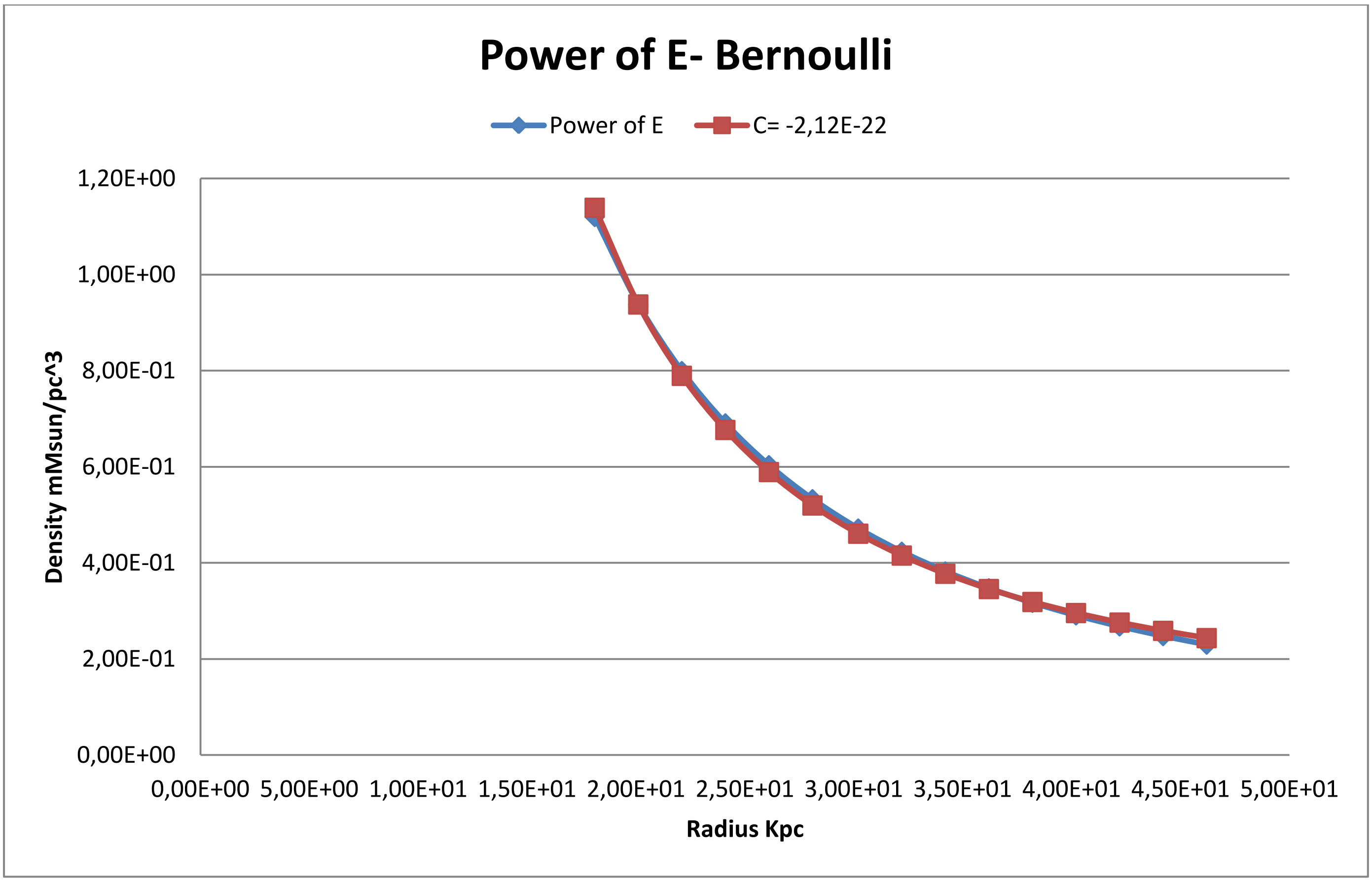
$E(r) = \left(Cr^{1,38} + Dr \right)^{-1,45} \;\; where\; D = 4{,}2613 \cdot 10^{-14}$ and C is calculated below.

7.1 CALCULUS OF PARAMETER C

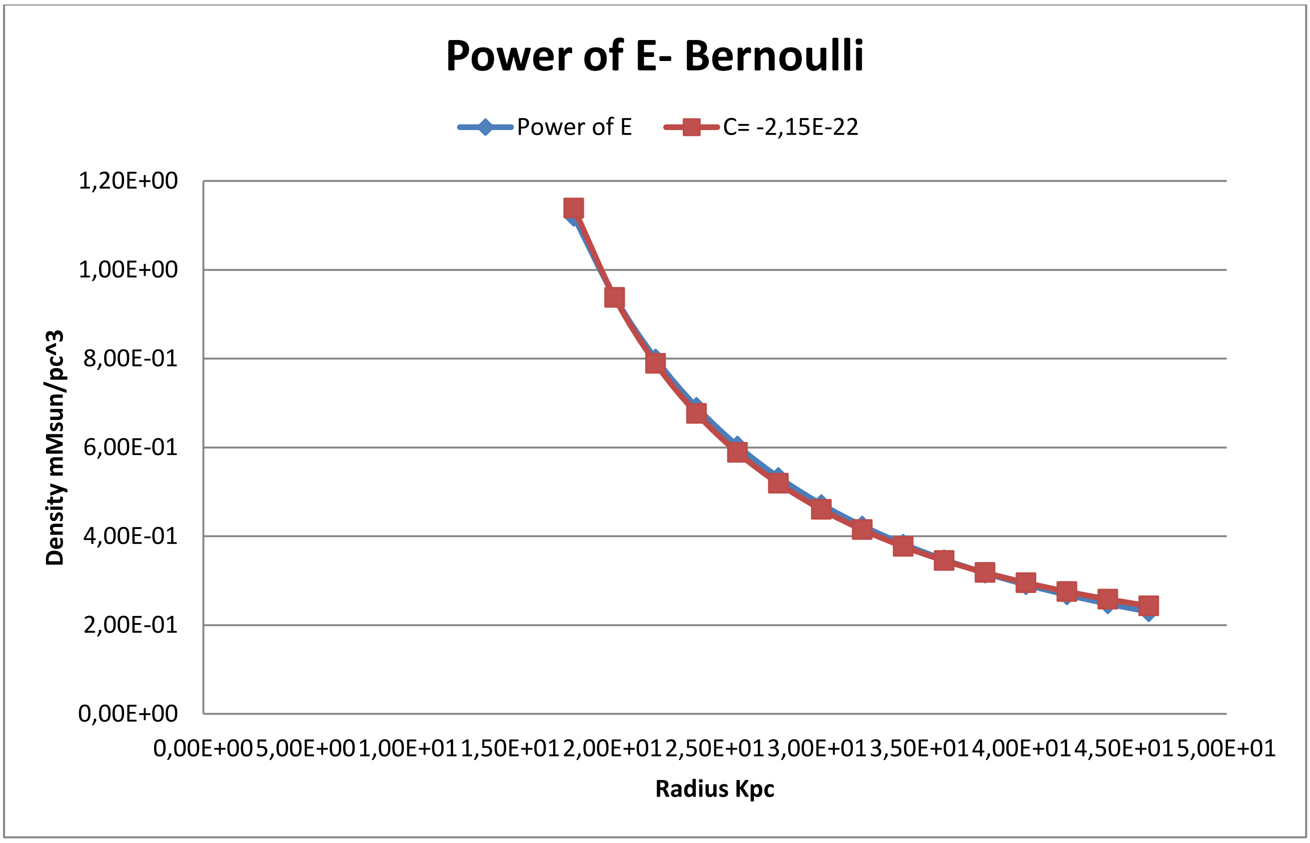
Radius	Radius	Gravt.field	C
Kpc	m	m/s^2	I.S.
18,1	5,59E+20	4,03E-11	$-2{,}1195\cdot10^{-22}$
26,1	8,05E+20	2,79E-11	$-2{,}16\cdot10^{-22}$
34,2	1,06E+21	2,13E-11	$-2{,}152\cdot10^{-22}$
44,2	1,36E+21	1,65E-11	$-2{,}1595\cdot10^{-22}$

In order to check quality of parameter C calculus, it will be calculated for four different values of initial condition.

Results are very close between them, however it must be chosen which minimize relative differences with DM density power of E. Below are plotted both functions for different values of parameter C.

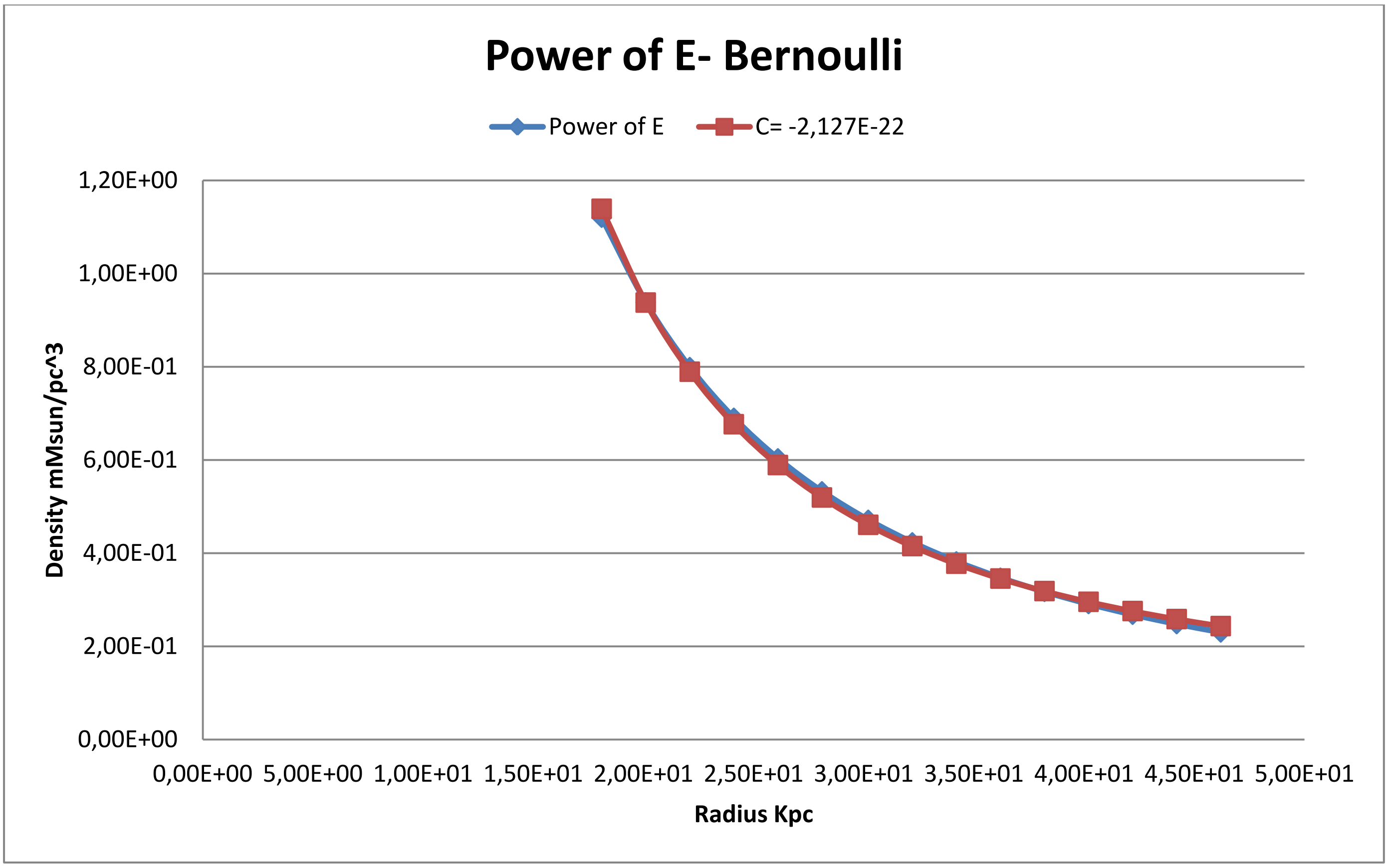


Visually it can be checked that Bernoulli function with C = -2,15E-22 is less accuracy that C=-2,12E-22



However numerically may be improved accuracy so it was checked that C = -2,127E-22 is the best parameter which minimizes relative difference between DM density as power of E and DM density got through Bernoulli method. Below is the table with both functions and its relative difference.

Radius	DM Power E	DM Bernoulli	Relativ. Diff.
Kpc	mMsun/pc^3	mMsun/pc^3	%
1,81E+01	1,12E+00	1,14E+00	1,68E+00
2,01E+01	9,38E-01	9,38E-01	-3,87E-02
2,21E+01	7,99E-01	7,89E-01	-1,25E+00
2,41E+01	6,90E-01	6,77E-01	-2,02E+00
2,61E+01	6,03E-01	5,89E-01	-2,43E+00
2,81E+01	5,33E-01	5,20E-01	-2,52E+00
3,02E+01	4,72E-01	4,61E-01	-2,33E+00
3,22E+01	4,23E-01	4,15E-01	-1,90E+00
3,42E+01	3,82E-01	3,77E-01	-1,27E+00
3,62E+01	3,47E-01	3,46E-01	-4,54E-01
3,82E+01	3,17E-01	3,19E-01	5,14E-01
4,02E+01	2,91E-01	2,96E-01	1,62E+00
4,22E+01	2,68E-01	2,76E-01	2,84E+00
4,42E+01	2,48E-01	2,59E-01	4,17E+00
4,62E+01	2,30E-01	2,44E-01	5,59E+00



Therefore the best function for DM density got by Berrnoulli method is

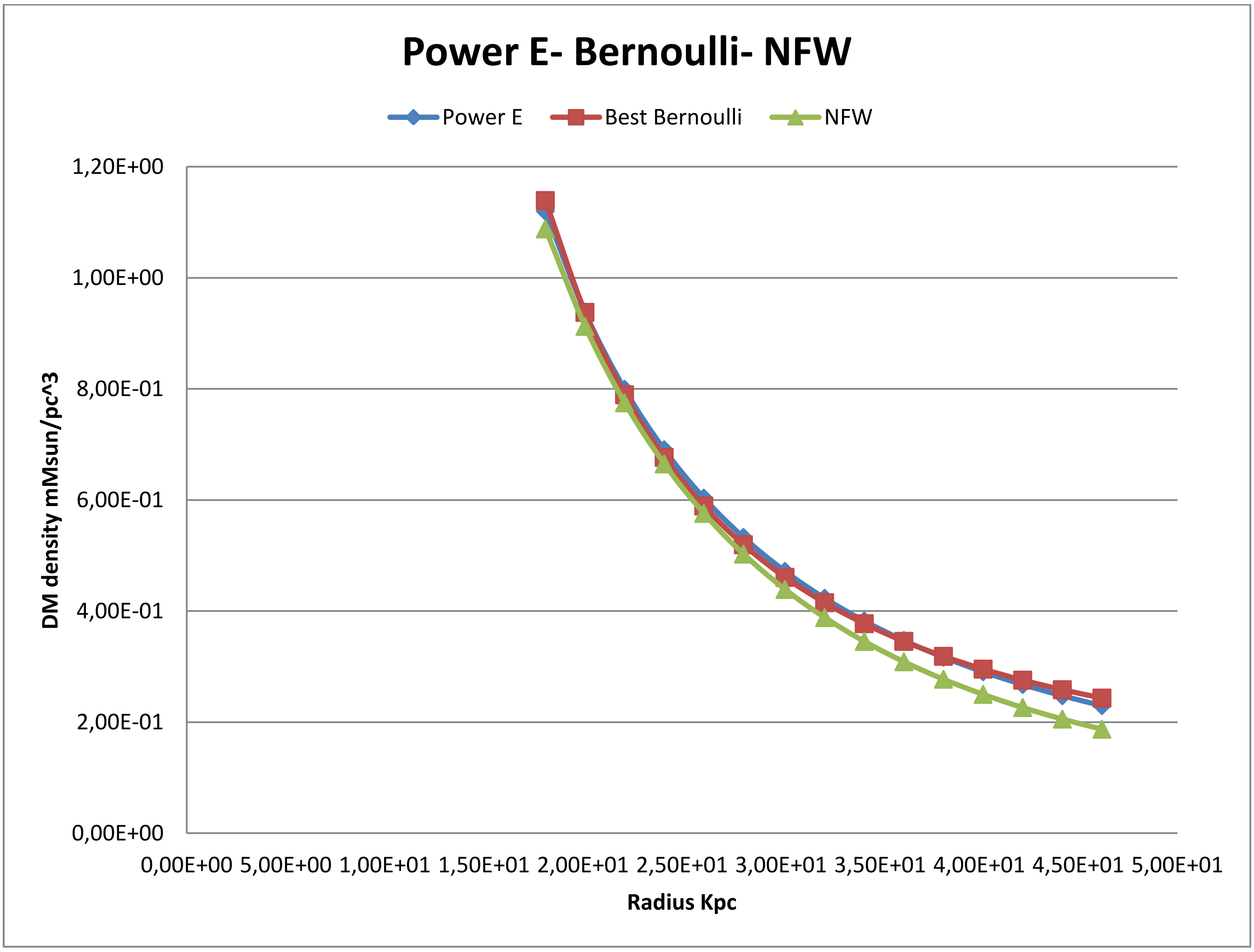
THE BEST DM DENSITY GOT BY BERNOULLI METHOD
$E(r) = \left(Cr^{1,38} + Dr\right)^{-1,45}$ where $D = 4{,}2613 \cdot 10^{-14}$ and $C = -2{,}127 \cdot 10^{-22}$
$\varphi_{DM\ BERNOULLI}(r) = A \cdot (Cr^{1,38} + Dr)^{-2,45}$ where $A = 2{,}8 \cdot 10^{-5}$

As it was said at the begin of epigraph this solution for Bernoulli equation belong to this DM density profile $\varphi_{DM}(r) = A \cdot E^{B}$ where $A = 2{,}8 \cdot 10^{-5}$ and $B = 1{,}69$ which is an approximation of this profile

$\varphi_{DM}(r) = A \cdot E^{B}$ where $A = 2{,}80080937 \cdot 10^{-5}$ and $B = 1{,}693308$ which fits data DM density with correlation coefficient = 0,99. Therefore it could be improved Bernoulli profile although I have considered that is not necessary maximum of accuracy to explain the main target this paper.

8. COMPARISON BETWEEN DENSITY AS POWER OF E DENSITY BERNOULLI AND NFW PROFILE

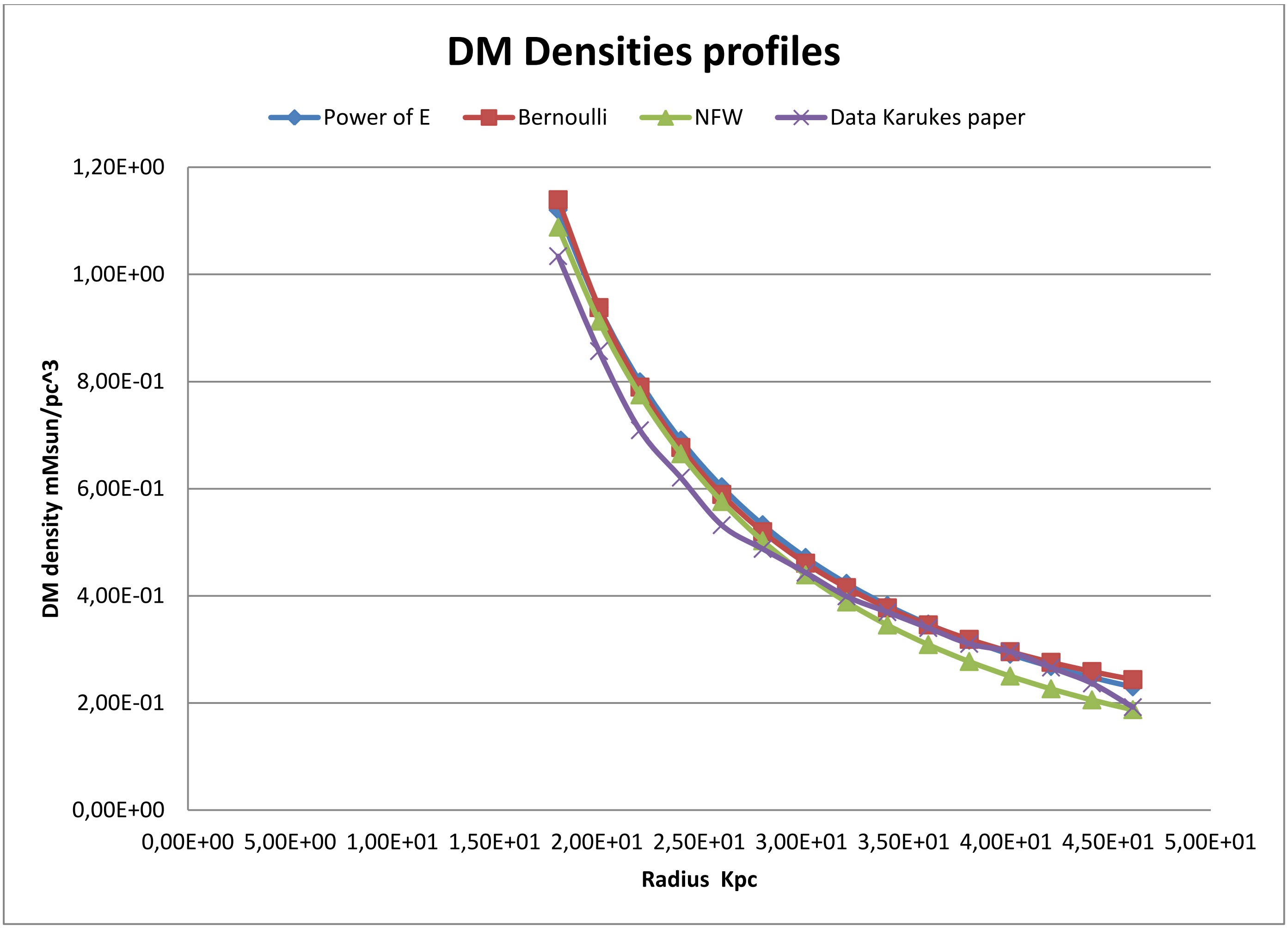
Radius	DM Power of E	DM Bernoulli C = the best	NFW Profile
Kpc	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3
1,81E+01	1,12E+00	1,14E+00	1,08814268
2,01E+01	9,38E-01	9,38E-01	0,91266076
2,21E+01	7,99E-01	7,89E-01	0,7750202
2,41E+01	6,90E-01	6,77E-01	0,66508429
2,61E+01	6,03E-01	5,89E-01	0,57592609
2,81E+01	5,33E-01	5,20E-01	0,50266888
3,02E+01	4,72E-01	4,61E-01	0,43902368
3,22E+01	4,23E-01	4,15E-01	0,38836481
3,42E+01	3,82E-01	3,77E-01	0,34545553
3,62E+01	3,47E-01	3,46E-01	0,3088261
3,82E+01	3,17E-01	3,19E-01	0,27733752
4,02E+01	2,91E-01	2,96E-01	0,25009598
4,22E+01	2,68E-01	2,76E-01	0,22639208
4,42E+01	2,48E-01	2,59E-01	0,20565705
4,62E+01	2,30E-01	2,44E-01	0,18743065



Plot shows that DM Density by Bernoulli method fit perfectly to power of E whereas NFW profile is a bit different.

9. COMPARISON BETWEEN DM DENSITY PROFILES DATA - BERNOULLI & DATA - NFW

Radius	DM Power of E	DM Bernoulli	NFW	Den DM data	Relat. Diff %	Rel. Diff. %
Kpc	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	Data-Bernll.	Data - nFW
1,81E+01	1,12E+00	1,14E+00	1,08814268	1,03E+00	1,02E+01	5,24E+00
2,01E+01	9,38E-01	9,38E-01	0,91266076	8,57E-01	9,48E+00	6,53E+00
2,21E+01	7,99E-01	7,89E-01	0,7750202	7,09E-01	1,14E+01	9,31E+00
2,41E+01	6,90E-01	6,77E-01	0,66508429	6,20E-01	9,09E+00	7,21E+00
2,61E+01	6,03E-01	5,89E-01	0,57592609	5,32E-01	1,08E+01	8,31E+00
2,81E+01	5,33E-01	5,20E-01	0,50266888	4,87E-01	6,58E+00	3,12E+00
3,02E+01	4,72E-01	4,61E-01	0,43902368	4,43E-01	4,00E+00	9,27E-01
3,22E+01	4,23E-01	4,15E-01	0,38836481	3,99E-01	4,12E+00	2,62E+00
3,42E+01	3,82E-01	3,77E-01	0,34545553	3,69E-01	2,20E+00	6,45E+00
3,62E+01	3,47E-01	3,46E-01	0,3088261	3,40E-01	1,72E+00	9,10E+00
3,82E+01	3,17E-01	3,19E-01	0,27733752	3,10E-01	2,72E+00	1,06E+01
4,02E+01	2,91E-01	2,96E-01	0,25009598	2,95E-01	5,90E-02	1,53E+01
4,22E+01	2,68E-01	2,76E-01	0,22639208	2,66E-01	3,71E+00	1,49E+01
4,42E+01	2,48E-01	2,59E-01	0,20565705	2,36E-01	9,39E+00	1,30E+01
4,62E+01	2,30E-01	2,44E-01	0,18743065	1,92E-01	2,68E+01	2,39E+00
			Rel. Diff. →	Total Sum →	1,12E+02	1,15E+02



As plot shows Bernoulli profile does not fit well data profile in first half of dominion. The reason is that in order to simplify calculus in differential equation instead to consider

$\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,80080937 \cdot 10^{-5} \ and \ B = 1,693308$ this formula was approximate by

$\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,8 \cdot 10^{-5} \ and \ B = 1,69$ which is a good approximation for the second half of dominion but not for the first half.

In epigraph 6.1 it was calculated total sum of relative differences between power of E versus data profile and NFW versus data profile. Below are results which means that power of E profile fits data profile better than NFW profile.

Total sum of relt. differences between DM density as power of E & Data profiles	Total sum of relt. differences between NFW & Data profiles
6,52E+01%	1,22E+02 %

However in table of epigraph 8 results of total sum of relative differences are

Total sum of relt. differences between Bernoulli & Data profiles	Total sum of relt. differences between NFW & Data profiles
112 %	115%

The only reason to explain the increasing of difference relative in Bernoulli profile is that DM density was approximate by this formula $\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,8 \cdot 10^{-5} \ and \ B = 1,69$ instead to use this one:

$\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,80080937 \cdot 10^{-5} \ and \ B = 1,693308$. in order to simplify calculus to solve Bernoulli differential equation.

This loss of accuracy is not important because the main target this paper is not to achive maximum of accuracy for DM density profile but to show that DM is generated by gravitational field. It is clear that the only way that Bernoulli differential equation fits so well DM density data is why DM is generated by gravitational field according this law: $\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,80080937 \cdot 10^{-5} \ and \ B = 1,693308$ for NGC 3198 galaxy and similar laws with different coefficients for other galaxies or cluster of galaxies.

Reader can solve the Bernoulli equation using $\varphi_{DM}(r) = A \cdot E^B \ where \ A = 2,80080937 \cdot 10^{-5} \ and \ B = 1,693308$ to achieve more accuracy for Bernoulli profile and so fit better DM data profile.

10. CONCLUSION

It seem clear that inner logic of development this paper allow to state that this paper has demonstrated that DM origin is gravitational field.

This is the inner logic: DM density data are fitted with a function as power of E. Thanks this function it has been possible to state a Bernoulli differential equation inside galactic halo where density of baryonic is negligible in comparison with DM density.

Solution of Bernoulli equation is a new DM profile which has been compared with DM density data getting relative differences under 10% inside main part of dominion.

In adition, comparing NFW profile and Bernoulli profile with DM Data profile, Bernoulli is even better than NFW.

What is the conclusion?

11. BIBLIOGRAPHY

[1] Abarca,M.2014,viXra:1410.0200
Dark matter model by quantum vacuum

[2] Abarca,M.2015,viXra:**1510.0324**
Dark matter density function depending on gravitational field as Universal law

[3] E.V. Karukes, 2015. A&A. N3198A.
The dark matter distribution in the spiral NGC 3198 out to 0.22 Rvir