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

Author Manuel Abarca Hernandez **email** mabarcaher1@gmail.com

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 a similar 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 a new DM density profile, called Bernoulli profile in this paper, 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. Therefore 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.

In fourth epigraph, starting from spin speed from Karukes data, it is right to calculate gravitational field E, through Virial theorem. So in this epigraph has been tabulate gravitational field and density of dark matter inside a wide region of halo, from 18 kpc to 46 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= 4,04598703 $\cdot 10^{-5}$ and B= 1,70654481

In sixth and seventh epigraph it has been compared DM density data, DM density as power of E, NFW & Burket profiles. Tables and plots show clearly that DM density power of E adjusts better than the other ones.

In eight 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 $\varphi_{DM}(r) = A \cdot E^B(r)$ then $M'(r) = 4\pi r^2 \cdot A \cdot E^B$. 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 nineth epigraph Bernoulli, NFW and Burket DM density profiles have been compared to Karukes data of DM density. Results show clearly that Bernoulli profile fits better than the other ones.

Paper finish concluding that results supports clearly hypothesis about DM nature defended by the author.

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 $\cdot 10^{-5} \cdot E^B$ 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 $_{DM}$ = 4,04598703 $\cdot 10^{-5} \cdot E^B$ where B= 1,70654481 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 and Burket are DM density profile well known by astrophysics researchers is a good test to compare the new density profile with both profiles. Chapter 9 is dedicated to this assignment with very successful results.

3. OBSERVATIONAL DATA FROM KARUKES.2015 PAPER

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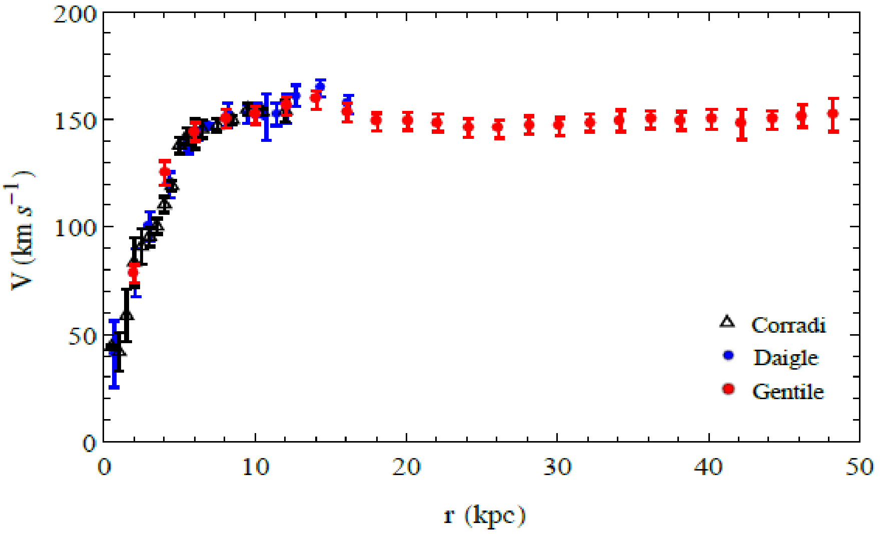


Fig. 1. Comparison between Hα and HI RCs black open triangles with error bars from Corradi et al. (1991), blue circles with error bars are from Daigle et al. (2006), and red circles with error bars are from Gentile et al. (2013).

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

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

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

In order to guarantee that baryonic gas density is negligible 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.

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

The two last columns belong to D.M. density according Karukes data into International System and mMsun/pc^3

Radius kpc	Radius m	Velocity km/s	Virial E m/s^2	DM Den. data kg/m^3	DM Den. data mMsun/pc^3
20,1	6,20E+20	1,49E+02	3,58E-11	5,8E-23	8,57E-01
22,1	6,82E+20	1,48E+02	3,23E-11	4,80E-23	7,09E-01
24,1	7,44E+20	1,46E+02	2,87E-11	4,20E-23	6,21E-01
26,1	8,05E+20	1,46E+02	2,63E-11	3,60E-23	5,32E-01
28,1	8,67E+20	1,47E+02	2,50E-11	3,30E-23	4,88E-01
30,2	9,32E+20	1,47E+02	2,30E-11	3,00E-23	4,43E-01
32,2	9,94E+20	1,48E+02	2,22E-11	2,70E-23	3,99E-01
34,2	1,06E+21	1,49E+02	2,11E-11	2,50E-23	3,69E-01
36,2	1,12E+21	1,50E+02	2,01E-11	2,30E-23	3,40E-01
38,2	1,18E+21	1,49E+02	1,89E-11	2,10E-23	3,10E-01
40,2	1,24E+21	1,50E+02	1,81E-11	2,00E-23	2,96E-01
~~42,1~~	~~1,30E+21~~	~~1,47E+02~~	~~1,66E-11~~	~~1,80E-23~~	~~2,66E-01~~
44,2	1,36E+21	1,50E+02	1,65E-11	1,60E-23	2,36E-01
46,2	1,43E+21	1,52E+02	1,61E-11	1,30E-23	1,92E-01

Data at radius 42,1 Kpc has been cross out because it is anomalous. In addition it has a bigger experimental error as it is seen in Karukes data table. So anomalous data has been substituted by a logic data, velocity = 150 Km/s

Radius kpc	Radius m	Velocity km/s	Virial E m/s^2	DM Den. data kg/m^3	DM Den. data mMsunes/pc^3
20,1	6,20E+20	1,49E+02	3,58E-11	5,8E-23	8,57E-01
22,1	6,82E+20	1,48E+02	3,23E-11	4,80E-23	7,09E-01
24,1	7,44E+20	1,46E+02	2,87E-11	4,20E-23	6,21E-01
26,1	8,05E+20	1,46E+02	2,63E-11	3,60E-23	5,32E-01
28,1	8,67E+20	1,47E+02	2,50E-11	3,30E-23	4,88E-01
30,2	9,32E+20	1,47E+02	2,30E-11	3,00E-23	4,43E-01
32,2	9,94E+20	1,48E+02	2,22E-11	2,70E-23	3,99E-01
34,2	1,06E+21	1,49E+02	2,11E-11	2,50E-23	3,69E-01
36,2	1,12E+21	1,50E+02	2,01E-11	2,30E-23	3,40E-01
38,2	1,18E+21	1,49E+02	1,89E-11	2,10E-23	3,10E-01
40,2	1,24E+21	1,50E+02	1,81E-11	2,00E-23	2,96E-01
42,1	1,30E+21	1,50E+02	1,73E-11	1,80E-23	2,66E-01
44,2	1,36E+21	1,50E+02	1,65E-11	1,60E-23	2,36E-01
46,2	1,43E+21	1,52E+02	1,61E-11	1,30E-23	1,92E-01

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

From previous table, it has been written down this columns, which will be used to find DM density depending on E through a power function.

Radius	Virial Field E v^2/R	DM density Karukes data
Kpc	m/s^2	Kg/m^3
20,1	3,58E-11	5,8E-23
22,1	3,23E-11	4,80E-23
24,1	2,87E-11	4,20E-23
26,1	2,63E-11	3,60E-23
28,1	2,50E-11	3,30E-23
30,2	2,30E-11	3,00E-23
32,2	2,22E-11	2,70E-23
34,2	2,11E-11	2,50E-23
36,2	2,01E-11	2,30E-23
38,2	1,89E-11	2,10E-23
40,2	1,81E-11	2,00E-23
42,2	1,73E-11	1,80E-23
44,2	1,65E-11	1,60E-23
46,2	1,62E-11	1,30E-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 $_{\text{DARK MATTER}} = A\cdot E^B$

DM Density Power of E $D_{DM\ PwE} = A\cdot E^B$ Where $A= 4{,}04598703 \cdot 10^{-5}$ $B= 1{,}70654481$ being correlation coefficient r = 0,9899977.

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.

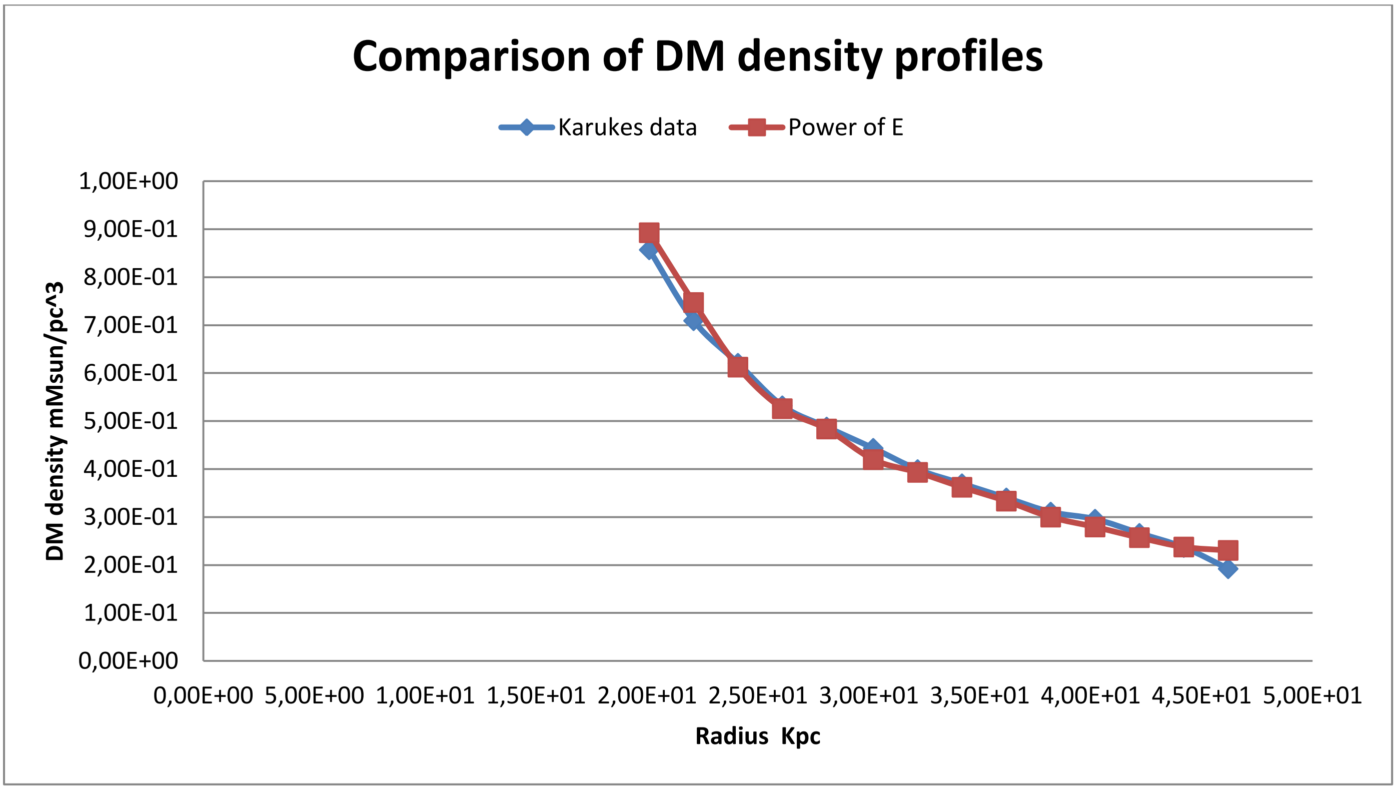
Dark matter density function as Universal law for big galaxies – International System of Units						
$\text{Density}_{DM} = 2{,}526 \cdot 10^{-5} \cdot E^B$ where B= 1,74						
Where Unit for Density $_{D.M.}$ is Kg / m^3 and Unit for E is m/s^2						
E gravt. I.S.	$3{,}24\cdot 10^{-12}$	$1{,}62\cdot 10^{-11}$	$4{,}86\cdot 10^{-11}$	$9{,}72\cdot 10^{-11}$	$1{,}458\cdot 10^{-10}$	$2{,}106\cdot 10^{-10}$
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 coefficients A and B for NGC 3198 are close to values got for big galaxies and both parameters increase DM density in comparison with parameters for big galaxies. Reason to explain this fact is that intermediate galaxy near big galaxies could appropriate a part of DM density generated by gravitational field of big 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 mainly under 6% in the whole dominion 20 Kpc < radius < 46 Kpc.

Kpc	m/s^2	I.S.	I.S.	mMsun/pc^3	mMsun/pc^3	Relt diff %
Radius	Virial E	DM power E	DM Karukes	DM power E	DM Karukes	
2,01E+01	3,58E-11	6,04E-23	5,80E-23	8,93E-01	8,57E-01	4,00E+00
2,21E+01	3,23E-11	5,06E-23	4,80E-23	7,47E-01	7,09E-01	5,08E+00
2,41E+01	2,87E-11	4,14E-23	4,20E-23	6,12E-01	6,21E-01	1,33E+00
2,61E+01	2,63E-11	3,56E-23	3,60E-23	5,26E-01	5,32E-01	1,15E+00
2,81E+01	2,50E-11	3,27E-23	3,30E-23	4,83E-01	4,88E-01	8,53E-01
3,02E+01	2,30E-11	2,84E-23	3,00E-23	4,20E-01	4,43E-01	5,63E+00
3,22E+01	2,22E-11	2,66E-23	2,70E-23	3,93E-01	3,99E-01	1,50E+00
3,42E+01	2,11E-11	2,45E-23	2,50E-23	3,62E-01	3,69E-01	2,03E+00
3,62E+01	2,01E-11	2,25E-23	2,30E-23	3,33E-01	3,40E-01	2,02E+00
3,82E+01	1,89E-11	2,03E-23	2,10E-23	3,00E-01	3,10E-01	3,51E+00
4,02E+01	1,81E-11	1,89E-23	2,00E-23	2,79E-01	2,96E-01	5,85E+00
4,22E+01	1,73E-11	1,74E-23	1,80E-23	2,57E-01	2,66E-01	3,49E+00
4,42E+01	1,65E-11	1,61E-23	1,60E-23	2,37E-01	2,36E-01	4,42E-01
4,62E+01	1,62E-11	1,56E-23	1,30E-23	2,30E-01	1,92E-01	1,66E+01



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

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.

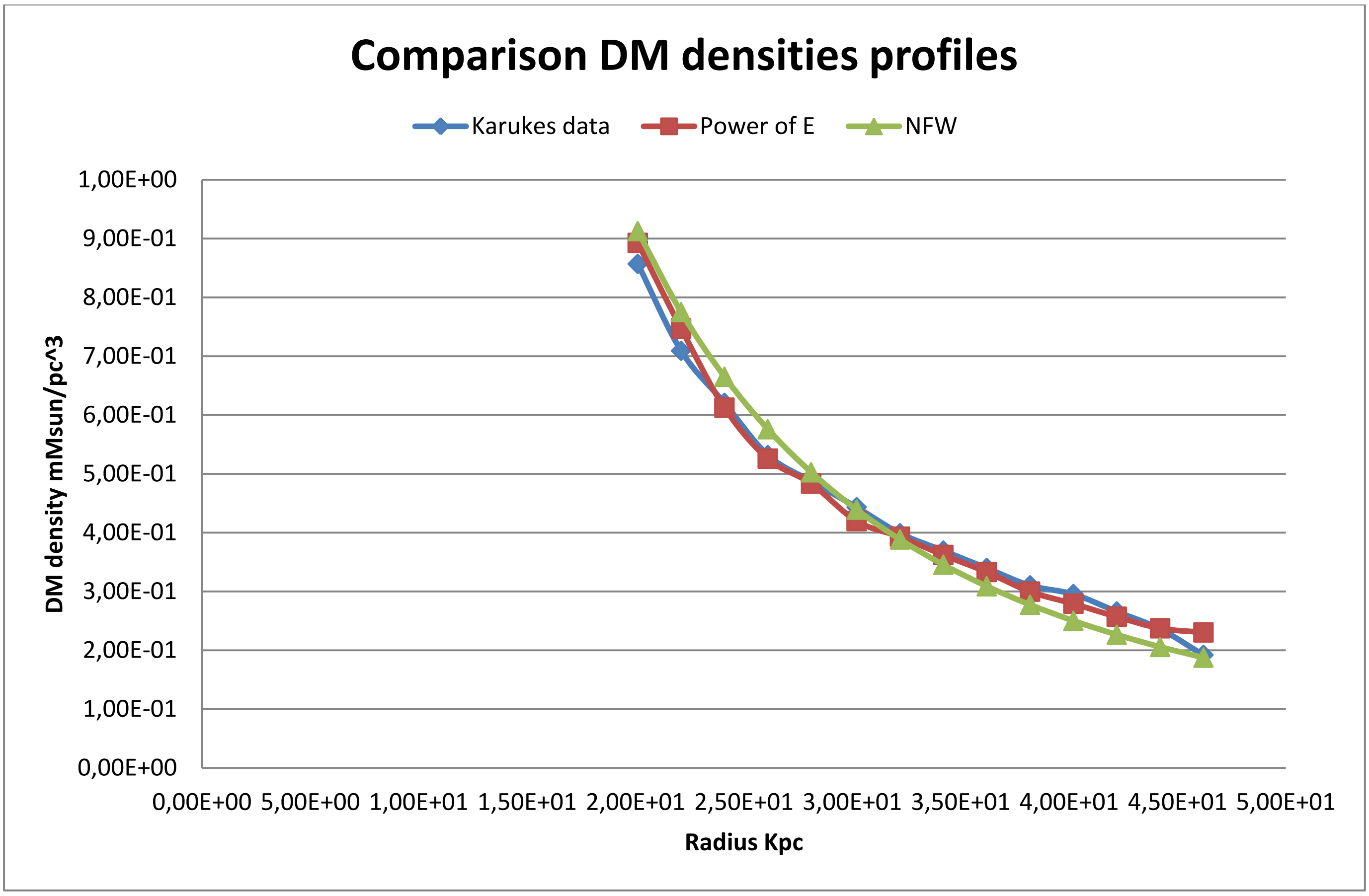
$$D_{NFW}(R) = \frac{D_0}{x \cdot (1+x)^2}$$

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.

	karukes	Pow E	NFW profile	Rel. Diff	Relt. Diff.
Radius Kpc	mMsunes	mMsuns	mMsuns	Data-Power	Data- NFW
2,01E+01	8,57E-01	8,93E-01	9,13E-01	4,00E+00	6,10E+00
2,21E+01	7,09E-01	7,47E-01	7,75E-01	5,08E+00	8,49E+00
2,41E+01	6,21E-01	6,12E-01	6,65E-01	1,33E+00	6,69E+00
2,61E+01	5,32E-01	5,26E-01	5,76E-01	1,15E+00	7,64E+00
2,81E+01	4,88E-01	4,83E-01	5,03E-01	8,53E-01	3,00E+00
3,02E+01	4,43E-01	4,20E-01	4,39E-01	5,63E+00	9,65E-01
3,22E+01	3,99E-01	3,93E-01	3,88E-01	1,50E+00	2,72E+00
3,42E+01	3,69E-01	3,62E-01	3,45E-01	2,03E+00	6,93E+00
3,62E+01	3,40E-01	3,33E-01	3,09E-01	2,02E+00	1,00E+01
3,82E+01	3,10E-01	3,00E-01	2,77E-01	3,51E+00	1,19E+01
4,02E+01	2,96E-01	2,79E-01	2,50E-01	5,85E+00	1,82E+01
4,22E+01	2,66E-01	2,57E-01	2,26E-01	3,49E+00	1,75E+01
4,42E+01	2,36E-01	2,37E-01	2,06E-01	4,42E-01	1,50E+01
4,62E+01	1,92E-01	2,30E-01	1,87E-01	1,66E+01	2,48E+00
	Total sum of Rel. Diff. % -->			5,35E+01	1,18E+02

It is clear that relative differences between DM density karukes data and power of E is less than a half that karukes data and NFW ones.



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

7.COMPARISON BETWEEN DM DENSITY DATA - DM DENSITY AS POWER OF E AND BURKET PROFILE

According [3] E.V. Karukes, 2015 these are Burket profile parameters for NGC 3198

Dark matter density Burket profile
Rc = 17,7 Kpc
Do = 4,71 mMsolar/pc^3

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

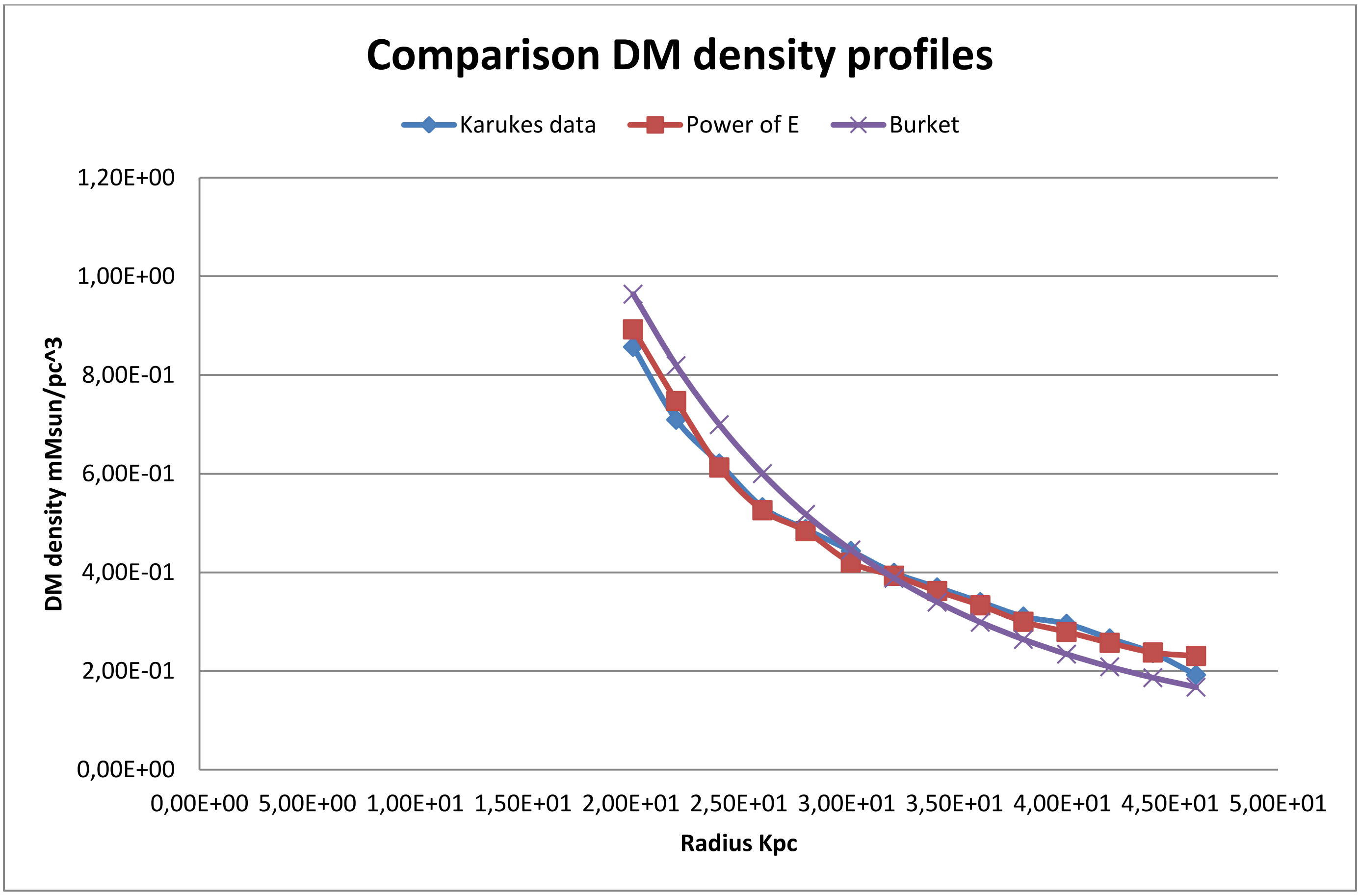
$$D_{BURKET}(R) = \frac{D_0}{(1+x)\cdot(1+x^2)}$$

Where x= radius/ R_C R_C is called length scale and Do is density scale.

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

Radius	Karukes data	Power of E	Burket profile	Rel diff %	Rel. Diff %
Kpc	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	data-pow E	data- Burket
2,01E+01	8,57E-01	8,93E-01	9,64E-01	4,00E+00	1,11E+01
2,21E+01	7,09E-01	7,47E-01	8,19E-01	5,08E+00	1,34E+01
2,41E+01	6,21E-01	6,12E-01	6,99E-01	1,33E+00	1,13E+01
2,61E+01	5,32E-01	5,26E-01	6,00E-01	1,15E+00	1,14E+01
2,81E+01	4,88E-01	4,83E-01	5,17E-01	8,53E-01	5,77E+00
3,02E+01	4,43E-01	4,20E-01	4,45E-01	5,63E+00	4,60E-01
3,22E+01	3,99E-01	3,93E-01	3,88E-01	1,50E+00	2,83E+00
3,42E+01	3,69E-01	3,62E-01	3,40E-01	2,03E+00	8,77E+00
3,62E+01	3,40E-01	3,33E-01	2,99E-01	2,02E+00	1,38E+01
3,82E+01	3,10E-01	3,00E-01	2,64E-01	3,51E+00	1,76E+01
4,02E+01	2,96E-01	2,79E-01	2,34E-01	5,85E+00	2,63E+01
4,22E+01	2,66E-01	2,57E-01	2,08E-01	3,49E+00	2,76E+01
4,42E+01	2,36E-01	2,37E-01	1,86E-01	4,42E-01	2,69E+01
4,62E+01	1,92E-01	2,30E-01	1,67E-01	1,66E+01	1,49E+01
		Total sum of	Rel. Diff. →	5,35E+01	1,92E+02

It is clear that power of E profile fit much more accurately that Burket profile.



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

It will be considered the region 20 Kpc < Radius < 46 Kpc where density of baryonic matter is negligible. So for radius bigger than 20 Kpc, Dark matter is the only kind of matter which exits in a significant amount or at least derivative of baryonic matter is negligible in relation to derivative of DM.

As it is known in this formula $E = G\frac{M(r)}{r^2}$, M(r) represents mass enclosed by a sphere with radius r. If it is considered radius > 20 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 $\varphi_{DM}(r) = A \cdot E^B(r)$ Where A= 4,04598703·10^-5^ B= 1,70654481 then $M'(r) = 4\pi r^2 \cdot A \cdot E^B$

Now it will differentiated E(r) when r > 20 Kpc

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

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

$E'(r) = K \cdot E^B(r) - 2\frac{E(r)}{r}$ being $K = 4\pi \cdot G \cdot A$ then $K = 3{,}39277825 \cdot 10^{-14}$ unit I.S. as A= $4{,}04598703 \cdot 10^{-5}$

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

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

General solution is $E(r) = \left(Cr^{2B-2} + \frac{Kr(1-B)}{3-2B} \right)^{\frac{1}{1-B}}$ $with\ B \neq 1\ and\ B \neq 3/2$

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

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

$\alpha = 2B - 2$ = 1,41308962 $\beta = \frac{1}{1-B}$ = -1,4153384 $D = \left(\frac{K(1-B)}{3-2B} \right)$ = $5{,}80299 \cdot 10^{-14}$ I.S.

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

Initial condition for parameter C calculus

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

In order to check calculus it will be calculated parameter C for different initial condition.

Radius Kpc	Gravt. Field	Parameter C
20,1	3,58E-11	-4,97E-23
24,1	2,87E-11	-4,84E-23
28,1	2,50E-11	-5,01E-23
32,2	2,22E-11	-5,12E-23
36,2	2,01E-11	-5,19E-23
40,2	1,81E-11	-5,16E-23

As it was expected parameter C is very similar for different initial condition.

Ro =	32,2 Kpc = 9,94E20 m
Eo =	2,22E-11 m/s^2
C =	-5,12E-23 I.S.

Above are the initial conditions (Ro, Eo) whose parameter C minimize difference with karukes data along the whole halo dominion. Minimum property has been checked numerically.

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

Bernoulli Solution for Gravitational field inside halo of NGC 3198
$E(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = -5,12· 10^{-23} D= 5,80299 · 10^{-14} α = 1,41308962 β = - 1,4153384 Units I. S.

8.1 DM DENSITY BERNOULLI PROFILE

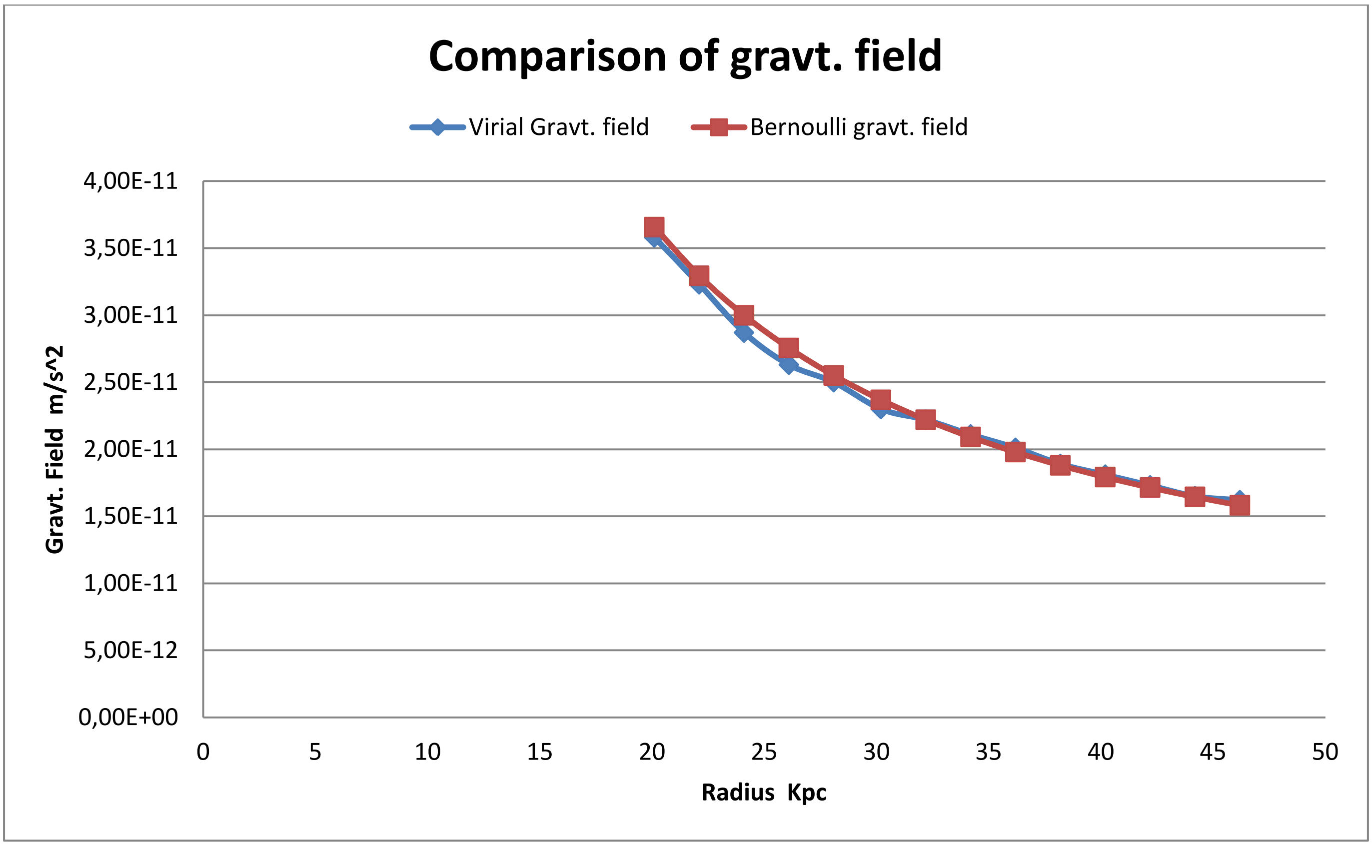
Thanks Bernoulli solution for Gravt. Field is right to get DM density through power of E formula.

DM Density Bernoulli profile for NGC 3198
$E(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = -5,12· 10^{-23} D= 5,80299 · 10^{-14} α = 1,41308962 β = - 1,4153384 Units I. S.
Density $_{\text{D.M. BERNOULLI}}$(r) = $D_{DM\,B}$(r) = A· E^B Where A= 4,04598703·10^{-5} B= 1,70654481 Density unit Kg/ m^3

9. COMPARISON BETWEEN BERNOULLI – NFW – BURKETT PROFILES AND KARUKES DATA

9.1 COMPARISON BETWEEN VIRIAL GRAVT. FIELD AND BERNOULLI SOLUTION FOR E

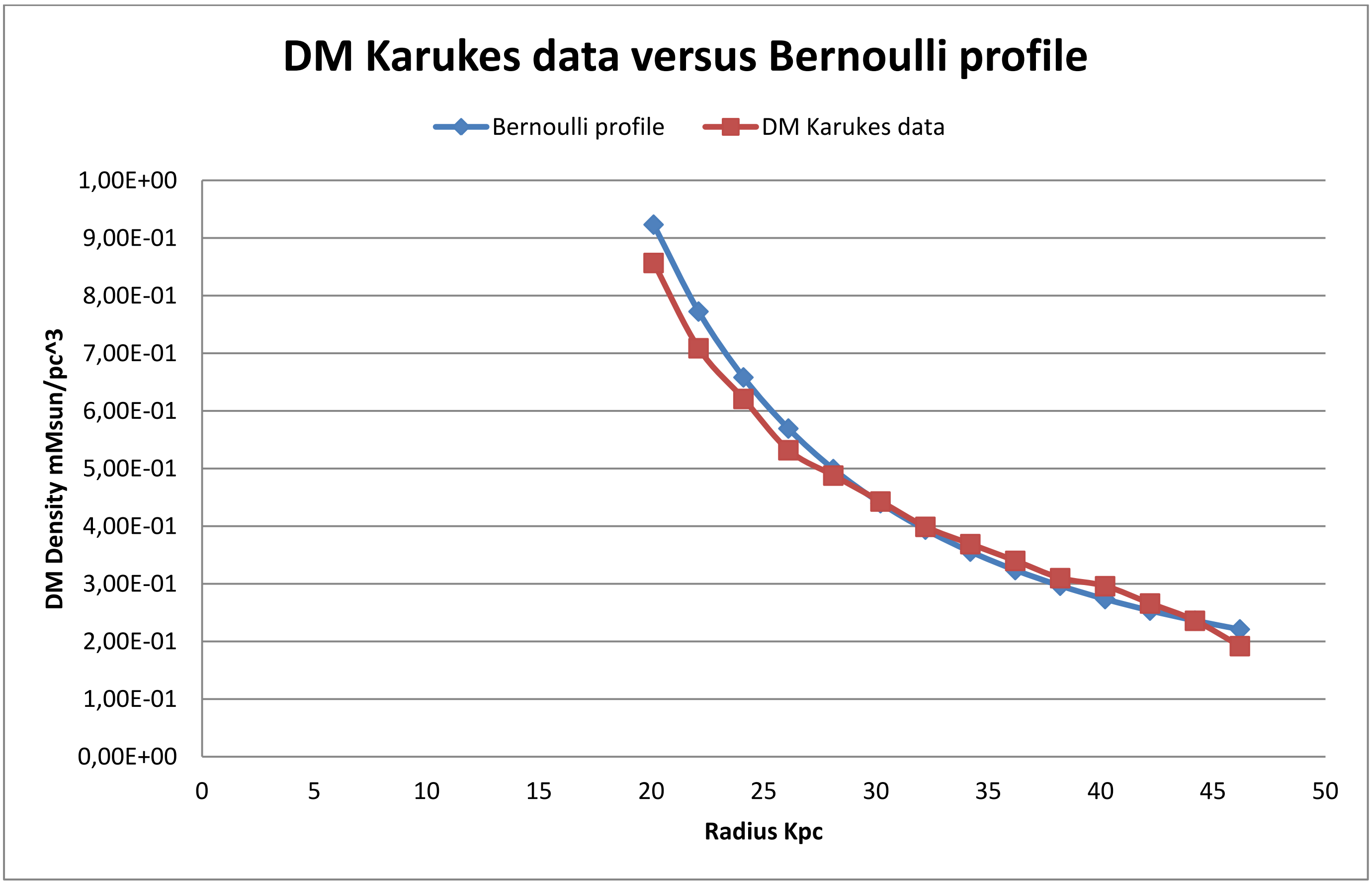
Radius	Virial field E	Bernoulli field E	Relt Diff.
Kpc	m/s^2	m/s^2	%
20,1	3,58E-11	3,66E-11	2,09E+00
22,1	3,23E-11	3,29E-11	1,94E+00
24,1	2,87E-11	3,00E-11	4,30E+00
26,1	2,63E-11	2,75E-11	4,53E+00
28,1	2,50E-11	2,55E-11	1,97E+00
30,2	2,30E-11	2,37E-11	2,88E+00
32,2	2,22E-11	2,22E-11	4,37E-14
34,2	2,11E-11	2,09E-11	8,87E-01
36,2	2,01E-11	1,98E-11	1,56E+00
38,2	1,89E-11	1,88E-11	5,20E-01
40,2	1,81E-11	1,79E-11	9,68E-01
42,2	1,73E-11	1,71E-11	8,95E-01
44,2	1,65E-11	1,64E-11	3,14E-01
46,2	1,62E-11	1,58E-11	2,40E+00
	Total sum of	Relt. Diff.	2,52E+01



Bernoulli solution for gravitational field fits almost perfectly to Virial gravitational data got through observational values of spin speed of rotational curve of NGC 3198 galaxy.

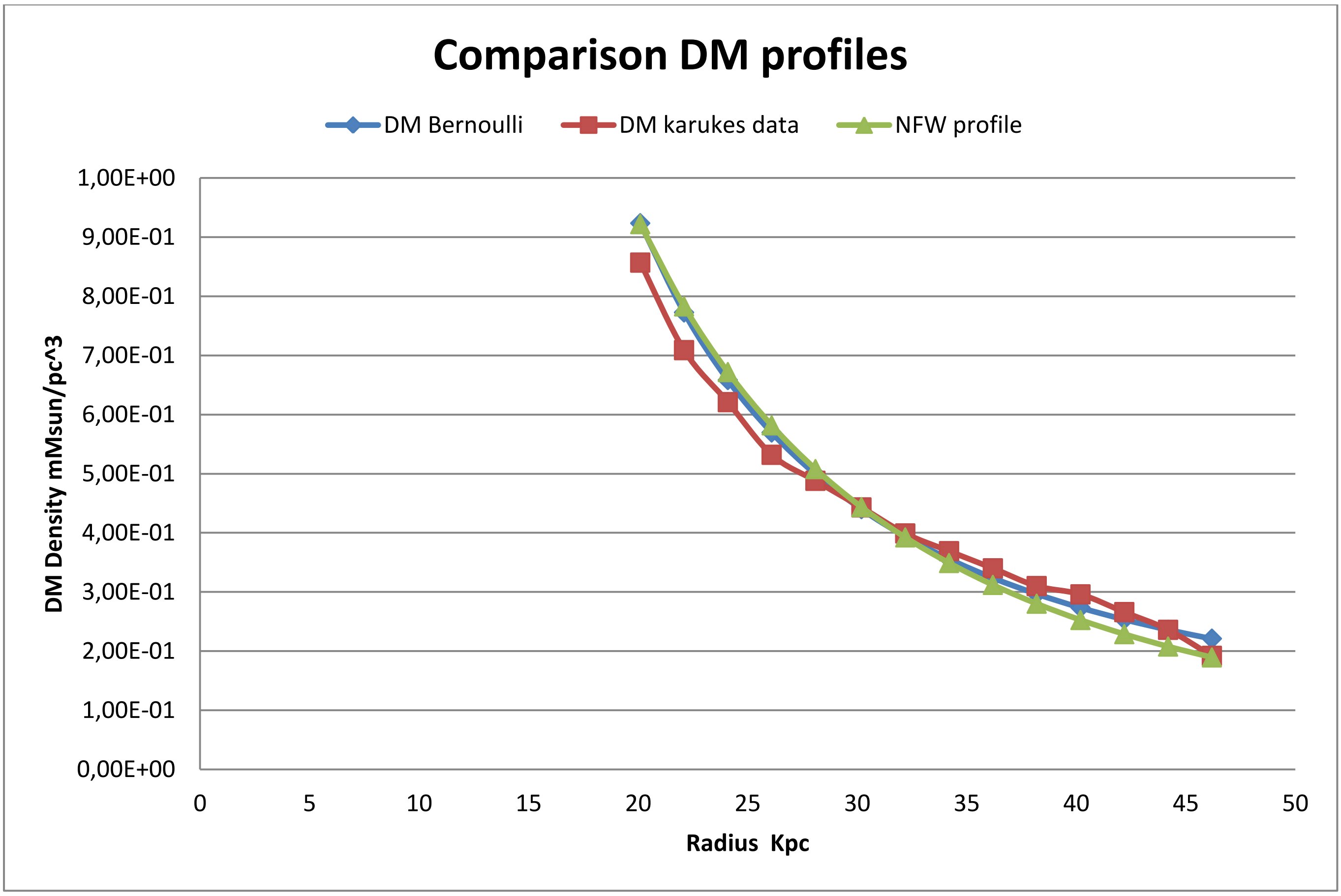
9.2 COMPARISON BETWEEN DM DENSITY KARUKES DATA AND BERNOULLI PROFILE

Kpc	m/s^2	m/s^2	I. S.	mMsun/pc^3	mMsun/pc^3	
Radius	Virial field	Bernoulli field	DM Bernoulli Profile		DM Karukes	Relt Diff %
20,1	3,58E-11	3,66E-11	6,25E-23	9,24E-01	8,57E-01	7,21E+00
22,1	3,23E-11	3,29E-11	5,23E-23	7,73E-01	7,09E-01	8,25E+00
24,1	2,87E-11	3,00E-11	4,46E-23	6,58E-01	6,21E-01	5,68E+00
26,1	2,63E-11	2,75E-11	3,86E-23	5,70E-01	5,32E-01	6,61E+00
28,1	2,50E-11	2,55E-11	3,38E-23	4,99E-01	4,88E-01	2,27E+00
30,2	2,30E-11	2,37E-11	2,98E-23	4,40E-01	4,43E-01	6,59E-01
32,2	2,22E-11	2,22E-11	2,67E-23	3,94E-01	3,99E-01	1,24E+00
34,2	2,11E-11	2,09E-11	2,41E-23	3,56E-01	3,69E-01	3,66E+00
36,2	2,01E-11	1,98E-11	2,19E-23	3,24E-01	3,40E-01	4,95E+00
38,2	1,89E-11	1,88E-11	2,01E-23	2,97E-01	3,10E-01	4,43E+00
40,2	1,81E-11	1,79E-11	1,85E-23	2,74E-01	2,96E-01	8,17E+00
42,2	1,73E-11	1,71E-11	1,72E-23	2,54E-01	2,66E-01	4,88E+00
44,2	1,65E-11	1,64E-11	1,60E-23	2,36E-01	2,36E-01	1,12E-01
46,2	1,62E-11	1,58E-11	1,50E-23	2,21E-01	1,92E-01	1,32E+01
				Total sum of	Relt. Diff. →	7,13E+01 %



9.3 COMPARISON BETWEEN DM DENSITY BERNOULLI - NFW PROFILE – KARUKES DATA

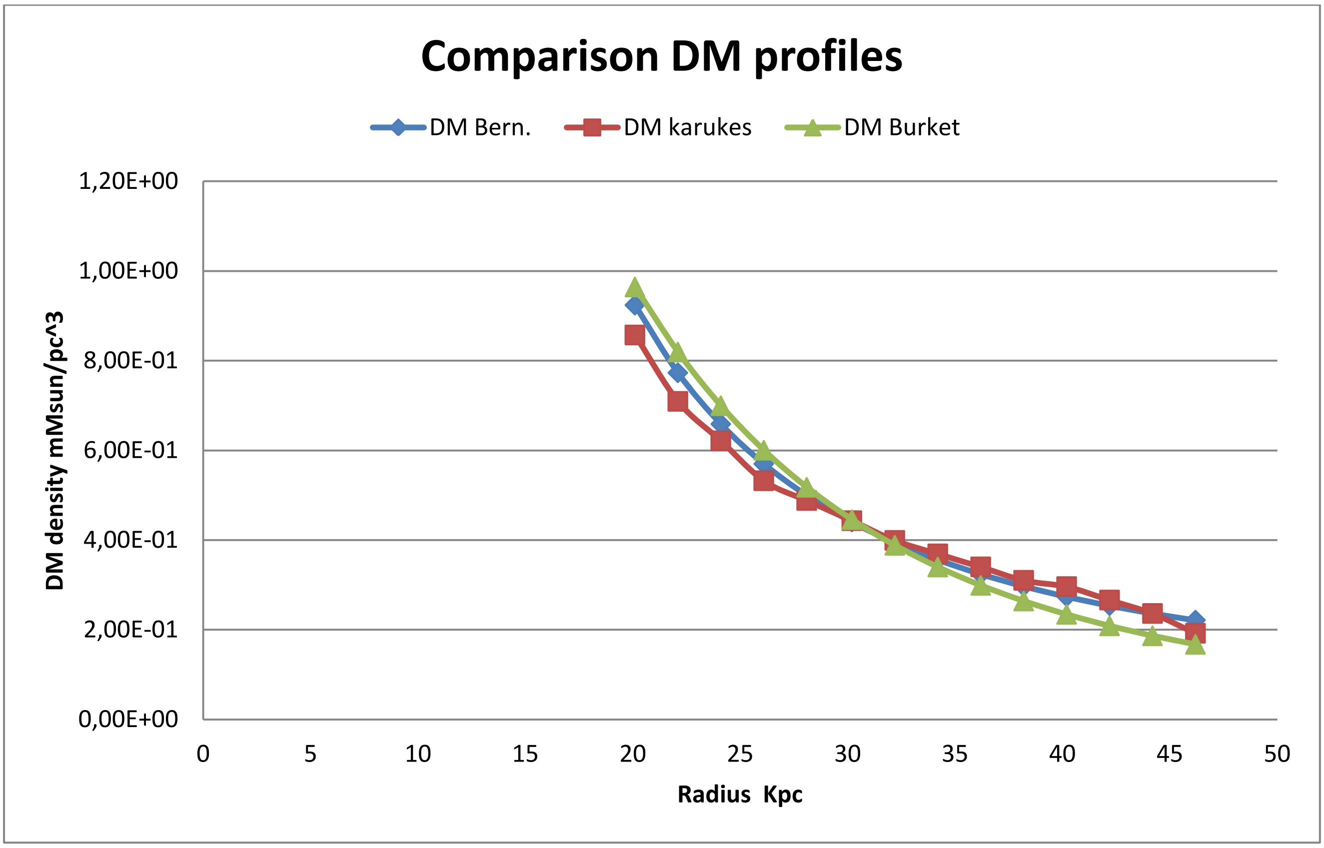
Kpc	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	Relt. Diff	Relt. Diff
Radius	DM Bern.	DM karukes	DM NFW	Bern-Kar. Data	NFW-Kar. Data
20,1	9,24E-01	8,57E-01	9,22E-01	7,21E+00	7,59E+00
22,1	7,73E-01	7,09E-01	7,83E-01	8,25E+00	1,04E+01
24,1	6,58E-01	6,21E-01	6,72E-01	5,68E+00	8,20E+00
26,1	5,70E-01	5,32E-01	5,82E-01	6,61E+00	9,37E+00
28,1	4,99E-01	4,88E-01	5,08E-01	2,27E+00	4,06E+00
30,2	4,40E-01	4,43E-01	4,44E-01	6,59E-01	1,19E-01
32,2	3,94E-01	3,99E-01	3,92E-01	1,24E+00	1,67E+00
34,2	3,56E-01	3,69E-01	3,49E-01	3,66E+00	5,42E+00
36,2	3,24E-01	3,40E-01	3,12E-01	4,95E+00	8,24E+00
38,2	2,97E-01	3,10E-01	2,80E-01	4,43E+00	9,62E+00
40,2	2,74E-01	2,96E-01	2,53E-01	8,17E+00	1,46E+01
42,2	2,54E-01	2,66E-01	2,29E-01	4,88E+00	1,40E+01
44,2	2,36E-01	2,36E-01	2,08E-01	1,12E-01	1,20E+01
46,2	2,21E-01	1,92E-01	1,89E-01	1,32E+01	1,38E+00
		Total sum of	Relt. Diff. →	7,13E+01	1,07E+02



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

9.4 COMPARISON BETWEEN DM DENSITY BERNOULLI - BURKET PROFILE – KARUKES DATA

Radius	DM Bern.	DM karukes	DM Burket	Rel. Diff. Bernoull-Karukes	Relt. Diff. Burket- Karukes
KPC	mMsun/pc^3	mMsun/pc^3	mMsun/pc^3	%	%
20,1	9,24E-01	8,57E-01	9,64E-01	7,21E+00	1,11E+01
22,1	7,73E-01	7,09E-01	8,19E-01	8,25E+00	1,34E+01
24,1	6,58E-01	6,21E-01	6,99E-01	5,68E+00	1,12E+01
26,1	5,70E-01	5,32E-01	6,00E-01	6,61E+00	1,13E+01
28,1	4,99E-01	4,88E-01	5,17E-01	2,27E+00	5,69E+00
30,2	4,40E-01	4,43E-01	4,45E-01	6,59E-01	5,19E-01
32,2	3,94E-01	3,99E-01	3,88E-01	1,24E+00	2,85E+00
34,2	3,56E-01	3,69E-01	3,40E-01	3,66E+00	8,66E+00
36,2	3,24E-01	3,40E-01	2,99E-01	4,95E+00	1,38E+01
38,2	2,97E-01	3,10E-01	2,64E-01	4,43E+00	1,75E+01
40,2	2,74E-01	2,96E-01	2,34E-01	8,17E+00	2,65E+01
42,2	2,54E-01	2,66E-01	2,08E-01	4,88E+00	2,77E+01
44,2	2,36E-01	2,36E-01	1,86E-01	1,12E-01	2,67E+01
46,2	2,21E-01	1,92E-01	1,67E-01	1,32E+01	1,49E+01
		Total sum of	Relt. Diff. →	7,13E+01	1,92E+02



It is clear that Bernoulli profile fit much better than Burket one.

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, relative differences between Bernoulli profile and Karukes data about DM density are lower than relative differences between NFW or Burket profiles and Karukes data

What is the conclusion? It is clear. Isn´t?

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