A NEW DARK MATTER DENSITY PROFILE FOR M33 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. That paper studied six big galaxies whose velocity in flat area of rotation curve is bigger than 200 km/s.

Current paper studies a similar law for M33, which is an intermediate satellite galaxy of M31, it is 850 kpc away from Earth and its velocity in flat area of rotation curve is approximately 120 km/s.

In this work has been calculated a new function for DM density for M33. Reader could think, why disturb me with a new DM density profile, called Bernoulli profile in this paper, whose values have relative differences with Burket ones below 2%?

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 Burket DM profile 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.* [2] Abarca,M.2015. *Dark matter density function depending on gravitational field as Universal law.*   [3] Abarca,M.2015. *A new dark matter density profile for NGC 3198 galaxy to demonstrate that dark matter is generated by gravitational field.*

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 M33 galaxy. These data come from [4] E. Corbelli, 2014.

In fourth epigraph, considering rotation curve of M33 from Corbelli data, it is right to calculate gravitational field E, through Virial theorem. So in this epigraph has been tabulate gravitational field inside a wide region of halo, from 8 kpc to 22 Kpc.

In fifth epigraphs has been tabulated and plotted data of Burket DM density profile published by [4] E. Corbelli, 2014. for M33.

In sixth epigraph has been fitted data of Burket DM density profile as power of gravitational field, E, with a correlation coefficient bigger than 0,999. Particularly formula found is $\varphi_{DM}(r) = A \cdot E^B$ Where A= 29,02219371 and B= 2,242193511 into I.S. of units.

In seventh epigraph it has been compared DM density as power of E and Burket profiles. Tables and plots show clearly that relative differences between both profiles are mainly below 5%.

In eight epigraph it is considered derivative of gravitational field in halo region where density of baryonic matter is negligible regarding DM density. 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 allows to get a new DM density profile through formula $\varphi_{DM}(r) = A \cdot E^B(r)$.

In nineth epigraph   Bernoulli and Burket DM density profiles have been compared. Its relative differences are below 2% for radius bigger than 10 kpc, which is a superb result.

The tenth chapter makes a comparison between DM densities as power of E for M33 and NGC 3198 galaxies. The goal is to show a general law for galaxies: the more massive galaxy is the less DM density at a specific value of E.

In the eleven chapter it is fitted DM density as power of E for a reduced data set, and it is studied its behaviour outside dominion regression. In chapter twelve DM Bernoulli profile is extrapolated up to 70 kpc and it is compared with Burket profile.


2.   INTRODUCTION

M33 galaxy is a satellite galaxy of M31. Also is known as Triangle galaxy and is the third massive galaxy of Local Group. M33 is approximately 880 kpc away and its distance to M31 is 220 kpc aprox. In addition stellar galactic radius is 8 kpc approximately. Therefore it has been considered that baryonic density is negligible versus DM density for radius bigger than 8 kpc, although at the end of work will be found evidences to consider baryonic density negligible for radius bigger than 10 kpc not for 8 kpc.

Some data mass of M33 are quoted from the meticulous work [4] E. Corbelli, 2014. Stellar mass of M 33 galaxy is $M_* = (4,8 \pm 0,6) \cdot 10^9 \ M_\Theta$. When is added gas to stellar mass this gives a baryonic fraction of order of 0.02 and halo mass are found to be $M_{halo} = (4,3 \pm 1) \cdot 10^{11} \ M_\Theta$.

The main target this paper is to get a new DM density profile got through a Bernoulli differential equation. Hereafter this new profile will be called Bernoulli profile. It is required as starting point to get DM density as power of gravitational field $\varphi_{DM}(r) = A \cdot E^B$. Therefore it is needed data about DM density and data about gravitational field E at specific radius. Data of E may be calculated from rotation curve through Virial theorem. Data about DM density has been calculated by Corbelli through NFW and Burket profiles. I have chosen Burket profile for this paper.

In my previous paper [3] Abarca,M.2015, I have got Bernoulli DM density for NGC 3198. As initial data I used [5] E.V. Karukes, 2015. In this paper, Karukes published galactic rotation curve and a table of DM density depending on radius. Thanks these data I was be able to calculate parameters of $\varphi_{DM}(r) = A \cdot E^B$ where A= 4,04598703 $\cdot 10^{-5}$ and B= 1,70654481 into I.S. of units. However $\varphi_{DM}(r) = A \cdot E^B$ for M33 have different coefficients. Specifically are A= 29,02219371 and B= 2,242193511 into I. S. of units. Reason why these coefficients are different will be explained at the end of paper, in chapter 10, although briefly I will say that remarkable difference of values of A and B is due to difference of masses between both galaxies.

3.   OBSERVATIONAL DATA FROM CORBELLI. 2014 PAPER
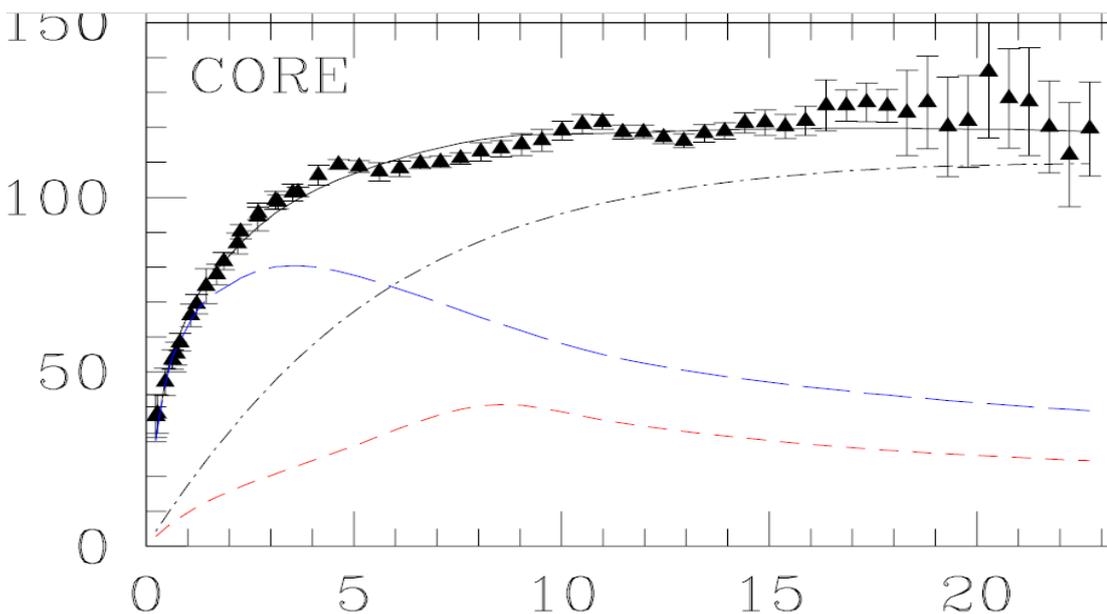
Graphic come from [4] E Corbelli, 2014. Fig. 15

The rotation curve of M33, data are filled triangles and the best fitting model is the solid line.   Dark matter halo with a constant density core is known as Burket profile. The dark halo contribution to rotation curve is shown with a dashed and pointed line. The small and large dashed lines show respectively the gas and stellar disk as contribution to the rotation curves.

According [4] E Corbelli, 2014.   parameters of Burket profile are   Rs = 7,5 Kpc and Do = 0,018 Msun/pc^3.

4.   GRAVITATIONAL FIELD E THROUGH VIRIAL THEOREM

In this work dominion of radius extend from 8 kpc to 22 kpc, despite the fact that rotation curve has accuracy measures for radius lower than 8 kpc. 8 kpc is an approximate measure of galactic radius. Therefore it is supposed that for radius bigger than 8 kpc density of baryonic matter is negligible versus DM density. This hypothesis will be used to get a differential equation for gravitational field in this paper. This is the reason why it is studied only rotation curve for radius bigger than 8 kpc.

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. Data of velocity has been got from solid line, which fits series of triangles in above figure.

Radius	Radius	Velocity	Virial E
m	kpc	km/s	m/s^2
2,47E+20	8	116,3	5,47918E-11
2,78E+20	9	118,7	5,07347E-11
3,09E+20	10	118,7	4,56612E-11
3,39E+20	11	118,7	4,15102E-11
3,70E+20	12	119,3	3,84367E-11
4,01E+20	13	118,7	3,51240E-11
4,32E+20	14	119,3	3,29457E-11
4,63E+20	15	119,88	3,10491E-11
4,94E+20	16	119,88	2,91085E-11
5,25E+20	17	119,88	2,73962E-11
5,55E+20	18	119,88	2,58742E-11
5,86E+20	19	119,88	2,45124E-11
6,17E+20	20	119,88	2,32868E-11
6,48E+20	21	119,88	2,21779E-11
6,79E+20	22	119,3	2,09655E-11
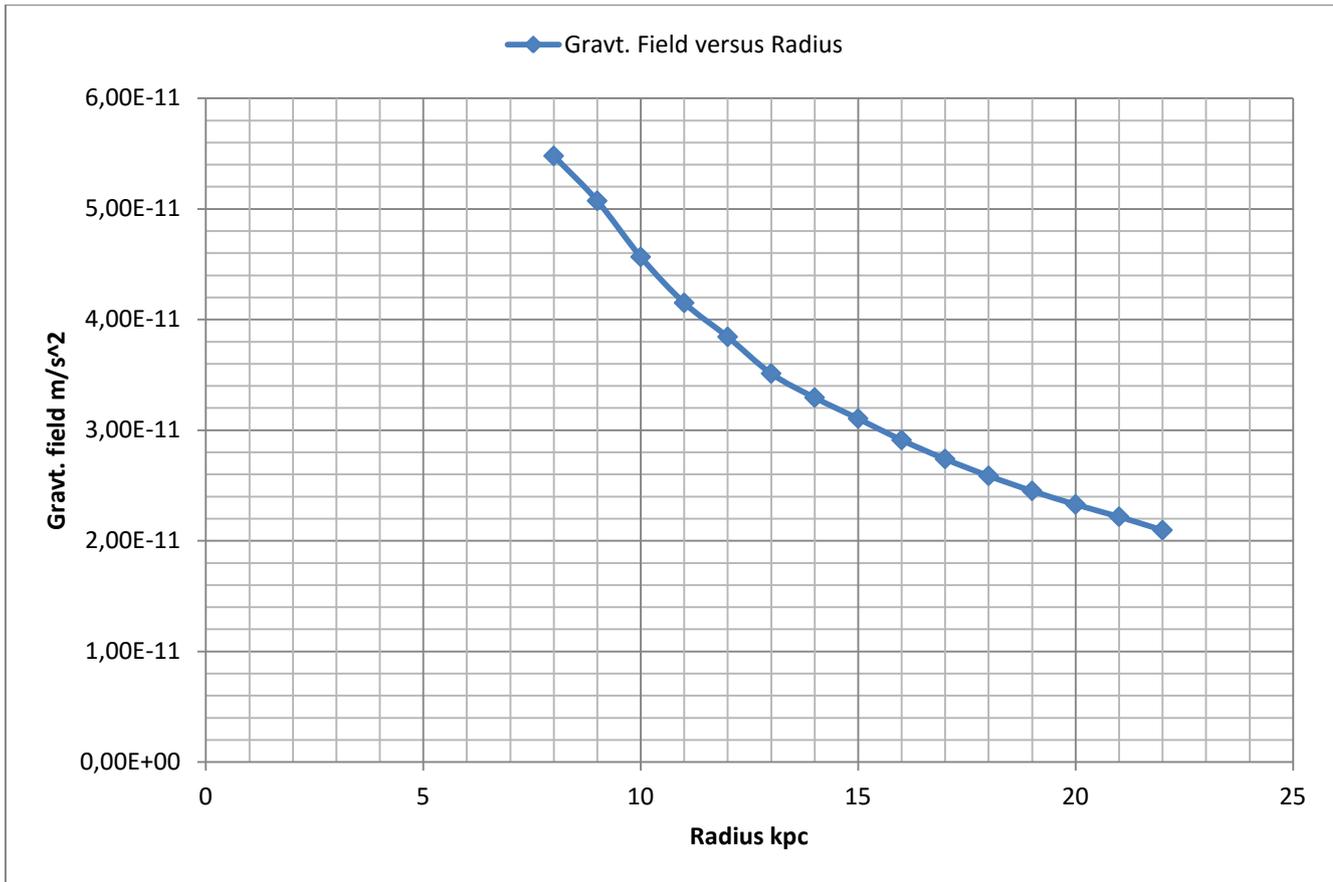
5. BURKET DARK MATTER DENSITY PROFILE

According [4] E. Corbelli. 2014 these are Burket profile parameters for M33.

Dark matter density Burket profile
Rs = 7,5   Kpc
Do = 18 mMsolar/pc^3

Unit of Do is 0,001 Msun/pc^3 = mMsun/pc^3 which is a very common unit for galactic densities.

Rs is called length scale and Do is density scale.

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

Radius	Burket DM profile
Kpc	mMsun/pc^3
8	4,07417343
9	3,35320417
10	2,77714286
11	2,31578546
12	1,94468453
13	1,64451423
14	1,400189
15	1,2
16	1,03487045
17	0,89775229
18	0,7831535

19	0,68677436
20	0,60523039
21	0,53584187
22	0,47647433

Burket DM profile versus radius
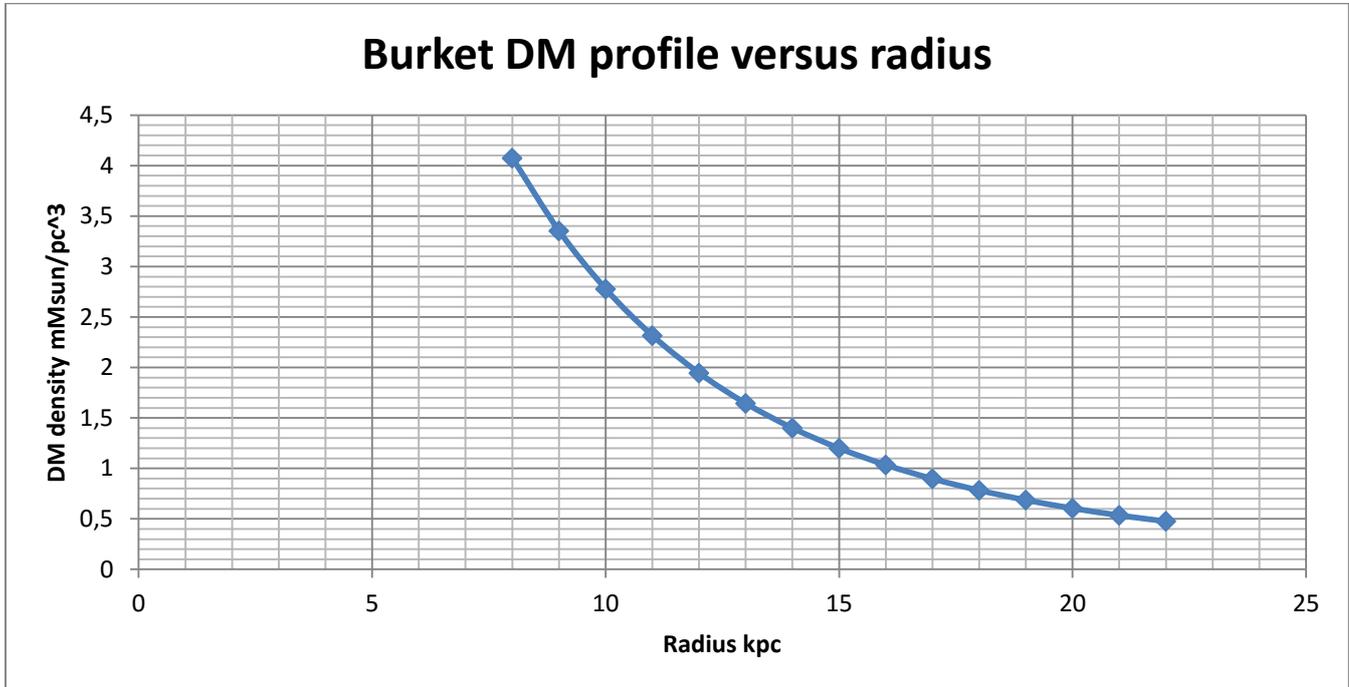
6.   BURKET D.M. DENSITY AS POWER OF VIRIAL FIELD E

Below are tabulated values of gravitational field E and Burket DM density, because DM density will be fitted with a power function of E. Units are International System.

Reason why the author has decided to fit this function is explained in [2] Abarca,M.2015. & [1] Abarca,M.2014. Briefly, the author defends hypothesis that DM is generated by the own gravitational field. In paper [2] is defended DM density depend on E according a Universal law for big galaxies, as M33 is an intermediate galaxy there is a similar law with different coefficients.

Radius	Virial E	Burket DM	Burket DM
kpc	m/^2	mMsun/pc^3	Kg/m^3
8	5,48E-11	4,07417343	2,7582E-22
9	5,07E-11	3,35320417	2,2701E-22
10	4,57E-11	2,77714286	1,8801E-22
11	4,15E-11	2,31578546	1,5678E-22
12	3,84E-11	1,94468453	1,3166E-22
13	3,51E-11	1,64451423	1,1133E-22
14	3,29E-11	1,400189	9,4793E-23
15	3,10E-11	1,2	8,1240E-23
16	2,91E-11	1,03487045	7,0061E-23
17	2,74E-11	0,89775229	6,0778E-23
18	2,59E-11	0,7831535	5,3019E-23
19	2,45E-11	0,68677436	4,6495E-23

20	2,33E-11	0,60523039	4,0974E-23
21	2,22E-11	0,53584187	3,6276E-23
22	2,10E-11	0,47647433	3,2257E-23

Burket DM profile versus Virial E

Doing power regression of DM density versus gravitational field according formula Density $_{\text{DARK MATTER}}$ = A· E^B through International System of units, it is right to get A = 29,02219371   and B= 2,242193511 being correlation coefficient r = 0,9990083703. There is a very high correlation between DM density and gravitational field.

Burket Dark Matter Density as power of Virial E for M33   inside dominion   8 kpc < radius < 22 kpc
$D_{\text{DM Pw VE}}$ = A·E^B
A = 29,02219371   B= 2,242193511   and correlation coefficient r = 0,9990083703.

Hereafter dark matter density as power of Virial E will be shortened as $D_{\text{DM Pw VE}}$ = A·E^B

Radius	Virial E	DM pow VE	DM pow VE
kpc	m/s^2	Kg/m^3	mMsun/pc^3
8,00E+00	5,48E-11	2,85E-22	4,21E+00
9,00E+00	5,07E-11	2,40E-22	3,54E+00
1,00E+01	4,57E-11	1,89E-22	2,80E+00
1,10E+01	4,15E-11	1,53E-22	2,26E+00
1,20E+01	3,84E-11	1,29E-22	1,90E+00
1,30E+01	3,51E-11	1,05E-22	1,55E+00
1,40E+01	3,29E-11	9,11E-23	1,35E+00
1,50E+01	3,11E-11	7,98E-23	1,18E+00

1,60E+01	2,91E-11	6,91E-23	1,02E+00
1,70E+01	2,74E-11	6,03E-23	8,91E-01
1,80E+01	2,59E-11	5,30E-23	7,84E-01
1,90E+01	2,45E-11	4,70E-23	6,94E-01
2,00E+01	2,33E-11	4,19E-23	6,19E-01
2,10E+01	2,22E-11	3,75E-23	5,55E-01
2,20E+01	2,10E-11	3,31E-23	4,89E-01
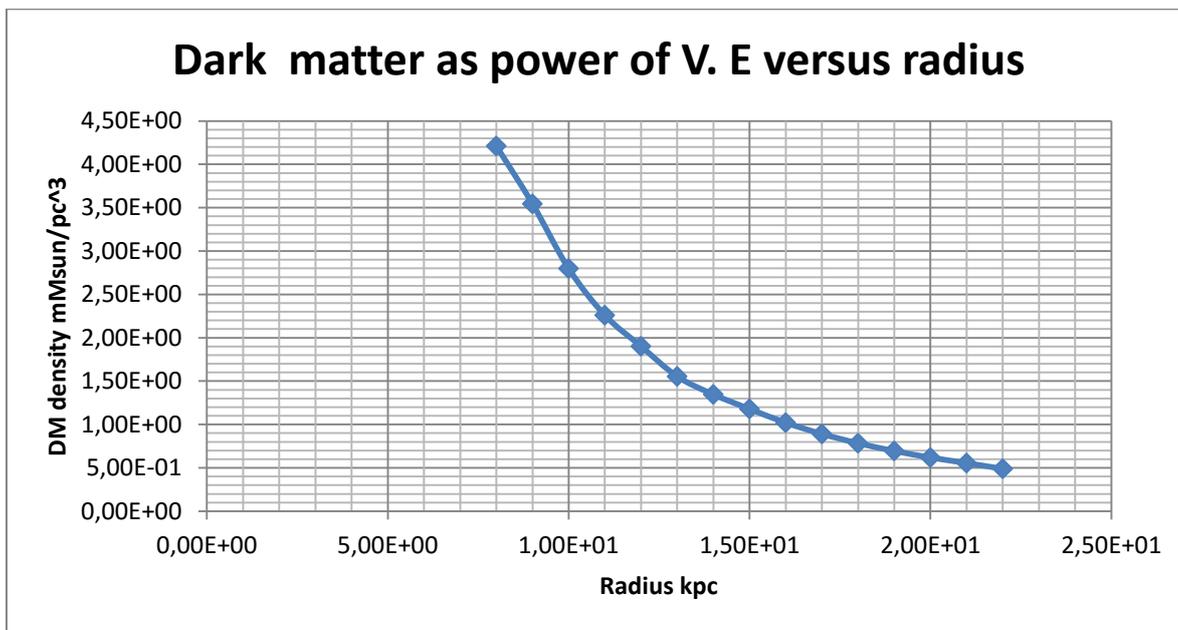
7. COMPARISON BETWEEN DM DENSITY AS POWER OF E AND BURKET PROFILE

According [4] E. Corbelli. 2014 these are Burket profile parameters for M33.

Dark matter density Burket profile
Rs = 7,5   Kpc
Do = 18 mMsolar/pc^3

Unit of Do is 0,001 Msun/pc^3 = mMsun/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/ Rs   Rs is called length scale and Do is density scale.

According results in previous epigraph DM density as power of virial E is the following formula.

Burket Dark Matter Density as power of Virial E for M33   inside dominion   8 kpc < radius < 22 kpc
$D_{DM\ Pw\ VE} = A \cdot E^B$
A = 29,02219371   B= 2,242193511   and correlation coefficient r = 0,9990083703.

Below are compared Burket DM density with DM density as power of E. Except five values differences are below 3%, and all of them are below 6%.

Radius	Burket DM	DM as power of E	Relt. Diff.
kpc	Kg/m^3	Kg/m^3	%
8	2,7582E-22	2,85066E-22	3,3516E+00
9	2,2701E-22	2,39901E-22	5,6778E+00
10	1,8801E-22	1,89424E-22	7,5077E-01
11	1,5678E-22	1,52977E-22	2,4252E+00
12	1,3166E-22	1,28740E-22	2,2139E+00
13	1,1133E-22	1,05185E-22	5,5230E+00
14	9,4793E-23	9,11187E-23	3,8759E+00
15	8,1240E-23	7,97755E-23	1,8027E+00
16	7,0061E-23	6,90278E-23	1,4744E+00
17	6,0778E-23	6,02545E-23	8,6112E-01
18	5,3019E-23	5,30066E-23	2,4323E-02
19	4,6495E-23	4,69549E-23	9,8992E-01
20	4,0974E-23	4,18536E-23	2,1465E+00
21	3,6276E-23	3,75165E-23	3,4182E+00
22	3,2257E-23	3,30733E-23	2,5295E+00
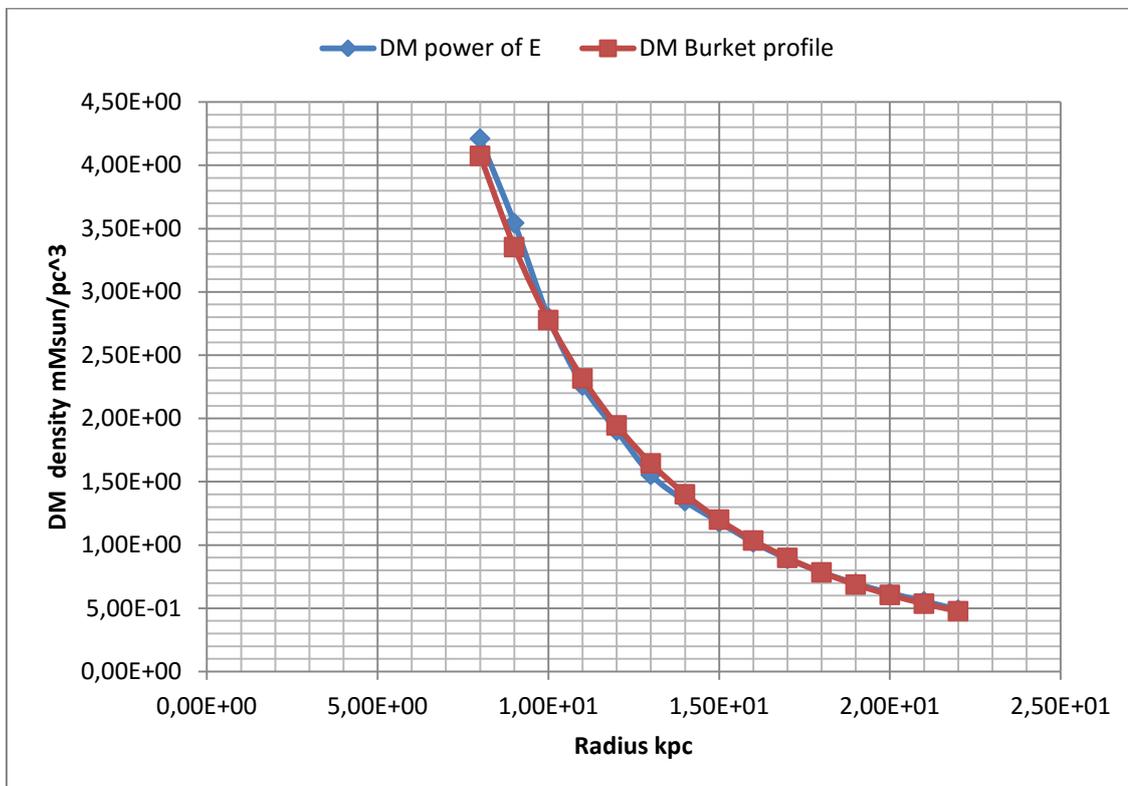
8. BERNOULLI DIFFERENTIAL EQUATION FOR GRAVITATIONAL FIELD IN M33 HALO

It will be considered the region 8 Kpc < Radius < 22 Kpc where density of baryonic matter is negligible versus baryonic density. So for radius bigger than 8 Kpc, it will be considered that derivative of M(r) depend on dark matter density only. Results at the end of chapter might suggest that this hypothesis it is not very good for 8 kpc although it would be good for radius bigger than 10 kpc.

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 > 8 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= 29,02219371 B= 2,242193511 then $M'(r) = 4\pi r^2 \cdot A \cdot E^B$
Now it will differentiated E(r) when r > 8 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 $\varphi_{DM}(r) = A \cdot E^B(r)$ 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= 2,43367309·10⁻⁸ I.S. as A= 29,022119371

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

Bernoulli family equations $y` = K \cdot y^B - \dfrac{2 \cdot y}{r}$ 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:

$\alpha = 2B - 2$ = 2.484387022 $\beta = \dfrac{1}{1-B}$ = - 0.80502755 $D = \left(\dfrac{K(1-B)}{3-2B} \right)$ = 2.03659·10⁻⁸

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 R_O	Virial E_O	C
Kpc	m/s^2	I.S.
22	2,10E-11	8,052965E-40
20	2,33E-11	7,986818E-40
18	2,59E-11	8,278137E-40
16	2,91E-11	8,483274E-40
14	3,29E-11	9,178529E-40
12	3,84E-11	8,921487E-40
10	4,57E-11	8,886540E-40
8	5,48E-11	1,197559E-39

As it was expected parameter C is very similar for different initial condition, although its value for R = 8 kpc is clearly different the other ones. This fact shows clearly that hypothesis about Density of baryonic matter is negligible versus DM density is not good for radius = 8 kpc.

Numerically may be checked that data below minimize relative difference between Burket DM density and DM density got through Bernoulli solution therefore these values will be considered as initial condition.

Initial condition values Ro & Eo	
Ro =	17 Kpc
Eo =	2,74E-11 m/s^2
C =	8,40· 10 $^{-40}$ 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   8 kpc < Radius < 22 kpc
$E_{BER}(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$ C = 8.40 ·10^{-40} D= 2.03659 · 10^{-8} $\alpha =$ 2.484387022 $\beta =$ -0.80502755

8.1 BERNOULLI PROFILE OF DARK MATTER DENSITY FOR M33 GALAXY

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

DM Density Bernoulli profile for M33 inside halo 8 kpc < radius < 22 kpc

$$E_{BER}(r) = \left(Cr^{\alpha} + Dr\right)^{\beta}$$ C = 8,40 · 10^{-40} D= 2,03659 · 10^{-8} α = 2,484387022 β = -0,80502755

Density $_{D.M.\ BERNOULLI}$ (r) = D$_{DM\ B}$(r) = A· E^{B} Where A= 29.02219371 & B= 2.242193511 unit Kg/ m^{3}

9. COMPARISON BETWEEN BERNOULLI AND BURKETT PROFILES

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

Radius	Virial E	Bernoulli E	Rel. diff.
kpc	m/s^2	m/s^2	%
8,00E+00	5,48E-11	5,61E-11	2,38E+00
9,00E+00	5,07E-11	5,05E-11	4,68E-01
1,00E+01	4,57E-11	4,59E-11	4,52E-01
1,10E+01	4,15E-11	4,20E-11	1,13E+00
1,20E+01	3,84E-11	3,87E-11	6,15E-01
1,30E+01	3,51E-11	3,58E-11	1,93E+00
1,40E+01	3,29E-11	3,33E-11	1,11E+00
1,50E+01	3,11E-11	3,11E-11	1,68E-01
1,60E+01	2,91E-11	2,92E-11	1,14E-01
1,70E+01	2,74E-11	2,74E-11	3,34E-02
1,80E+01	2,59E-11	2,58E-11	2,65E-01
1,90E+01	2,45E-11	2,44E-11	5,72E-01
2,00E+01	2,33E-11	2,31E-11	9,46E-01
2,10E+01	2,22E-11	2,19E-11	1,38E+00
2,20E+01	2,10E-11	2,08E-11	8,54E-01

Virial E & Bernoulli E
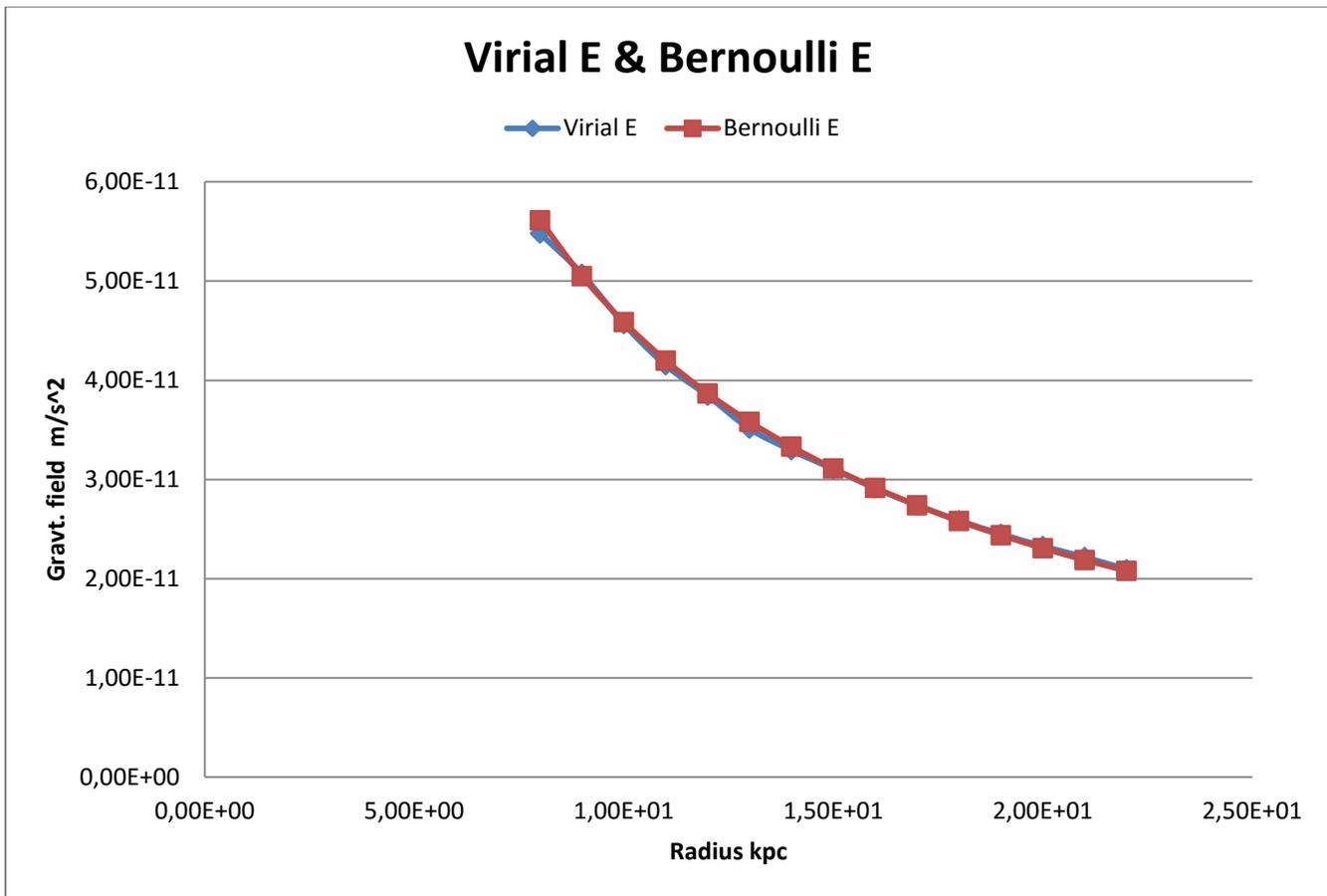
Bernoulli solution for gravitational field fits almost perfectly to Virial gravitational data got through observational values of spin speed of rotational curve of M33 galaxy.

9.2 COMPARISON BETWEEN BURKET DM PROFILE AND BERNOULLI DM PROFILE

Radius	Bernoulli DM profile	Burket DM profile	Relt. Diff.
kpc	mMsun/pc^3	mMsun/pc^3	%
8,00E+00	4,44E+00	4,07E+00	9,09E+00
9,00E+00	3,51E+00	3,35E+00	4,58E+00
1,00E+01	2,83E+00	2,78E+00	1,78E+00
1,10E+01	2,32E+00	2,32E+00	9,62E-02
1,20E+01	1,93E+00	1,94E+00	8,51E-01
1,30E+01	1,62E+00	1,64E+00	1,31E+00
1,40E+01	1,38E+00	1,40E+00	1,44E+00
1,50E+01	1,18E+00	1,20E+00	1,36E+00
1,60E+01	1,02E+00	1,03E+00	1,15E+00
1,70E+01	8,90E-01	8,98E-01	8,61E-01
1,80E+01	7,79E-01	7,83E-01	5,42E-01
1,90E+01	6,85E-01	6,87E-01	2,19E-01
2,00E+01	6,06E-01	6,05E-01	8,78E-02
2,10E+01	5,38E-01	5,36E-01	3,62E-01
2,20E+01	4,79E-01	4,76E-01	5,94E-01

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Reader can check that relative differences are lower than 2% for radius bigger than 10 kpc., which is a superb result¡. For radius 8 kpc and 9 kpc relative differences are a bit bigger because density of baryonic matter is not so negligible as happens for bigger radius.
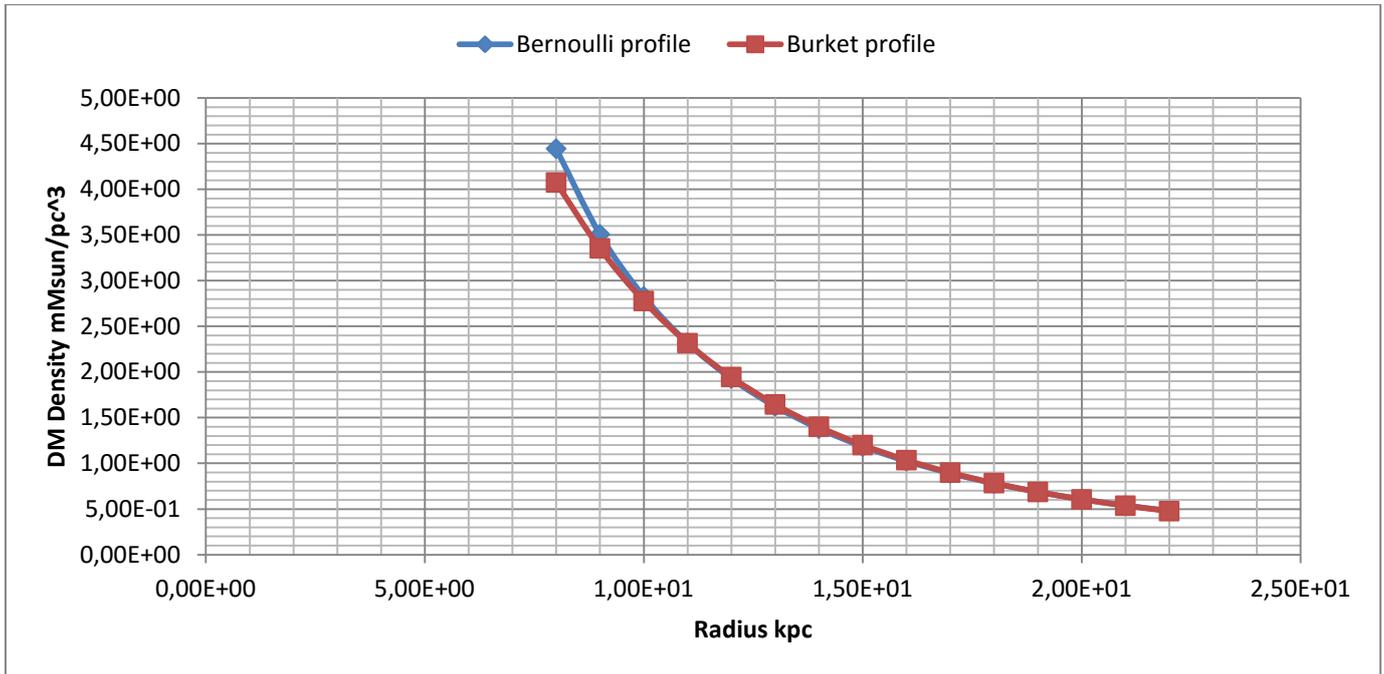
10. COMPARISON BETWEEN D.M. DENSITY DEPENDING ON E IN M33 AND NGC 3198 GALAXIES

Below is reproduced rotation curve of NGC 3198 published by [5] E.V. Karukes, 2015.

Taking that information from Karukes paper and with the same method followed in this paper by M33 I have got Bernoulli DM profile for NGC 3198 and results were published in **[3]** Abarca,M.2015.

Rotation velocity is approximately 150 Km/s inside flat area, this velocity is bigger than velocity in M33. Reason why dark matter density is lower in NGC 3198 than DM density in M33 is that NGC 3198 is a galaxy more massive than M33. In paper [**2**] Abarca,M.2015 are exposed what is the reason, in my view, to explain why the more massive galaxies the less DM density.
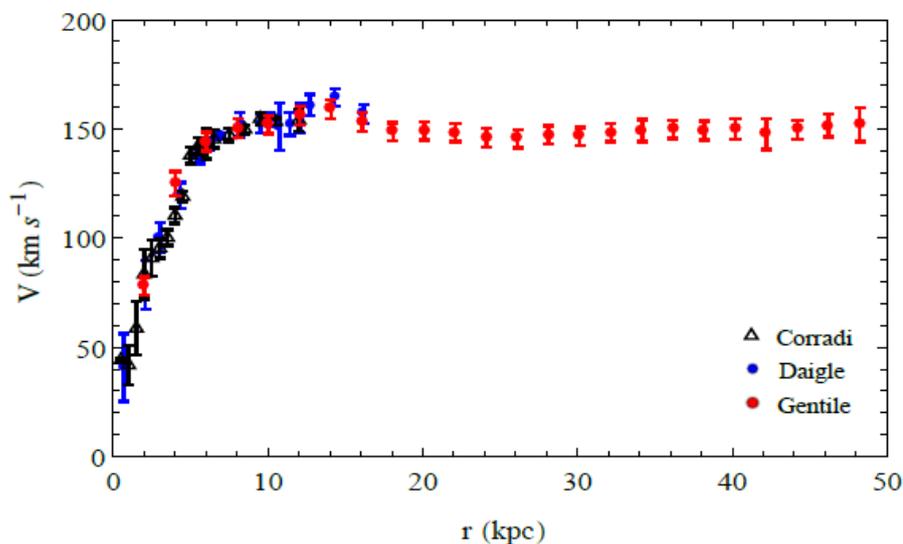
10.1 DARK MATTER DENSITY DEPENDING ON GRAVITATIONAL FIELD IN NGC 3198

As galactic radius is approximately 15 kpc data of DM was studied for radius bigger than 20 kpc in order to assure that density of baryonic matter is negligible. Below are results published in **[3]** Abarca,M.2015 about DM density depending on E.

NGC 3198 Galaxy			
Radius kpc	Virial E m/s^2	DM Den. data kg/m^3	DM Den. data mMsunes/pc^3
20,1	3,58E-11	5,8E-23	8,57E-01
22,1	3,23E-11	4,80E-23	7,09E-01
24,1	2,87E-11	4,20E-23	6,21E-01
26,1	2,63E-11	3,60E-23	5,32E-01
28,1	2,50E-11	3,30E-23	4,88E-01
30,2	2,30E-11	3,00E-23	4,43E-01
32,2	2,22E-11	2,70E-23	3,99E-01
34,2	2,11E-11	2,50E-23	3,69E-01
36,2	2,01E-11	2,30E-23	3,40E-01
38,2	1,89E-11	2,10E-23	3,10E-01
40,2	1,81E-11	2,00E-23	2,96E-01
42,1	1,73E-11	1,80E-23	2,66E-01
44,2	1,65E-11	1,60E-23	2,36E-01
46,2	1,61E-11	1,30E-23	1,92E-01

Doing power regression of measures into international system, formula for DM Density as Power of E   is:

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

10.2 DARK MATTER DENSITY DEPENDING ON GRAVITATIONAL FIELD IN M33

M33 Galaxy			
Radius kpc	Virial E m/^2	Burket DM mMsun/pc^3	Burket DM Kg/m^3
8	5,48E-11	4,07417343	2,7582E-22
9	5,07E-11	3,35320417	2,2701E-22
10	4,57E-11	2,77714286	1,8801E-22
11	4,15E-11	2,31578546	1,5678E-22
12	3,84E-11	1,94468453	1,3166E-22
13	3,51E-11	1,64451423	1,1133E-22
14	3,29E-11	1,400189	9,4793E-23
15	3,10E-11	1,2	8,1240E-23
16	2,91E-11	1,03487045	7,0061E-23
17	2,74E-11	0,89775229	6,0778E-23
18	2,59E-11	0,7831535	5,3019E-23
19	2,45E-11	0,68677436	4,6495E-23

20	2,33E-11	0,60523039	4,0974E-23
21	2,22E-11	0,53584187	3,6276E-23
22	2,10E-11	0,47647433	3,2257E-23

In chapter 6 was calculated coefficient of formula into I.S.

Density $_{DARK\ MATTER}$ = A· E^B , being A = 29,02219371   B= 2,242193511 and r = 0,9990083703

10.3 COMPARISON OF BOTH GALAXIES

In tables below has been selected common values of gravitational field for both galaxies.

NGC 3198 Galaxy	
Virial E	DM Den. data
m/s^2	mMsun/pc^3
3,58E-11	8,57E-01
3,23E-11	7,09E-01
2,87E-11	6,21E-01
2,63E-11	5,32E-01
2,50E-11	4,88E-01
2,30E-11	4,43E-01
2,22E-11	3,99E-01
2,11E-11	3,69E-01

M33 Galaxy	
Virial E	Burket DM
m/^2	mMsun/pc^3
3,51E-11	1,64451423
3,29E-11	1,400189
3,10E-11	1,2
2,91E-11	1,03487045
2,74E-11	0,89775229
2,59E-11	0,7831535
2,45E-11	0,68677436
2,33E-11	0,60523039
2,22E-11	0,53584187
2,10E-11	0,47647433

When are compared values of density which belong the same value of E, it is clearly shown that DM density is bigger in M33 regarding NGC 3198. Because M33 is less massive than NGC 3198.

In paper [2] Abarca,M.2015 were studied a set of sis big galaxies, whose velocity of rotation curve inside flat area is bigger than 200 km/s. It was checked that DM density at a specific value of E is lower inside these galaxies than DM density inside NGC 3198, because these galaxies are more massive than NGC 3198. Therefore it has been found that the more massive the galaxy the less DM density is at a specific value of E. Results in paper [2] Abarca,M.2015 also suggest that two galaxies with similar mass have similar DM density at a specific value of E.

11. STUDY OF D.M. DENSITY AS POWER OF E CALCULATED WITH REDUCED DATA SET

Radius	Virial E	Burket DM	Burket DM
kpc	m/^2	mMsun/pc^3	Kg/m^3
8	5,48E-11	4,07417343	2,7582E-22
9	5,07E-11	3,35320417	2,2701E-22
10	4,57E-11	2,77714286	1,8801E-22
11	4,15E-11	2,31578546	1,5678E-22
12	3,84E-11	1,94468453	1,3166E-22
13	3,51E-11	1,64451423	1,1133E-22
14	3,29E-11	1,400189	9,4793E-23
15	3,10E-11	1,2	8,1240E-23
16	2,91E-11	1,03487045	7,0061E-23
17	2,74E-11	0,89775229	6,0778E-23
18	2,59E-11	0,7831535	5,3019E-23
19	2,45E-11	0,68677436	4,6495E-23
20	2,33E-11	0,60523039	4,0974E-23
21	2,22E-11	0,53584187	3,6276E-23
22	2,10E-11	0,47647433	3,2257E-23

In chapter six was fitted a power regression function to Burket DM density depending on E. Dominion extend from 8 kpc to 22 kpc. Measures were into I.S. and correlation coefficient is bigger than 0.999.

In this chapter it will be fitted the same magnitudes   with a reduced set of data.

Initially data set will be the whole interval [8-22]kpc and progressively this interval will be reduced [8-20] , [8-18] and so on.

Similarly will be increased lower bound [10-22], [12-22] [14-22] and so on.

Results will be tabulated, and values whose radius do not belong to data set will be painted in grey in order to differentiate both kind of results.

The main objective is check how works power of E function for radius outside regression dominion.

Table below is complete. Last column shows rotational velocity at a specific radius and the following one column shows Virial field E into m/s^2. Column beside radius shows Burket DM density into mMsun/pc^3 units and fifth column shows the same magnitude into Kg/m^3. In order to change units it has been considered 1mMsun/pc^3 = =6,77·10^-23 Kg/m^3 and 1kpc = 3.0857·10^19 m.

Burket DM density depending on E into I.S. has been calculated with a regression power DM pow E = A*E^B with measures into I.S. Coefficients A & B are shown in the last row. In third column are shown results of DM as power of E and fourth column shows relative difference between Burket DM density and DM density as power of E.

	mMsun/pc^3	mMsun/pc^3		Kg/m^3	Kg/m^3	m/s^2	Km/s
Radius Kpc	DM burket	DM Pow E	Rel diff. %	DM Burket	DM pow E	Virial E	Rot. Vel.
8	4,074173429	4,21E+00	3,36E+00	2,7582E-22	2,85E-22	5,4792E-11	116,3
9	3,353204173	3,54E+00	5,68E+00	2,2701E-22	2,40E-22	5,0735E-11	118,7
10	2,777142857	2,80E+00	7,44E-01	1,8801E-22	1,89E-22	4,5661E-11	1,19E+02
11	2,315785461	2,26E+00	2,44E+00	1,5678E-22	1,53E-22	4,1510E-11	1,19E+02
12	1,944684529	1,90E+00	2,23E+00	1,3166E-22	1,29E-22	3,8437E-11	1,19E+02
13	1,644514225	1,55E+00	5,55E+00	1,1133E-22	1,05E-22	3,5124E-11	1,19E+02
14	1,400188997	1,35E+00	3,91E+00	9,4793E-23	9,11E-23	3,2946E-11	1,19E+02
15	1,2	1,18E+00	1,77E+00	8,1240E-23	7,98E-23	3,1059E-11	1,20E+02
16	1,03487045	1,02E+00	1,44E+00	7,0061E-23	6,90E-23	2,9118E-11	1,20E+02
17	0,897752294	8,90E-01	8,35E-01	6,0778E-23	6,03E-23	2,7405E-11	1,20E+02
18	0,783153498	7,83E-01	3,18E-03	5,3019E-23	5,30E-23	2,5883E-11	1,20E+02
19	0,686774365	6,94E-01	1,01E+00	4,6495E-23	4,70E-23	2,4521E-11	1,20E+02
20	0,605230386	6,18E-01	2,16E+00	4,0974E-23	4,19E-23	2,3295E-11	1,20E+02
21	0,535841867	5,54E-01	3,43E+00	3,6276E-23	3,75E-23	2,2185E-11	1,20E+02
22	0,476474325	4,88E-01	2,46E+00	3,2257E-23	3,30E-23	2,0965E-11	1,19E+02
DM pow E	Coeff. Correl.	0,9990053597	← r A→	29,59901569	B→	2,243022838	

11.1 REDUCED DATA SET DECREASING UPPER BOUND OF RADIUS

Table below show results of Burket DM density fitted to a regression power of E inside radius interval [8-20] kpc values in grey do not have been fitted although DM as power of E has been calculated as well in order to compare relative differences.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,17E+00	2,45E+00
9	3,353204173	3,52E+00	4,97E+00
10	2,777142857	2,79E+00	3,68E-01
11	2,315785461	2,26E+00	2,54E+00
12	1,944684529	1,90E+00	2,12E+00
13	1,644514225	1,56E+00	5,20E+00
14	1,400188997	1,35E+00	3,38E+00
15	1,2	1,19E+00	1,06E+00
16	1,03487045	1,03E+00	5,58E-01
17	0,897752294	9,00E-01	2,27E-01
18	0,783153498	7,93E-01	1,23E+00
19	0,686774365	7,03E-01	2,41E+00
20	0,605230386	6,28E-01	3,73E+00
21	0,535841867	5,63E-01	5,16E+00
22	0,476474325	4,97E-01	4,34E+00
DM pow E	15,07011251	←A B→	2,214828911
Coeff.	correlation	0,9988751177	

In table below dominion for regression as power of E is [8-18] kpc. Reader can check how relative differences increases for radius out dominion of regression. Also it is remarkable that coefficients A & B are decreasing.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,13E+00	1,31E+00
9	3,353204173	3,49E+00	4,13E+00
10	2,777142857	2,78E+00	4,60E-03
11	2,315785461	2,26E+00	2,52E+00
12	1,944684529	1,91E+00	1,80E+00
13	1,644514225	1,57E+00	4,54E+00
14	1,400188997	1,37E+00	2,45E+00
15	1,2	1,20E+00	1,33E-01
16	1,03487045	1,04E+00	9,11E-01
17	0,897752294	9,15E-01	1,96E+00
18	0,783153498	8,08E-01	3,22E+00
19	0,686774365	7,19E-01	4,65E+00
20	0,605230386	6,43E-01	6,22E+00
21	0,535841867	5,78E-01	7,91E+00
22	0,476474325	5,11E-01	7,31E+00
DM pow E	5,674279975	←A B→	2,173961377
Coeff.	correlation	0,9988254304	

In table below dominion for regression as power of E is [8-16] kpc. Reader can check that relative difference for radius 21 and 22 kpc are bigger than 10% and coefficients A& B are lower than previous ones.

Radius	DM Burket	DM Pow E	
Kpc	mMsun/pc^3	mMsun/pc^3	Rel diff. %
8	4,074173429	4,0799E+00	1,41E-01
9	3,353204173	3,4652E+00	3,34E+00
10	2,777142857	2,7707E+00	2,33E-01
11	2,315785461	2,2631E+00	2,27E+00
12	1,944684529	1,9222E+00	1,16E+00
13	1,644514225	1,5874E+00	3,47E+00
14	1,400188997	1,3857E+00	1,04E+00
15	1,2	1,2227E+00	1,89E+00
16	1,03487045	1,0661E+00	3,02E+00
17	0,897752294	9,3737E-01	4,41E+00
18	0,783153498	8,3026E-01	6,02E+00
19	0,686774365	7,4023E-01	7,78E+00
20	0,605230386	6,6386E-01	9,69E+00
21	0,535841867	5,9854E-01	1,17E+01
22	0,476474325	5,3083E-01	1,14E+01
DM pow E	1,678403422	←A B→	2,122897715
Coeff.	correlation	0,9987686946	

In table below dominion for regression as power of E is [8-14] kpc. Reader can check how relative differences for radius inside regression dominion are lower than 3% whereas relative differences for outside radius are bigger than 5% even reach to 18%. Regression coefficients follows decreasing.

Radius	DM Burket	DM Pow E	
Kpc	mMsun/pc^3	mMsun/pc^3	Rel diff. %
8	4,074173429	4,0242E+00	1,23E+00
9	3,353204173	3,4385E+00	2,54E+00
10	2,777142857	2,7722E+00	1,78E-01
11	2,315785461	2,2814E+00	1,49E+00
12	1,944684529	1,9494E+00	2,40E-01
13	1,644514225	1,6213E+00	1,41E+00
14	1,400188997	1,4224E+00	1,59E+00
15	1,2	1,2609E+00	5,07E+00
16	1,03487045	1,1050E+00	6,78E+00
17	0,897752294	9,7620E-01	8,74E+00
18	0,783153498	8,6853E-01	1,09E+01
19	0,686774365	7,7764E-01	1,32E+01
20	0,605230386	7,0022E-01	1,57E+01
21	0,535841867	6,3374E-01	1,83E+01
22	0,476474325	5,6455E-01	1,85E+01
DM pow E	0,2595713628	←A B→	2,044479769
Coeff.	correlation	0,9991742345	

In table below dominion for regression as power of E is [8-12] kpc. Therefore regression function has been calculated with 5 values only. Relative differences grow up a bit and for radius 22 kpc reach 20 %.

Radius	DM Burket	DM Pow E	
Kpc	mMsun/pc^3	mMsun/pc^3	Rel diff. %
8	4,074173429	4,0131E+00	1,50E+00
9	3,353204173	3,4336E+00	2,40E+00
10	2,777142857	2,7733E+00	1,40E-01
11	2,315785461	2,2860E+00	1,29E+00
12	1,944684529	1,9559E+00	5,76E-01
13	1,644514225	1,6293E+00	9,27E-01
14	1,400188997	1,4310E+00	2,20E+00
15	1,2	1,2697E+00	5,81E+00
16	1,03487045	1,1140E+00	7,65E+00
17	0,897752294	9,8518E-01	9,74E+00
18	0,783153498	8,7739E-01	1,20E+01
19	0,686774365	7,8630E-01	1,45E+01
20	0,605230386	7,0865E-01	1,71E+01
21	0,535841867	6,4191E-01	1,98E+01
22	0,476474325	5,7238E-01	2,01E+01
DM pow E	0,172416025	←A B→	2,027280724
Coeff.	correlation	0,9985477592	

In table below dominion for regression as power of E is [8-10] kpc. This time function regression has been fitted with only three values and surprisingly relative differences outside dominion regression is a bit better than previous table.

Radius	DM Burket	DM Pow E	
Kpc	mMsun/pc^3	mMsun/pc^3	Rel diff. %
8	4,074173429	4,0230E+00	1,26E+00
9	3,353204173	3,4272E+00	2,21E+00
10	2,777142857	2,7517E+00	9,18E-01
11	2,315785461	2,2560E+00	2,58E+00
12	1,944684529	1,9219E+00	1,17E+00
13	1,644514225	1,5929E+00	3,14E+00
14	1,400188997	1,3939E+00	4,47E-01
15	1,2	1,2328E+00	2,73E+00
16	1,03487045	1,0777E+00	4,14E+00
17	0,897752294	9,4979E-01	5,80E+00
18	0,783153498	8,4315E-01	7,66E+00
19	0,686774365	7,5332E-01	9,69E+00
20	0,605230386	6,7696E-01	1,19E+01
21	0,535841867	6,1152E-01	1,41E+01
22	0,476474325	5,4355E-01	1,41E+01
DM pow E	0,6544817913	←A B→	2,083633659
Coeff.	correlation	0,9950775946	

CONCLUSION

As reader can check, the more far away is radius from set of radius for regression the more relative difference increase. For example in this table maximum relative difference belong to 22 kpc.

From these table it is deduced that it is possible to duplicate radius for extrapolated data of DM density with relative differences below 15 %

This results show clearly that function of DM density as power of E might work with error not very big outside region where this function has been calculated. This property is very useful to estimate DM density for region without experimental data.

11.2 REDUCED DATA SET DECREASING UPPER BOUND OF RADIUS AND LOWER BOUND 10 KPC

This complete table is similar to table in previous epigraph. Difference is that radius begin at 10 kpc instead 8.

Reason this specific study is that for radius bigger than 10 kpc baryonic density is clearly negligible regarding DM density and it worth to show results in order to compare with results of previous epigraph.

kpc	mMsun/pc^3	mMsun/pc^3		Kg/m^3	Kg/m^3	m/s^2	Km/s
Radius	DM burket	DM Pow E	Rel diff. %	DM Burket	DM pow E	Virial E	Rot. ve.
10	2,777142857	2,90E+00	4,42E+00	1,8801E-22	1,96E-22	4,5661E-11	1,19E+02
11	2,315785461	2,33E+00	4,67E-01	1,5678E-22	1,58E-22	4,1510E-11	1,19E+02
12	1,944684529	1,95E+00	1,55E-01	1,3166E-22	1,32E-22	3,8437E-11	1,19E+02
13	1,644514225	1,58E+00	3,83E+00	1,1133E-22	1,07E-22	3,5124E-11	1,19E+02
14	1,400188997	1,36E+00	2,58E+00	9,4793E-23	9,23E-23	3,2946E-11	1,19E+02
15	1,2	1,19E+00	8,10E-01	8,1240E-23	8,06E-23	3,1059E-11	1,20E+02
16	1,03487045	1,03E+00	9,19E-01	7,0061E-23	6,94E-23	2,9118E-11	1,20E+02
17	0,897752294	8,91E-01	7,16E-01	6,0778E-23	6,03E-23	2,7405E-11	1,20E+02
18	0,783153498	7,81E-01	2,70E-01	5,3019E-23	5,29E-23	2,5883E-11	1,20E+02
19	0,686774365	6,89E-01	3,68E-01	4,6495E-23	4,67E-23	2,4521E-11	1,20E+02
20	0,605230386	6,12E-01	1,16E+00	4,0974E-23	4,14E-23	2,3295E-11	1,20E+02
21	0,535841867	5,47E-01	2,08E+00	3,6276E-23	3,70E-23	2,2185E-11	1,20E+02
22	0,476474325	4,80E-01	7,33E-01	3,2257E-23	3,25E-23	2,0965E-11	1,19E+02
	DM pow E	Coeff. Corr.	0,9993694329	A →	154,190326	B →	2,31083634

Firstly might be seen how coefficient A is more than five times bigger than coefficient for dominion [8-22] and coefficient B is almost one tenth bigger.

In table below dominion for regression as power of E is [10-21] kpc.

kpc	mMsun/pc^3	mMsun/pc^3	
Radius	DM burket	DM Pow E	Rel diff. %
10	2,777142857	2,90E+00	4,29E+00
11	2,315785461	2,32E+00	3,88E-01
12	1,944684529	1,95E+00	1,11E-01
13	1,644514225	1,58E+00	3,83E+00
14	1,400188997	1,36E+00	2,56E+00
15	1,2	1,19E+00	7,57E-01
16	1,03487045	1,03E+00	8,35E-01
17	0,897752294	8,92E-01	6,05E-01
18	0,783153498	7,82E-01	1,32E-01
19	0,686774365	6,90E-01	5,32E-01
20	0,605230386	6,13E-01	1,35E+00
21	0,535841867	5,48E-01	2,29E+00
22	0,476474325	4,81E-01	9,71E-01
DM Power of E	138,0219398	←A B→	2,306235482
Coefficient	correlation	0,9992375652	

In this dominion A is 16 units lower and B is lightly lower. Relative difference for 22 kpc is low.

In table below dominion for regression as power of E is [10-19] kpc.

Kpc	mMsun/pc^3	mMsun/pc^3	
Radius	DM burket	DM Pow E	Rel diff. %
10	2,777142857	2,87E+00	3,46E+00
11	2,315785461	2,31E+00	8,67E-02
12	1,944684529	1,94E+00	9,96E-02
13	1,644514225	1,58E+00	3,74E+00
14	1,400188997	1,37E+00	2,25E+00
15	1,2	1,20E+00	2,40E-01
16	1,03487045	1,03E+00	9,88E-02
17	0,897752294	9,01E-01	3,42E-01
18	0,783153498	7,91E-01	1,02E+00
19	0,686774365	7,00E-01	1,88E+00
20	0,605230386	6,23E-01	2,89E+00
21	0,535841867	5,57E-01	4,02E+00
22	0,476474325	4,90E-01	2,87E+00
DM Power of E	60,5883977	← A B→	2,271992996
Coefficient	correlation	0,9990956684	

There is no difference between relative difference for radius inside dominion and radius outside.

In table below dominion for regression as power of E is [10-17] kpc.

Kpc	mMsun/pc^3	mMsun/pc^3	
Radius	DM burket	DM Pow E	Rel diff. %
10	2,777142857	2,85E+00	2,61E+00
11	2,315785461	2,30E+00	4,98E-01
12	1,944684529	1,94E+00	1,82E-01
13	1,644514225	1,59E+00	3,45E+00
14	1,400188997	1,38E+00	1,68E+00
15	1,2	1,21E+00	5,93E-01
16	1,03487045	1,05E+00	1,01E+00
17	0,897752294	9,13E-01	1,72E+00
18	0,783153498	8,04E-01	2,66E+00
19	0,686774365	7,13E-01	3,77E+00
20	0,605230386	6,36E-01	5,03E+00
21	0,535841867	5,70E-01	6,41E+00
22	0,476474325	5,03E-01	5,49E+00
DM Power of E	21,6406828	←A B→	2,229098170
Coefficient	correlation	0,9987941474	

In this case maximum relative difference for radius inside regression dominion is 3,45 % whereas is 6,41 % for radius outside.

In table below dominion for regression as power of E is [10-15] kpc.

In this case maximum relative difference for radius inside regression dominion is 2,62 % whereas is 10,9 % for radius outside.

Kpc	mMsun/pc^3	mMsun/pc^3	
Radius	DM burket	DM Pow E	Rel diff. %
10	2,777142857	2,82E+00	1,55E+00
11	2,315785461	2,30E+00	8,49E-01
12	1,944684529	1,95E+00	1,97E-02
13	1,644514225	1,60E+00	2,62E+00
14	1,400188997	1,39E+00	3,79E-01
15	1,2	1,23E+00	2,36E+00
16	1,03487045	1,07E+00	3,27E+00
17	0,897752294	9,38E-01	4,45E+00
18	0,783153498	8,29E-01	5,85E+00
19	0,686774365	7,38E-01	7,41E+00
20	0,605230386	6,60E-01	9,12E+00
21	0,535841867	5,94E-01	1,09E+01
22	0,476474325	5,26E-01	1,04E+01
DM Power of E	3,8388717	← A B→	2,156901790
Coefficient	correlation	0,9984077725	

In table below dominion for regression as power of E is [10-13] kpc.

In this case maximum relative difference for radius inside regression dominion is 1,06 % whereas is 21,3 % for radius outside.

Kpc	mMsun/pc^3	mMsun/pc^3	
Radius	DM burket	DM Pow E	Rel diff. %
10	2,777142857	2,78E+00	1,98E-01
11	2,315785461	2,30E+00	8,74E-01
12	1,944684529	1,97E+00	1,06E+00
13	1,644514225	1,64E+00	3,74E-01
14	1,400188997	1,44E+00	2,82E+00
15	1,2	1,28E+00	6,51E+00
16	1,03487045	1,12E+00	8,42E+00
17	0,897752294	9,93E-01	1,06E+01
18	0,783153498	8,85E-01	1,29E+01
19	0,686774365	7,93E-01	1,55E+01
20	0,605230386	7,15E-01	1,81E+01
21	0,535841867	6,48E-01	2,09E+01
22	0,476474325	5,78E-01	2,13E+01
DM Power of E	0,1419646	←A B→	2,018976886
Coefficient	correlation	0,9993241369	

In table below dominion for regression as power of E is [10-12] kpc.

In this case maximum relative difference for radius inside regression dominion is 1,02 % whereas is 17,6 % for radius outside.

Kpc Radius	mMsun/pc^3 DM burket	mMsun/pc^3 DM Pow E	Rel diff. %
10	2,777142857	2,79E+00	4,61E-01
11	2,315785461	2,29E+00	1,02E+00
12	1,944684529	1,96E+00	5,74E-01
13	1,644514225	1,62E+00	1,24E+00
14	1,400188997	1,42E+00	1,64E+00
15	1,2	1,26E+00	5,02E+00
16	1,03487045	1,10E+00	6,60E+00
17	0,897752294	9,74E-01	8,44E+00
18	0,783153498	8,65E-01	1,05E+01
19	0,686774365	7,74E-01	1,27E+01
20	0,605230386	6,96E-01	1,51E+01
21	0,535841867	6,30E-01	1,75E+01
22	0,476474325	5,60E-01	1,76E+01
DM Power of E	0,3989837	←A B→	2,062266783
Coefficient	correlation	0,9987402846	

Results for this epigraph is similar to epigraph 11.1

11.3 REDUCED DATA SET INCREASING LOWER BOUND OF RADIUS

kpc Radius	mMsun/pc^3 DM burket	mMsun/pc^3 DM Pow E	Rel diff. %	Kg/m^3 DM Burket	Kg/m^3 DM pow E	m/s^2 Virial E	Km/s Rot. Vel.
8	4,074173429	4,21E+00	3,36E+00	2,7582E-22	2,85E-22	5,4792E-11	116,3
9	3,353204173	3,54E+00	5,68E+00	2,2701E-22	2,40E-22	5,0735E-11	118,7
10	2,777142857	2,80E+00	7,44E-01	1,8801E-22	1,89E-22	4,5661E-11	1,19E+02
11	2,315785461	2,26E+00	2,44E+00	1,5678E-22	1,53E-22	4,1510E-11	1,19E+02
12	1,944684529	1,90E+00	2,23E+00	1,3166E-22	1,29E-22	3,8437E-11	1,19E+02
13	1,644514225	1,55E+00	5,55E+00	1,1133E-22	1,05E-22	3,5124E-11	1,19E+02
14	1,400188997	1,35E+00	3,91E+00	9,4793E-23	9,11E-23	3,2946E-11	1,19E+02
15	1,2	1,18E+00	1,77E+00	8,1240E-23	7,98E-23	3,1059E-11	1,20E+02
16	1,03487045	1,02E+00	1,44E+00	7,0061E-23	6,90E-23	2,9118E-11	1,20E+02
17	0,897752294	8,90E-01	8,35E-01	6,0778E-23	6,03E-23	2,7405E-11	1,20E+02
18	0,783153498	7,83E-01	3,18E-03	5,3019E-23	5,30E-23	2,5883E-11	1,20E+02
19	0,686774365	6,94E-01	1,01E+00	4,6495E-23	4,70E-23	2,4521E-11	1,20E+02
20	0,605230386	6,18E-01	2,16E+00	4,0974E-23	4,19E-23	2,3295E-11	1,20E+02
21	0,535841867	5,54E-01	3,43E+00	3,6276E-23	3,75E-23	2,2185E-11	1,20E+02
22	0,476474325	4,88E-01	2,46E+00	3,2257E-23	3,30E-23	2,0965E-11	1,19E+02
Coefficient	correlation	0,9990053597	A→	29,59901569	B→	2,243022838	

In table below dominion for regression as power of E is [10-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 4,4 % whereas is 10,3 % for radius outside. There is a remarkable difference between relative differences inside dominion regression and outside.

In this tables regression coefficients are increasing whereas in tables of previous epigraph are decreasing.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,42E+00	8,44E+00
9	3,353204173	3,70E+00	1,03E+01
10	2,777142857	2,90E+00	4,40E+00
11	2,315785461	2,33E+00	4,56E-01
12	1,944684529	1,95E+00	1,45E-01
13	1,644514225	1,58E+00	3,84E+00
14	1,400188997	1,36E+00	2,59E+00
15	1,2	1,19E+00	8,15E-01
16	1,03487045	1,03E+00	9,22E-01
17	0,897752294	8,91E-01	7,18E-01
18	0,783153498	7,81E-01	2,71E-01
19	0,686774365	6,89E-01	3,69E-01
20	0,605230386	6,12E-01	1,16E+00
21	0,535841867	5,47E-01	2,08E+00
22	0,476474325	4,80E-01	7,38E-01
DM pow E	153,320061	←A B→	2,31E+00
Coeff.	correlation	0,9993686761	

In table below dominion for regression as power of E is [12-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 2,59 % whereas is 14,9 % for radius outside.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,62E+00	1,35E+01
9	3,353204173	3,85E+00	1,49E+01
10	2,777142857	3,00E+00	8,08E+00
11	2,315785461	2,39E+00	3,39E+00
12	1,944684529	2,00E+00	2,59E+00
13	1,644514225	1,61E+00	2,03E+00
14	1,400188997	1,38E+00	1,14E+00
15	1,2	1,20E+00	3,00E-01
16	1,03487045	1,03E+00	2,01E-01
17	0,897752294	8,94E-01	3,63E-01
18	0,783153498	7,81E-01	2,62E-01
19	0,686774365	6,87E-01	4,89E-02
20	0,605230386	6,08E-01	5,26E-01
21	0,535841867	5,42E-01	1,14E+00
22	0,476474325	4,74E-01	5,35E-01
DM pow E	675,003749	←A B→	2,37E+00
Coeff.	correlation	0,9996724455	

In table below dominion for regression as power of E is [14-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 0,91 % whereas is 16,5 % for radius outside. Coefficients A & B follow increasing.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,70E+00	1,53E+01
9	3,353204173	3,91E+00	1,65E+01
10	2,777142857	3,04E+00	9,36E+00
11	2,315785461	2,42E+00	4,42E+00
12	1,944684529	2,01E+00	3,45E+00
13	1,644514225	1,62E+00	1,39E+00
14	1,400188997	1,39E+00	6,21E-01
15	1,2	1,21E+00	7,08E-01
16	1,03487045	1,04E+00	7,57E-02
17	0,897752294	8,96E-01	2,09E-01
18	0,783153498	7,81E-01	2,22E-01
19	0,686774365	6,87E-01	1,96E-02
20	0,605230386	6,07E-01	3,54E-01
21	0,535841867	5,40E-01	8,66E-01
22	0,476474325	4,72E-01	9,16E-01
DM pow E	1101,99903	←A B→	2,39E+00
Coeff.	correlation	0,9998758668	

In table below dominion for regression as power of E is [16-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 2,39 % whereas is 16,4 % for radius outside.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,69E+00	1,51E+01
9	3,353204173	3,90E+00	1,64E+01
10	2,777142857	3,03E+00	9,23E+00
11	2,315785461	2,42E+00	4,31E+00
12	1,944684529	2,01E+00	3,36E+00
13	1,644514225	1,62E+00	1,45E+00
14	1,400188997	1,39E+00	6,73E-01
15	1,2	1,21E+00	6,69E-01
16	1,03487045	1,04E+00	5,08E-02
17	0,897752294	8,96E-01	2,20E-01
18	0,783153498	7,81E-01	2,21E-01
19	0,686774365	6,87E-01	7,13E-03
20	0,605230386	6,08E-01	3,78E-01
21	0,535841867	5,41E-01	9,00E-01
22	0,476474325	4,72E-01	8,70E-01
DM pow E	1045,04194	←A B→	2,39E+00
Coeff.	correlation	0,9998057449	

In table below dominion for regression as power of E is [18-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 0,91 % whereas is 15,5 % for radius outside.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,65E+00	1,41E+01
9	3,353204173	3,87E+00	1,55E+01
10	2,777142857	3,01E+00	8,51E+00
11	2,315785461	2,40E+00	3,71E+00
12	1,944684529	2,00E+00	2,84E+00
13	1,644514225	1,61E+00	1,86E+00
14	1,400188997	1,39E+00	1,03E+00
15	1,2	1,20E+00	3,63E-01
16	1,03487045	1,03E+00	1,93E-01
17	0,897752294	8,94E-01	4,07E-01
18	0,783153498	7,80E-01	3,54E-01
19	0,686774365	6,86E-01	8,98E-02
20	0,605230386	6,07E-01	3,43E-01
21	0,535841867	5,41E-01	9,12E-01
22	0,476474325	4,73E-01	8,06E-01
DM pow E	830,609577	←A B→	2,38E+00
Coeff.	correlation	0,9994380236	

In table below dominion for regression as power of E is [20-22] kpc.

In this case maximum relative difference for radius inside regression dominion is 0,73 % whereas is 7 % for radius outside.

Radius Kpc	DM burket	DM Pow E	Rel diff.
8	4,074173429	4,18E+00	2,66E+00
9	3,353204173	3,51E+00	4,79E+00
10	2,777142857	2,77E+00	3,30E-01
11	2,315785461	2,23E+00	3,68E+00
12	1,944684529	1,87E+00	3,64E+00
13	1,644514225	1,53E+00	7,09E+00
14	1,400188997	1,32E+00	5,60E+00
15	1,2	1,16E+00	3,62E+00
16	1,03487045	9,99E-01	3,44E+00
17	0,897752294	8,71E-01	2,97E+00
18	0,783153498	7,65E-01	2,28E+00
19	0,686774365	6,77E-01	1,41E+00
20	0,605230386	6,03E-01	3,95E-01
21	0,535841867	5,40E-01	7,34E-01
22	0,476474325	4,75E-01	3,33E-01
DM pow E	49,0968122	←A B→	2,26E+00
Coeff.	correlation	0,998601121	

This results show clearly that function of DM density as power of E might work with error not very big outside region where this function has been calculated.
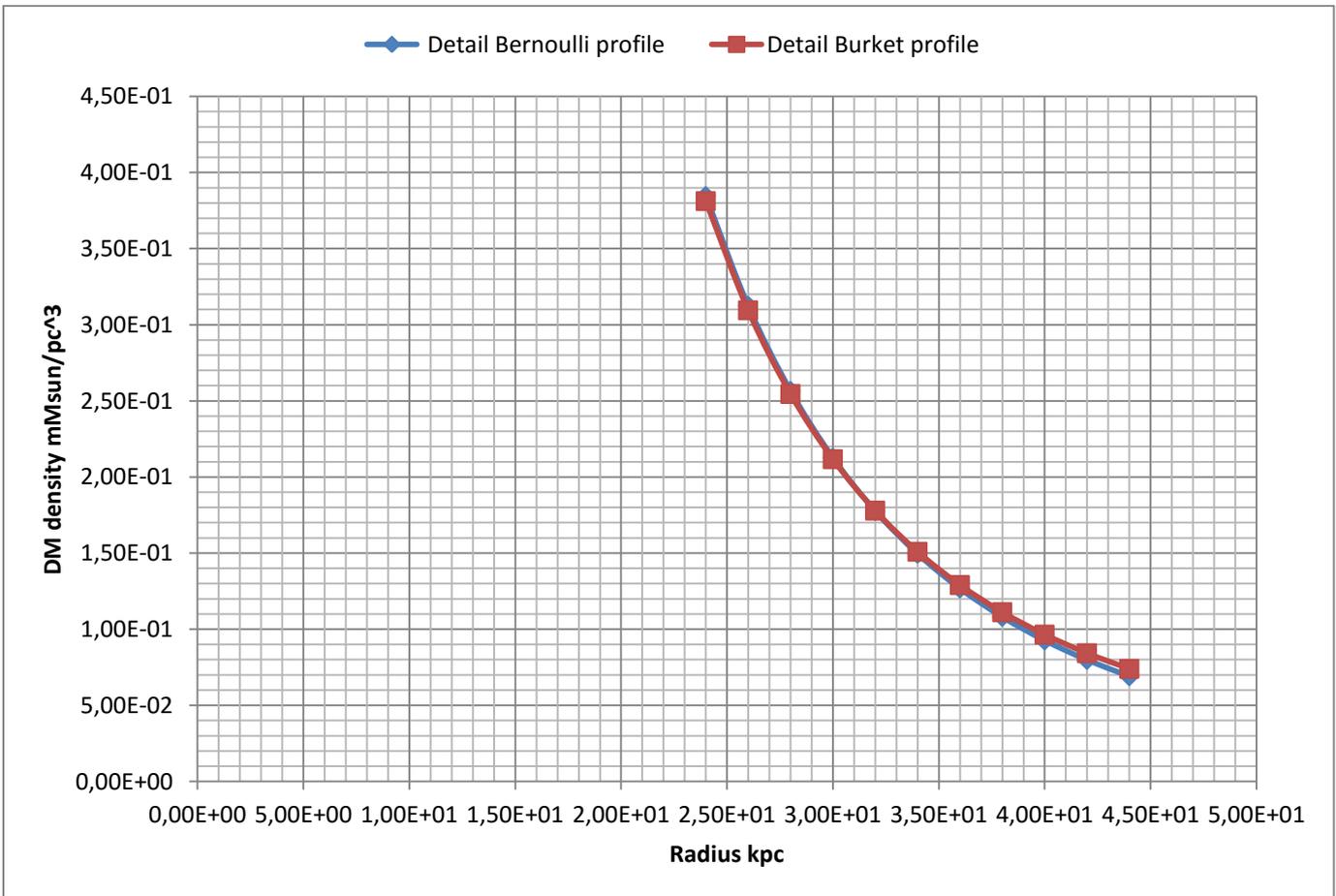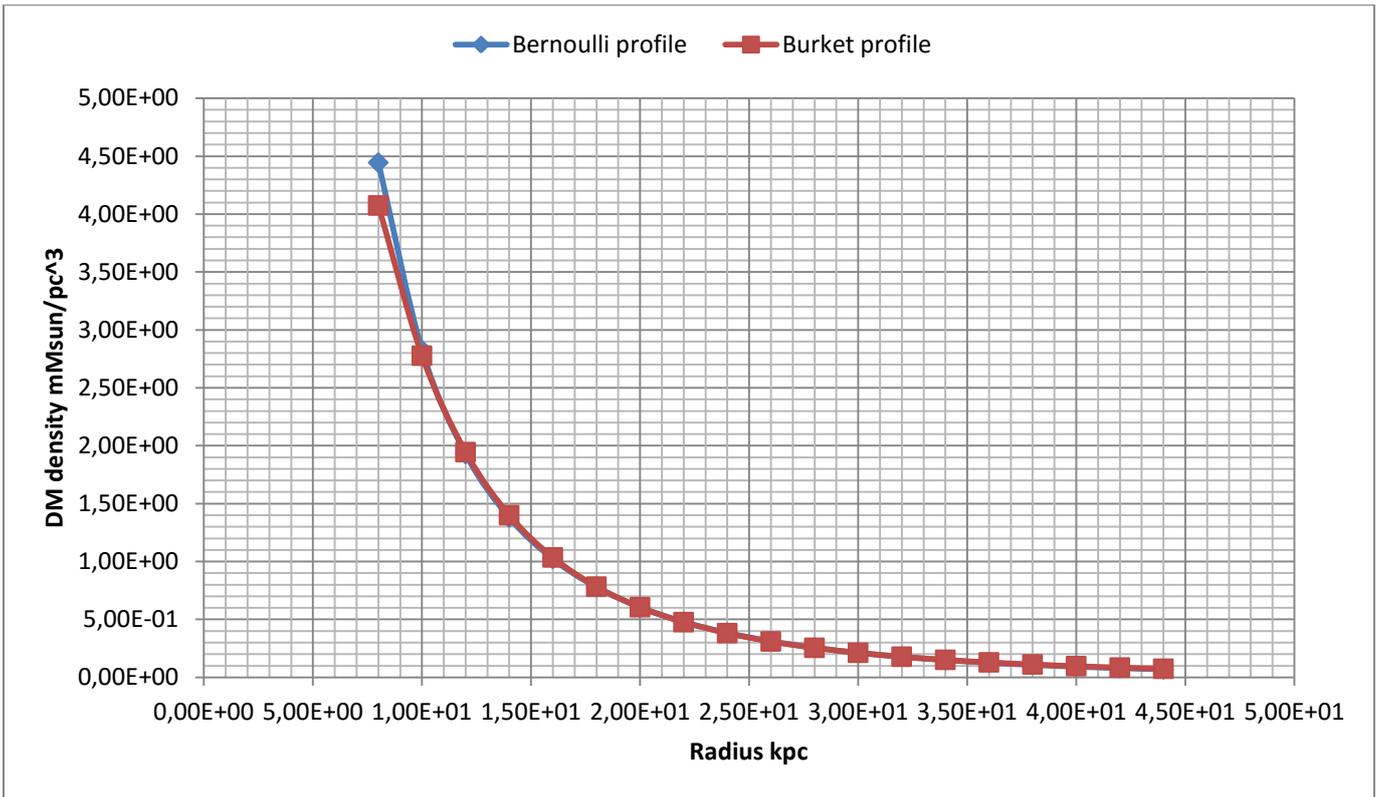
12. BERNOULLI PROFILE EXTRAPOLATED UP TO 70 KPC

The main consequence of chapter 11 is that Bernoulli profile calculated inside dominion 8kpc up to 22 kpc may be extrapolated out this dominion   and relative differences with Burket profile are not very big. In following paragraphs are shown results of dominion extrapolation, firstly up to 44 kpc, whose maximum relative difference is 6,5% and secondly up to 70 kpc, whose maximum relative difference is 26%.

12.1 BERNOULLI PROFILE EXTRAPOLATED UP TO 44 KPC

Radius	Bernoulli	Burket	Reltv. Diff.
kpc	mMsun/pc^3	mMsun/pc^3	%
8,00E+00	4,44E+00	4,07E+00	9,09E+00
1,00E+01	2,83E+00	2,78E+00	1,77E+00
1,20E+01	1,93E+00	1,94E+00	8,62E-01
1,40E+01	1,38E+00	1,40E+00	1,45E+00
1,60E+01	1,02E+00	1,03E+00	1,16E+00
1,80E+01	7,79E-01	7,83E-01	5,59E-01
2,00E+01	6,06E-01	6,05E-01	6,79E-02
2,20E+01	4,79E-01	4,76E-01	5,72E-01
2,40E+01	3,85E-01	3,81E-01	8,80E-01
2,60E+01	3,13E-01	3,10E-01	9,65E-01
2,80E+01	2,57E-01	2,55E-01	8,21E-01
3,00E+01	2,13E-01	2,12E-01	4,58E-01
3,20E+01	1,78E-01	1,78E-01	1,06E-01
3,40E+01	1,50E-01	1,51E-01	8,52E-01
3,60E+01	1,27E-01	1,29E-01	1,76E+00
3,80E+01	1,08E-01	1,11E-01	2,80E+00
4,00E+01	9,27E-02	9,65E-02	3,96E+00
4,20E+01	7,99E-02	8,43E-02	5,22E+00
4,40E+01	6,92E-02	7,40E-02	6,56E+00

As reader can check relative differences are below 3% for radius lower than 36 kpc, which is a remarkable results because data set for power regression have been form 8 kpc to 22 kpc.

Graph below show perfectly both profiles through the whole dominion of radius.

12.2 BERNOULLI PROFILE EXTRAPOLATED UP TO 70 KPC

210 kpc is approximately a half distance from M33 to M31, so it worth to explore DM density up to one third this distance.

According theory of DM generated by gravitational field, it is right to consider that a galactic halo extend up to radius where galactic gravitational field dominates over external gravitational field. Taking into account that M31 is a great deal more massive than M33, M31 halo has to be larger than M33 halo. Next paper will be explored DM density in M31 galaxy then it will be possible to estimate halo sizes for both galaxies.

As reader can check relative difference is below 10 % for radius lower than 50 kpc, is below 20 % for radius lower than 62 kpc and is below 26 % for radius lower than 70kpc.

Radius	Bernoulli profile	Burket profile	Relative difference
Kpc	mMsun/pc^3	mMsun/pc^3	%
1,00E+01	2,83E+00	2,78E+00	1,77E+00
1,20E+01	1,93E+00	1,94E+00	8,62E-01
1,40E+01	1,38E+00	1,40E+00	1,45E+00
1,60E+01	1,02E+00	1,03E+00	1,16E+00
1,80E+01	7,79E-01	7,83E-01	5,59E-01
2,00E+01	6,06E-01	6,05E-01	6,79E-02
2,20E+01	4,79E-01	4,76E-01	5,72E-01
2,40E+01	3,85E-01	3,81E-01	8,80E-01
2,60E+01	3,13E-01	3,10E-01	9,65E-01
2,80E+01	2,57E-01	2,55E-01	8,21E-01
3,00E+01	2,13E-01	2,12E-01	4,58E-01
3,20E+01	1,78E-01	1,78E-01	1,06E-01
3,40E+01	1,50E-01	1,51E-01	8,52E-01
3,60E+01	1,27E-01	1,29E-01	1,76E+00
3,80E+01	1,08E-01	1,11E-01	2,80E+00
4,00E+01	9,27E-02	9,65E-02	3,96E+00
4,20E+01	7,99E-02	8,43E-02	5,22E+00
4,40E+01	6,92E-02	7,40E-02	6,56E+00
4,60E+01	6,01E-02	6,53E-02	7,96E+00
4,80E+01	5,25E-02	5,80E-02	9,41E+00
5,00E+01	4,60E-02	5,17E-02	1,09E+01
5,20E+01	4,05E-02	4,62E-02	1,24E+01
5,40E+01	3,57E-02	4,15E-02	1,40E+01
5,60E+01	3,17E-02	3,75E-02	1,55E+01
5,80E+01	2,81E-02	3,39E-02	1,70E+01
6,00E+01	2,51E-02	3,08E-02	1,86E+01
6,20E+01	2,24E-02	2,80E-02	2,01E+01
6,40E+01	2,00E-02	2,56E-02	2,16E+01
6,60E+01	1,80E-02	2,34E-02	2,31E+01
6,80E+01	1,62E-02	2,15E-02	2,46E+01
7,00E+01	1,46E-02	1,98E-02	2,61E+01

In graph below have been plotted both profiles from 40 to 70 kpc. Reader can check how the bigger radius is the larger relative difference is.
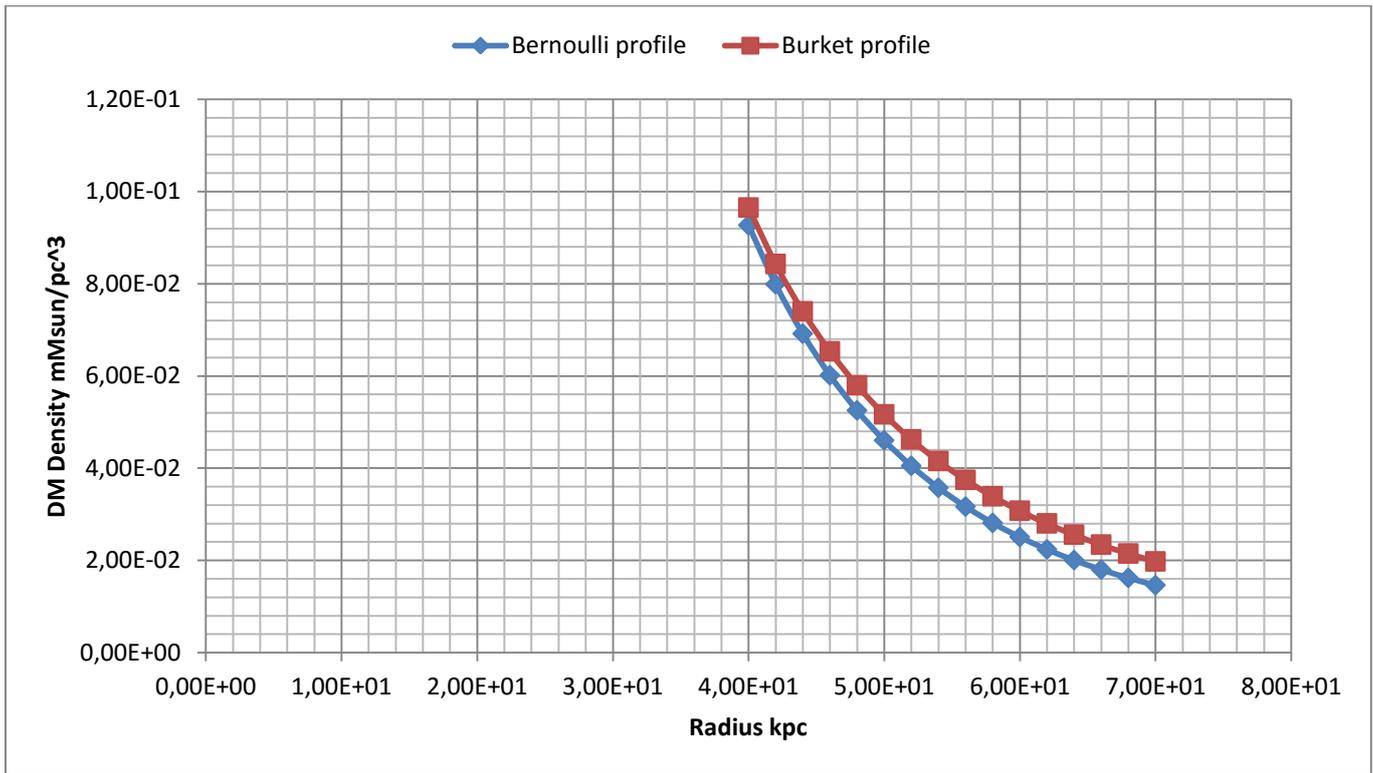
13.   CONCLUSION

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: Burket DM density profile, which has been got by meticulous measures of M33 rotation curve, is fitted with a function as power of E with a correlation coefficient bigger than 0.999. Thanks this function it has been possible to state a Bernoulli differential equation for gravitational field E, inside galactic halo where density of baryonic is negligible in comparison with DM density.

Solution of Bernoulli for gravitational field is used to get   a new DM profile called Bernoulli DM profile, which has been compared with Burket DM density getting relative differences under 2 % inside main part of dominion, exactly for radius bigger than 10 kpc up to 22 kpc. Even relative difference is below 2 % from 22 kpc up to 36 kpc, which is a region where DM Bernoulli has been extrapolated.

In my opinion these results suggest strongly that DM density is generated according a Universal law as power of E $D_{DM} = A \cdot E^{B}$ where A and B are parameters which depend on each galaxy, more exactly, values of coefficients A and B depend on mass of galaxies.

In addition, taking in consideration results of previous paper, it has been found that the more massive the galaxy the less DM density is at a specific value of E. Results also suggest that two galaxies with similar mass have similar DM density at a specific value of E.

14.   BIBLIOGRAPHYC REFERENCES

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