TWO NEW NON BARYONIC DARK MATTER DENSITY PROFILES FOR MILKY WAY HALO

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1. ABSTRACT

In this work has been calculated two new non baryonic DM density profiles inside halo region of Milky Way, MW hereafter, and it has been demonstrated that both ones are mathematically equivalents. Data have been got from rotation curve published in [17] Bhattacharjee, P.2014.

The first profile is called *Direct DM density* because it is got directly from velocity as power regression of radius in halo rotation curve. In other words velocity of rotation curve depend on radius as a power function.

The second one, *DM density as power of E*, E is gravitational field, has been introduced by author in previous papers, [8] Abarca,M.2016, where it has been used to study non baryonic DM in several galaxies. It is called “as power of E” because DM density depend on E as a power function.

Hypothesis which is the basis of theory is that non baryonic DM is generated locally by the own gravitational field according a power law. DM density = A· E^B where A& B are coefficients and E is gravitational intensity of field.

To find reasons that author has to do so daring statement, reader can consult [1] Abarca,M.2014. *Dark matter model by quantum vacuum*. [8] Abarca,M.2016. *Dark matter density on big galaxies depend on gravitational field as Universal law* and other papers quoted in bibliography.

Briefly will be explained method followed to develop this paper. Firstly are presented rotation curve and table with data points inside MW halo. These data come from [17] Bhattacharjee, P. Chaudary, S. Kundu, S.2014. In addition it is fitted a power regression of rotation curve points in halo region whose function is v = a·r^b .

In fourth chapter it is developed a mathematical method to get a new DM density depending on radius called direct DM density because it is got directly from power regression of velocity depending on radius. Also it is compared Direct DM got from rotation curve [17] Bhattacharjee, P.2014 and Direct DM got from rotation curve [5] Sofue, Y.2015. It is shown that relative difference oscillate between 2.6% at 40 kpc and 3.8 % at 190 kpc which is a very exiguous difference. It is a very good news that two prominent teams of researchers got so similar results.

In fifth chapter it has been demonstrated that Direct DM profile is mathematically equivalent to DM density depending on gravitational field, as a power function i.e. DM density = A· E^B, where A& B are cleared up depending on a & b (parameters of power regression of velocity).

In sixth chapter it has been got that for radius bigger than 40 kpc ratio baryonic density versus DM density is under 4% so it is reasonable to consider negligible baryonic density in order to develop theory introduced in this work.

In seventh chapter is compared Direct DM density got in this paper with NFW density profile fitted by Sofue in his paper. [5] Sofue, Y.2015. Throughout dominion NFW profile is bigger than Direct DM profile. Its relative difference oscillate between 25% at 40 kpc and 22% at 190 kpc.

In my opinion this remarkable fact could be explained because NFW profile is fitted with total DM enclosed inside galactic disc and as it is known inside bulge and disc there is an unknown amount of baryonic DM such as dwarf browns and cold gas clouds. However Direct DM profile is fitted with data which radius are bigger than 40 kpc where baryonic matter is negligible. It is clear that extra DM density data inside disc have influence over the whole NFW profile so it is right to conclude that relative difference between Direct DM and NFW profile might be explained by baryonic DM inside bulge and disc.

In eight chapter is compared DM density as power E in MW with DM density as power E in M31, which was published in [11] Abarca,M.2016. Results show that at a specific E, both DM densities are very similar. Relative differences are under 15 % inside main part of dominion. This fact support strongly author hypothesis about DM as power of E as Universal law.

2. INTRODUCTION

As reader knows Milky Way is the twin galaxy of M31 in Local Group of galaxies. Its disk radius is approximately 20 kpc and according [5] Sofue, Y. 2015 its baryonic mass is $M_{BARYONIC} = 1{,}37 \cdot 10^{11}\ M_{SUN}$
In previous paper [18] Abarca,M.2016 , author has calculated Direct DM and DM as power of E inside Milky Way halo through data which come from rotation curve published by [5] Sofue, Y. 2015, whereas in this paper both DM profiles have been calculated from rotation curve published in [17] Bhattacharjee, P.2014.

This new DM profile has been called direct DM density because this profile is fitted directly from data measures inside halo region. In this work radius dominion begin at 40 kpc because at this distance baryonic density is negligible as it will be shown in chapter six. Therefore the only one kind of matter in halo region it is supposed to be non baryonic dark matter or at least it is the dominant kind of matter.

It is known that there is baryonic dark matter such us giant planets, cold gas clouds, brown dwarfs but this kind of DM is more probable to be placed inside galactic disk and bulge. Reader can consult: [12] Nieuwenhuizen,T.M. 2010. [13] Nieuwenhuizen,T.M. 2012. [14] Nieuwenhuizen,T.M. 2010 [15] Wyrzykowski,L.2010. [16] M.R.S. Hawkins 2015.In fact there are an important amount of researchers in this way because baryonic DM and non baryonic DM are open problems still.

DM theory introduced in [1] Abarca, M.2014. *Dark matter model by quantum vacuum* and developed in others papers quoted in bibliography refers an original mechanism of non baryonic DM through the own gravitational field. So DM density is a power of gravitational field whose formula is $\varphi_{DM}(r) = A \cdot E^{B}$ .Therefore it is needed to consider a radius dominion where baryonic matter would be negligible in order to study purely non baryonic DM.

In fact, according [5] Sofue, Y. 2015 data, in chapter six will be got that for radius bigger than 40 kpc baryonic matter density is under 4 % regarding DM density. This is the reason why radius dominion in this work is from 40kpc up to 190 kpc.

In chapter seven is compared DM density NFW profile with direct DM density profile and it is shown that NFW profile is bigger than Direct DM density throughout the whole dominion and its relative difference oscillates between 26 % at 40 kpc and 21% at 190 kpc. Taking into account that NFW is got through total DM enclosed inside galactic disc whereas direct DM profile is got in halo region, where baryonic density is negligible, it is possible to conclude that extra density of NFW profile come from baryonic DM enclosed in bulge and galactic halo.

Baryonic DM depend on evolution history for each galaxy however results got in my previous papers and this paper itself allows me to postulate that non baryonic DM depend on gravitational field as a universal law for giant galaxies.

In paper [1] Abarca,M.2014, it was postulated that DM density depends on gravitational field according an universal law. Further papers [2] Abarca,M.2015 and others have studied DM density as power of gravitational field in several galaxies: M31 and others galaxies. Results got support such hypothesis, because $\varphi_{DM}(r) = A \cdot E^{B}$ produces similar values of density in different giant galaxies through its respective A&B parameters of each galaxy.

3. OBSERVATIONAL BHATTACHARJEE DATA FOR MILKY WAY ROTATION CURVE

Table below has been got from paper [17] Bhattacharjee, P. Chaudary, S. Kundu, S.2014.

In chapter six will be shown reason why dominion data begin at 40 kpc in this work, despite the fact that it is supposed radius of galactic disk is 20 kpc.

TABLE 2

THE CIRCULAR VELOCITY, V_c, AND ITS 1-σ ERROR, ΔV_c, FOR VARIOUS VALUES OF THE GALACTOCENTRIC DISTANCE, r, FOR A RADIAL PROFILE OF THE NON-DISK TRACERS' VELOCITY ANISOTROPY PARAMETER β DERIVED FROM FIGURE 2 OF RASHKOV ET AL. (2013), WITH $\left[\frac{R_0}{\mathrm{kpc}}, \frac{V_0}{\mathrm{km\,s^{-1}}}\right] = [8.3, 244]$.

r (kpc)	V_c ($\mathrm{km\,s^{-1}}$)	ΔV_c ($\mathrm{km\,s^{-1}}$)	r (kpc)	V_c ($\mathrm{km\,s^{-1}}$)	ΔV_c ($\mathrm{km\,s^{-1}}$)
0.20	233.0	13.32	38.41	191.57	11.73
0.38	268.92	4.67	40.42	197.59	14.12
0.66	250.75	11.35	42.40	192.79	5.92
1.61	217.83	5.81	44.49	213.22	17.17
2.57	219.58	1.48	45.99	179.39	11.23
3.59	223.11	2.43	48.06	213.03	24.72
4.51	247.88	2.99	49.49	178.57	17.63
5.53	253.14	1.69	51.39	183.31	23.58
6.50	270.95	2.19	53.89	157.89	19.57
7.56	267.80	0.96	56.89	191.76	24.35
8.34	270.52	0.66	57.98	210.72	29.81
9.45	235.58	8.44	60.92	168.02	25.67
10.50	249.72	13.44	64.73	206.47	36.27
11.44	261.96	11.71	69.31	203.62	40.89
12.51	284.30	17.50	72.96	190.53	40.98
13.53	271.54	15.57	76.95	222.72	74.37
14.59	251.43	25.60	81.13	186.29	66.53
16.05	320.70	25.27	84.90	122.25	36.46
18.64	286.46	101.18	89.35	143.95	29.49
26.30	189.64	6.74	92.44	154.66	67.23
28.26	237.99	11.54	97.41	184.0	72.86
29.51	209.82	9.16	100.72	108.68	40.99
32.04	179.14	6.65	106.77	137.15	53.17
33.99	170.37	6.93	119.98	150.18	25.46
36.49	175.92	6.62	189.49	125.01	37.32

3.1 POWER REGRESSION OF VELOCITY DEPENDING ON RADIUS IN ROTATION CURVE

In order to assure that baryonic matter density is negligible versus non baryonic matter density it has been considered radius bigger than 40 kpc. In chapter six will be explained reason to get 40 kpc as starting point.

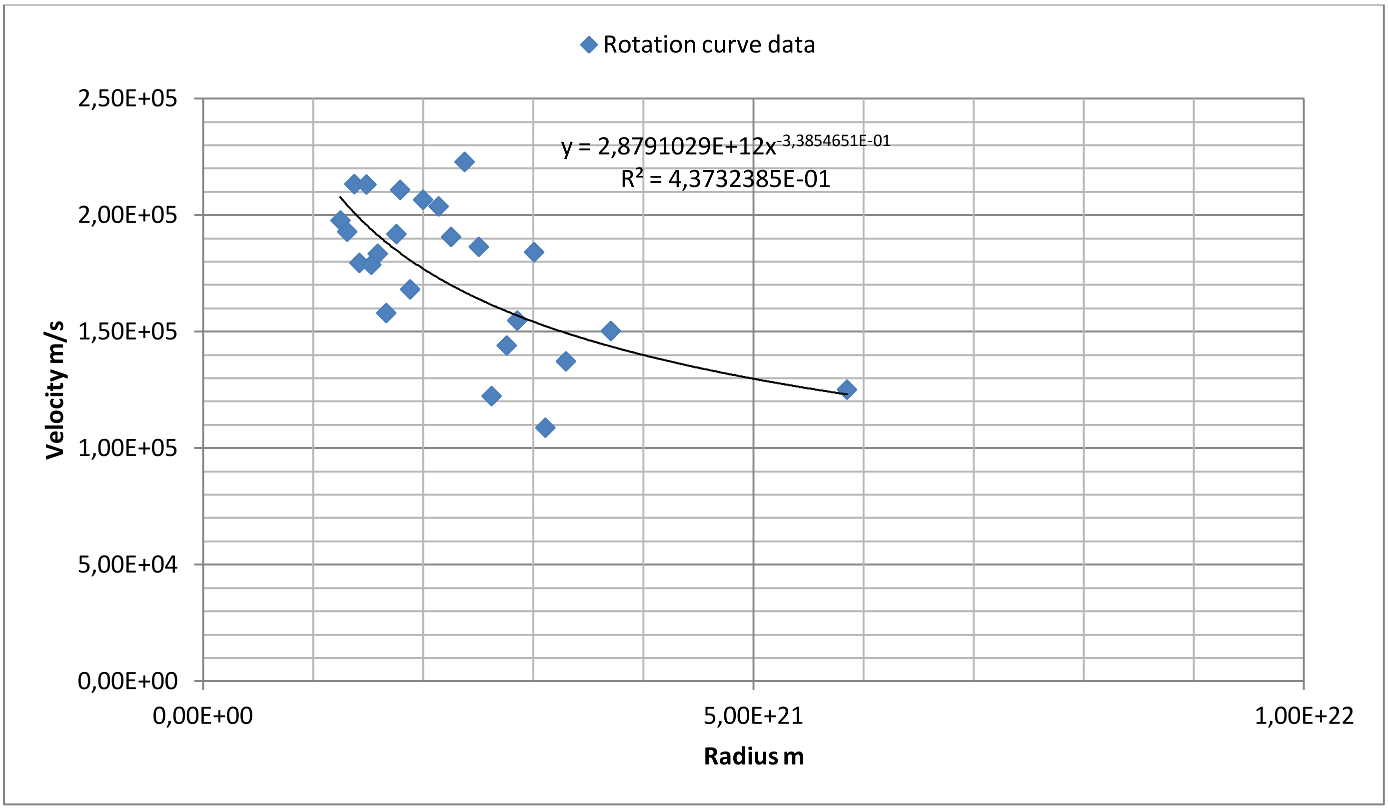
Equivalence data into International System			
Radius	Velocity	Radius	velocity
kpc	km/s	m	m/s
40,42	197,59	1,25E+21	1,98E+05
42,4	192,79	1,31E+21	1,93E+05
44,49	213,22	1,37E+21	2,13E+05
45,99	179,39	1,42E+21	1,79E+05
48,06	213,03	1,48E+21	2,13E+05
49,49	178,57	1,53E+21	1,79E+05
51,39	183,31	1,59E+21	1,83E+05
53,89	157,89	1,66E+21	1,58E+05
56,89	191,76	1,76E+21	1,92E+05
57,98	210,72	1,79E+21	2,11E+05
60,92	168,02	1,88E+21	1,68E+05
64,73	206,47	2,00E+21	2,06E+05
69,31	203,62	2,14E+21	2,04E+05
72,96	190,53	2,25E+21	1,91E+05
76,95	222,72	2,37E+21	2,23E+05
81,13	186,29	2,50E+21	1,86E+05
84,9	122,25	2,62E+21	1,22E+05
89,35	143,95	2,76E+21	1,44E+05
92,44	154,66	2,85E+21	1,55E+05
97,41	184	3,01E+21	1,84E+05
100,72	108,68	3,11E+21	1,09E+05
106,77	137,15	3,29E+21	1,37E+05
119,98	150,18	3,70E+21	1,50E+05
189,49	125,01	5,85E+21	1,25E+05

It is seen that experimental measures of rotation curve has a very good fitted curve by power regression.

Data fitted into I.S. are in grey columns below. Correlation coefficient is 0.66 which is an acceptable correlation coefficient. In particular coefficients of $v = a \cdot r^b$ are in table below. Units are into I.S.

Power regression for Milky Way rot. curve	
V=a*r^b	
a	$2.87910294 \cdot 10^{12}$
b	$-3,385465058 \cdot 10^{-1}$
Correlation coeff.	0.6613046575

Below is shown a graphic with measures data and power regression function.



A coefficient of 0,66 is an acceptable correlation coefficient. Therefore this value support hypothesis that rotation curve of Milky Way follows a law $v = a \cdot r^{b}$ where a & b are written above.

4. DIRECT FORMULA FOR DM DENSITY ON MILKY WAY HALO GOT FROM ROTATION CURVE

4.1 THEORETICAL DEVELOPPMENT FOR GALACTIC HALOS

Outside disk region, rotation curve it is fitted by power regression with a high correlation coefficient according formula $v = a \cdot r^{b}$. As $M(<r) = \dfrac{v^2 \cdot R}{G}$ represents total mass enclosed by a sphere with radius r, by substitution of velocity results $M = \dfrac{v^2 \cdot R}{G} = \dfrac{a^2 \cdot r^{2b+1}}{G}$

If it is considered outside region of disk where baryonic matter is negligible regarding dark matter it is possible to calculate DM density by a simple derivative. In chapter 6 will be shown that for r > 40 kpc baryonic matter is negligible regarding DM density because baryonic matter density is lower than 4% of DM density.

Density of D.M. is $D_{DM} = \dfrac{dm}{dV}$ where $dm = \dfrac{a^2 \cdot (2b+1) \cdot r^{2b} dr}{G}$ and $dV = 4\pi r^2 dr$ so $D_{DM} = \dfrac{a^2 \cdot (2b+1)}{4\pi G} \cdot r^{2b-2}$

Writing $L = \dfrac{a^2 \cdot (2b+1)}{4\pi G}$ results $D_{DM}(r) = L \cdot r^{2b-2}$. In case b = -1/2 DM density is cero which is Keplerian rotation.

4.2 DIRECT DM DENSITY FOR MILKY WAY HALO

Parameters a & b from power regression of Milky Way rotation curve allow calculate easily direct DM density.

Direct DM density for Milky Way halo 40 < r < 190 kpc
$D_{DM}(r) = L \cdot r^{2b-2}$ kg/m^3
L = 3,191984996 $\cdot 10^{33}$
2b -2 = -2,677093012

Beside is such function and table.

Below is shown results of DM density inside its dominion. Calculus are into I.S.

Radius	Radius	Direct DM
kpc	m	kg/m^3
40	1,234E+21	1,09744975E-23
50	1,543E+21	6,03875658E-24
60	1,851E+21	3,70656792E-24
70	2,160E+21	2,45329165E-24
80	2,469E+21	1,71592912E-24
90	2,777E+21	1,25187015E-24
100	3,086E+21	9,44196151E-25
110	3,394E+21	7,31560348E-25
120	3,703E+21	5,79544336E-25
130	4,011E+21	4,67762362E-25
140	4,320E+21	3,83587002E-25
150	4,629E+21	3,18896349E-25
160	4,937E+21	2,68295907E-25
170	5,246E+21	2,28101966E-25
180	5,554E+21	1,95737477E-25
190	5,863E+21	1,69360805E-25

4.3 DIRECT DM BHATTACHARJEE DATA VERSUS SOFUE DATA

Power regression for Milky Way rot. Curve Through Sofue data	
V=a*r^b	
a	3,492829549E+12
b	-3,425408589E-01
Correlation coeff.	0,85

In paper [18] Abarca,M.2016 it is got parameters a& b through Sofue data published in [5] Sofue, Y.2015.

To the left are shown parameters got through Sofue data.

Below are tabulated and compared direct DM density got through Sofue & Bhattacharjee data.

Radius	Radius	DM Sofue	DM Bhatacharjee	Relt. Diff.
kpc	m	kg/m^3	kg/m^3	%
40	1,234E+21	1,06869152E-23	1,0974497E-23	2,620E+00
50	1,543E+21	5,87003998E-24	6,0387566E-24	2,794E+00
60	1,851E+21	3,59776625E-24	3,7065679E-24	2,935E+00
70	2,160E+21	2,37834768E-24	2,4532916E-24	3,055E+00
80	2,469E+21	1,66173675E-24	1,7159291E-24	3,158E+00
90	2,777E+21	1,21119348E-24	1,2518701E-24	3,249E+00
100	3,086E+21	9,12748066E-25	9,4419615E-25	3,331E+00
110	3,394E+21	7,06656209E-25	7,3156035E-25	3,404E+00
120	3,703E+21	5,59426204E-25	5,7954434E-25	3,471E+00
130	4,011E+21	4,51235967E-25	4,6776236E-25	3,533E+00
140	4,320E+21	3,69815581E-25	3,8358700E-25	3,590E+00
150	4,629E+21	3,07278024E-25	3,1889635E-25	3,643E+00
160	4,937E+21	2,58387850E-25	2,6829591E-25	3,693E+00
170	5,246E+21	2,19571888E-25	2,2810197E-25	3,740E+00
180	5,554E+21	1,88331682E-25	1,9573748E-25	3,784E+00
190	5,863E+21	1,62882611E-25	1,6936080E-25	3,825E+00

Last column shows relative difference between both set of parameters. It is clear that difference is negligible throughout whole dominion.

5. DARK MATTER DENSITY AS POWER OF GRAVITATIONAL FIELD

As independent variable for this function is E, previously will be studied formula for E in the following paragraph.

5.1 GRAVITATIONAL FIELD E THROUGH VIRIAL THEOREM

Radius	Radius	$E = a^2 \cdot r^{2b-1}$
kpc	m	m/s^2
40	1,234E+21	3,518E-11
50	1,543E+21	2,419E-11
60	1,851E+21	1,782E-11
70	2,160E+21	1,376E-11
80	2,469E+21	1,100E-11
90	2,777E+21	9,028E-12
100	3,086E+21	7,566E-12
110	3,394E+21	6,448E-12
120	3,703E+21	5,573E-12
130	4,011E+21	4,873E-12
140	4,320E+21	4,303E-12
150	4,629E+21	3,833E-12
160	4,937E+21	3,440E-12
170	5,246E+21	3,107E-12
180	5,554E+21	2,823E-12
190	5,863E+21	2,579E-12

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, virial gravitational field, E, got through this formula will be called E.

By substitution of $v = a \cdot r^b$ in formula $E = \frac{v^2}{r}$ it is right to get $E = \frac{a^2 \cdot r^{2b}}{r} = a^2 \cdot r^{2b-1}$ briefly $E = a^2 \cdot r^{2b-1}$

5.2 DARK MATTER DENSITY AS POWER OF GRAVITATIONAL FIELD

According hypothesis dark matter by quantum vacuum $D_{DM} = A \cdot E^B$. Where A & B are parameters to be calculated. This hypothesis has been widely studied by author in previous papers. [1] Abarca,M. [2] Abarca,M.

[8] Abarca,M. [9] Abarca,M. [10] Abarca,M.

As it is known direct DM density $D_{DM} = \frac{a^2 \cdot (2b+1)}{4\pi G} \cdot r^{2b-2}$ depend on a & b parameters which come from power regression formula for velocity. In previous paragraph has been shown formula for gravitational field $E = \frac{a^2 \cdot r^{2b}}{r} = a^2 \cdot r^{2b-1}$ which depend on a & b as well. Through a simple mathematical treatment it is possible to get A & B to find function of DM density depending on E i.e. $D_{DM} = A \cdot E^B$

Specifically formulas are $A = \frac{a^{\frac{2}{2b-1}} \cdot (2b+1)}{4\pi G}$ & $B = \frac{2b-2}{2b-1}$.

According parameters a & b got in previous chapter, A& B parameters are:

Milky Way	$D_{DM} = A \cdot E^B$
A	5,33811096426447 $\cdot 10^{-7}$
B	1,5962698509166

Below is tabulated DM density as power of E and direct DM density, both are identical as it was expected.

Radius	Radius	$D_{DM}(r) = L \cdot r^{2b-2}$	$E = a^2 \cdot r^{2b-1}$	$D_{DM} = A \cdot E^B$
kpc	m	Kg/m^3	m/s^2	Kg/m^3
40	1,234E+21	1,0974497E-23	3,518E-11	1,0974497E-23
50	1,543E+21	6,0387566E-24	2,419E-11	6,0387566E-24
60	1,851E+21	3,7065679E-24	1,782E-11	3,7065679E-24
70	2,160E+21	2,4532916E-24	1,376E-11	2,4532916E-24
80	2,469E+21	1,7159291E-24	1,100E-11	1,7159291E-24
90	2,777E+21	1,2518701E-24	9,028E-12	1,2518701E-24
100	3,086E+21	9,4419615E-25	7,566E-12	9,4419615E-25
110	3,394E+21	7,3156035E-25	6,448E-12	7,3156035E-25
120	3,703E+21	5,7954434E-25	5,573E-12	5,7954434E-25

130	4,011E+21	4,6776236E-25	4,873E-12	4,6776236E-25
140	4,320E+21	3,8358700E-25	4,303E-12	3,8358700E-25
150	4,629E+21	3,1889635E-25	3,833E-12	3,1889635E-25
160	4,937E+21	2,6829591E-25	3,440E-12	2,6829591E-25
170	5,246E+21	2,2810197E-25	3,107E-12	2,2810197E-25
180	5,554E+21	1,9573748E-25	2,823E-12	1,9573748E-25
190	5,863E+21	1,6936080E-25	2,579E-12	1,6936080E-25

As conclusion, in this chapter has been demonstrated that a power law for velocity.

$v = a \cdot r^b$ *is mathematically equivalent a power law for DM density depending on E.* $D_{DM} = A \cdot E^B$

6. RATIO BARYONIC MASS VERSUS DM MASS DEPENDING ON RADIUS FOR MILKY WAY

In this paragraph will be estimated radius which is needed to consider negligible baryonic density regarding DM density in Milky Way galaxy.

[5] According Sofue, Y. data for Milky Way disk are

Milky Way	Baryonic Mass at disk	a_d	Σ_0
	$M_d = 2\pi \cdot \Sigma_0 \cdot a^2{}_d$		
	$M_d =$ 1,12·10^{11} Msun	5,73 kpc	1,134683098 kg/m^2

Where $\Sigma(r) = \Sigma_0 \exp(-r/a_d)$ represents superficial density at disk. Total mass disk is given by integration of superficial density from cero to infinite. $M_d = \int_0^\infty 2\pi \cdot r \Sigma(r) \cdot dr = 2\pi \cdot \Sigma_0 \cdot a^2{}_d$

In order to compare baryonic density and DM density it is considered differential baryonic mass and differential DM masses depending on radius.

$dM_{DISK} = 2\pi r \Sigma(r) dr$ where $\Sigma(r) = \Sigma_0 \exp(-r/a_d)$ and

$dM_{DM} = 4\pi r^2 D_{DM}(r) dr$ where $D_{DM}(r) = \dfrac{a^2 \cdot (2b+1)}{4\pi G} \cdot r^{2b-2}$ $\Sigma(r)$ $\dfrac{\Sigma(r)}{2 \cdot r \cdot D_{DM}(r)}$

It is defined ratio function as quotient of both differential quantities $Ratio = \dfrac{dM_{DISK}}{dM_{DM}} = \dfrac{\Sigma(r)}{2 \cdot r \cdot D_{DM}(r)}$

	m	$\frac{\Sigma(r)}{2 \cdot r \cdot D_{DM}(r)}$	$\Sigma(r)$	Direct DM
Radius Kpc	Radius	dimensionless	kg/m^2	kg/m^3
30	9,257100E+20	1,376320E-01	6,04061960105E-03	2,3705944363E-23
32	9,874240E+20	1,081782E-01	4,26084053722E-03	1,9944436051E-23
34	1,049138E+21	8,447141E-02	3,00544700422E-03	1,6956520640E-23
36	1,110852E+21	6,557752E-02	2,11993657502E-03	1,4550626748E-23
38	1,172566E+21	5,064642E-02	1,49532867350E-03	1,2589851941E-23
40	1,234280E+21	3,893338E-02	1,05475223559E-03	1,0974497455E-23
42	1,295994E+21	2,980385E-02	7,43985117242E-04	9,6307235736E-24
44	1,357708E+21	2,272841E-02	5,24780925798E-04	8,5030077315E-24
46	1,419422E+21	1,727267E-02	3,70162001496E-04	7,5490252483E-24
48	1,481136E+21	1,308494E-02	2,61099252308E-04	6,7361086220E-24
50	1,542850E+21	9,883669E-03	1,84170226226E-04	6,0387565778E-24
52	1,604564E+21	7,445579E-03	1,29907197851E-04	5,4368542409E-24

For a radius 40 kpc ratio baryonic matter versus DM is only 3.9 % therefore is a good approximation to consider negligible baryonic mass density regarding DM density when radius is bigger than 40 kpc.

This is the reason why in this work dominion for radius begin at 40 kpc.

7. COMPARISON BETWEEN DIRECT DM DENSITY AND NFW DARK MATTER DENSITY

According [5] Sofue,Y., 2015. Parameters of NFW profile for Milky Way are written in table below. It is clear that NFW profile fitted through Bhattacharjee data would be a bit different. However in epigraph 4.3 has been shown that relative difference between Sofue data and Bhattacharjee data is 3% in average throughout the whole dominion. Therefore NFW profile got by Sofue is a good approximation for data got by Bhattacharjee.

Dark matter density function profile NFW
Rs = 10,7 $\pm$ 2.9 Kpc
Do = 1,2318 $\cdot 10^{-21}$ kg/m^3

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

Below are tabulated NFW DM density and Direct DM density depending on radius both. Third column shows relative differences, which oscillate between 28% and 15% throughout dominion.

Direct DM	DM NFW	Relt. Diff.	Radius
Kg/m^3	Kg/m^3	%	kpc
1,0974497E-23	1,467627E-23	25,22	40,00
8,0065345E-24	1,080858E-23	25,92	50,00
6,0387566E-24	8,191136E-24	26,28	60,00
4,6788105E-24	6,356208E-24	26,39	70,00
3,7065679E-24	5,031546E-24	26,33	80,00
2,9916485E-24	4,051225E-24	26,15	90,00
2,4532916E-24	3,310140E-24	25,89	100,00

2,0395523E-24	2,739483E-24	25,55	110,00
1,7159291E-24	2,292910E-24	25,16	120,00
1,4588624E-24	1,938424E-24	24,74	130,00
1,2518701E-24	1,653446E-24	24,29	140,00
1,0831739E-24	1,421733E-24	23,81	150,00
9,4419615E-25	1,231392E-24	23,32	160,00
8,2858392E-25	1,073583E-24	22,82	170,00
7,3156035E-25	9,416387E-25	22,31	180,00
6,4948401E-25	8,304684E-25	21,79	190,00

It is remarkable the fact that NFW profile is bigger than direct DM profile through the whole dominion. Its relative difference oscillate between 26% and 22%.

In my opinion this is an important fact that could be explained because NFW profile is fitted with total DM enclosed inside galactic disc.

As it is known, NFW profile is fitted over bulge, disk and galactic halo and taking in consideration that there is an unknown amount of baryonic DM in bulge and galactic disk it is right to conclude that NFW profile is fitted through a set of DM data whose values include baryonic DM and non baryonic DM, especially in bulge and disk. Therefore it is right to get a function fitted, NFW, which produce high values of DM throughout its dominion, bulge, disk and halo.

However direct DM profile, as it is got through a power regression function fitted with data velocity in halo region, it is fitted only with non baryonic DM or at least with a negligible amount of baryonic matter. Therefore it is right to deduce that Direct DM profile has to be lower than NFW profile throughout dominion inside halo.

As it was pointed at introduction, it is known that there is baryonic dark matter such us giant planets, cold gas clouds, brown dwarfs but this kind of DM is more probable to be placed inside galactic disk and bulge.

Reader can consult these papers about this open problem: [12] Nieuwenhuizen,T.M. 2010. [13] Nieuwenhuizen,T.M. 2012. [14] Nieuwenhuizen,T.M. 2010 [15] Wyrzykowski,L.2010. [16] M.R.S. Hawkins 2015

Conclusion got in this brief chapter is that it is necessary to split baryonic DM and non baryonic DM regarding contribution to rotation curve of galaxies because nature of both are very different.

Any theory which study DM nature without split both kind of DM in my opinion is wrong.

In fact all papers I have published try to show that non baryonic dark matter is generated by gravitational field according a Universal law. Results got in several giant galaxies back this surprising hypothesis.

8. D.M. DENSITY AS POWER OF E IN MILKY WAY VERSUS D.M. DENSITY AS POWER OF E IN M31

In this chapter will be compared DM density as power of E through A&B parameters got for Milky Way and parameters A&B got for M31. The goal this chapter is to show that both couples of parameters produce very similar DM density throughout dominion specially at medium and large distance in halo region. This results back strongly hypothesis that non baryonic DM is generated according an Universal mechanism.

In chapter 5 were developed theory of DM density as power of E. DM density = $A \cdot E^B$. In that chapter was demonstrated that mathematically it is equivalent a law of $v = a \cdot r^b$ for rotation curve to a law for DM density as power of E. Where formula coefficients are: $A = \frac{a^{\frac{2}{2b-1}} \cdot (2b+1)}{4\pi G}$ & $B = \frac{2b-2}{2b-1}$.

In addition was shown formula for gravitational field through virial theorem. $E = a^2 \cdot r^{2b-1}$

Coefficients of Milky Way are below.

Power regression for Milky Way rot. curve	
V=a*r^b	
a	2,8791029E+12
b	-3,3854651E-01
Correlation coeff.	0.6613046575

Milky Way	$D_{DM} = A \cdot E^B$
A	5,338110964264E-07
B	1,596269850917

In paper [11] Abarca,M.2016. Two New Dark Matter Density Profiles for M31 Halo Got from Rotation Curve were published coefficients a &b for power regression velocity depending on radius for M31 galaxy. Also were published coefficients A&B for DM density as power of E. Below are both couple of data.

Power regression for M31 through Sofue data	
V=a*r^b	
a	4,15011040E+10
b	-2,47554520E-01
Correlation coeff.	0,952254

M31 galaxy	$D_{DM} = A \cdot E^B$
A	$3,766521943774E \cdot 10^{-6}$
B	1,668847537702

Seemingly A& B of MW are clearly different from A&B of M31. A&B of M31 are bigger than A&B of MW. However both couples produce a DM density very similar as it will be shown below.

First and second columns refers radius regarding Milky Way. At that radius is calculated gravitational field E, with a&b parameters of Milky Way. Values of E are used to calculate DM density for Milky Way and M31 through formulas of DM as power of E to compare both series of values.
Third column shows such E. Fourth and fifth column show DM density as power of E for Milky Way and M31 and sixth column shows relative difference between both DM densities.

Surprisingly relative difference for field E belonging to 90 kpc or bigger radius, fall below 10 %. See grey row.

Radius MW data	Radius MW data	E through MW data	DM powE MW	DM pow E M31	Relt. Diff. MW vs M31
kpc	m	m/s^2	kg/m^3	kg/m^3	%
40	1,234280E+21	3,51764395E-11	1,0974497E-23	1,3496734143E-23	18,69
50	1,542850E+21	2,41949525E-11	6,0387566E-24	7,2276270284E-24	16,45

60	1,851420E+21	1,78209339E-11	3,7065679E-24	4,3389262530E-24	14,57
70	2,159990E+21	1,37611417E-11	2,4532916E-24	2,8184527216E-24	12,96
80	2,468560E+21	1,10000986E-11	1,7159291E-24	1,9395552951E-24	11,53
90	2,777130E+21	9,02836355E-12	1,2518701E-24	1,3948767776E-24	10,25
100	3,085700E+21	7,56605460E-12	9,4419615E-25	1,0386499523E-24	9,09
110	3,394270E+21	6,44837207E-12	7,3156035E-25	7,9546090336E-25	8,03
120	3,702840E+21	5,57282181E-12	5,7954434E-25	6,2352768455E-25	7,05
130	4,011410E+21	4,87276953E-12	4,6776236E-25	4,9838288736E-25	6,14
140	4,319980E+21	4,30327563E-12	3,8358700E-25	4,0502723417E-25	5,29
150	4,628550E+21	3,83308148E-12	3,1889635E-25	3,3390489121E-25	4,49
160	4,937120E+21	3,43986402E-12	2,6829591E-25	2,7872481616E-25	3,74
170	5,245690E+21	3,10731438E-12	2,2810197E-25	2,3522629802E-25	3,03
180	5,554260E+21	2,82327860E-12	1,9573748E-25	2,0045150266E-25	2,35
190	5,862830E+21	2,57853930E-12	1,6936080E-25	1,7230192544E-25	1,71

Relative differences of DM density for MW vs DM density for M31 oscillate from a maximum 18,7 % at the biggest field E and decreases up to 1,7 % at the lowest field E.

DM density as power of E regarding both galaxies are astonishing similar despite the fact that both galaxies have very different rotation curves coefficients a & b, their baryonic masses are clearly different and their galactic disks have different laws for superficial density masses.

In addition it is well known that experimental errors are not negligible despite the fact measures are made by prestigious research teams equipped with high technology tools.

Despite these facts, relative differences fall below 15% at E belonging radius bigger 60 kpc in Milky Way and fall below 10 % at E belonging radius bigger 90 kpc.See rows in grey in tables above.
In my opinion this result suggest strongly that non baryonic DM is generated by gravitational field as power of E according a Universal law. Reader can consult a similar work with different galaxies in [8] Abarca,M.2016.

9. CONCLUSION

This work is focused in halo region of Milky Way where baryonic density is negligible regarding non baryonic DM. Reason is that the main hypothesis all my papers is that DM non baryonic is generated locally by gravitational field. Therefore it is needed to study radius dominion where it is possible to study gravitational field propagation without interference of baryonic mass density or at least where this density is negligible.

In order to defend properly conclusion this paper is important to emphasise a result got in chapter 3 which is that correlation coefficient of velocity as power regression of radius in halo region is 0,66 which is an acceptable value.

This acceptable value of correlation between radius and velocity, support that velocity of Milky Way rotation curve follows a power law regarding radius $v = a \cdot r^b$ whose coefficient a & b were got in chapter 3.

In chapter four was mathematically demonstrated that a power law $v = a \cdot r^b$ in halo region is mathematically equivalent a DM density called Direct DM, whose formula is $D_{DM} = \frac{a^2 \cdot (2b+1)}{4\pi G} \cdot r^{2b-2}$.

Also in this chapter is compared Direct DM got from rotation curve [17] Bhattacharjee, P.2014 and Direct DM got from rotation curve [5] Sofue, Y.2015. It is shown that relative difference oscillate between 2.6% at 40 kpc and 3.8 % at 190 kpc which is a very exiguous difference.

It is a very good news that two prominent teams of researchers got so similar results.

In chapter five was demonstrated mathematically that *a power law for velocity* $v = a \cdot r^b$ *fitted at rotation curve is mathematically equivalent a power law for DM density depending on E.* $D_{DM} = A \cdot E^B$

Being $E = \frac{a^2 \cdot r^{2b}}{r} = a^2 \cdot r^{2b-1}$ *and being* $A = \frac{a^{\frac{2}{2b-1}} \cdot (2b+1)}{4\pi G}$ & $B = \frac{2b-2}{2b-1}$.

Therefore joining chapters 3,4 and 5 it is concluded that a correlation coefficient as 0,66 at power regression law for rotation curve $v = a \cdot r^b$ in halo region support that DM density inside halo region is a power of gravitational field $D_{DM} = A \cdot E^B$ whose parameters A & B are written above.

In chapter seven was compared direct DM profile got in this paper with NFW fitted by [5] Sofue, Y.2015.It was checked that NFW profile is bigger than Direct DM profile a percentage which oscillates between a 25 % and 21% .

In my opinion this fact shows that inside galactic disc, non baryonic DM is not negligible whereas outside disc DM is mainly non baryonic DM.

In eight chapter was shown that such non baryonic DM is generated according a law very similar for Milky Way and M31. Formula for non baryonic DM density is $D_{DM} = A \cdot E^B$.Where A&B are lightly different for each galaxy.

To do this comparison was tabulated E at different radius and through this set of values of E were got DM density in MW halo with MW A&B parameters and DM density in M31 halo with M31 A&B parameters.

Results for both sets of values are astonishingly similar throughout halo dominion since relative differences oscillate between 18 % and 1.7 %. The less value E has, the less relative difference both profiles (MW vs M31) have.

Summarizing I would stand out two main conclusions got in chapter seven and eight.

In seven chapter is defended that remarkable relative differences between NFW profile and Direct DM show clearly that inside galactic disc non baryonic DM is not negligible whereas in halo region non baryonic DM is dominant.

In eight chapter it is shown that DM as power of E for MW is very similar to DM as power of E for M31. This fact back strongly hypothesis that non baryonic DM is generated by gravitational field according an Universal law in giant galaxies as I have found in previous papers with other different giant galaxies.

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