D.M. AS POWER OF GRAVIT. FIELD FOR MW VS M31. TWO SIMILAR LAWS.

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1. ABSTRACT

The main target this paper is to check a theory about non baryonic dark matter nature, which was published by the author in [1] Abarca,M.2014. [3] Abarca,M.2015. [8] Abarca,M.2016. [11] Abarca,M.2016 and others papers. It was postulated that non baryonic dark matter density depend on E, gravitational field, through a power of E as a Universal law. In order to check this theory in this paper will be studied DM density in halo region of MW and M31. Throughout the paper, DM refers to Non Baryonic DM.

Briefly will be described paper procedure.
In third chapter are introduced rotation curves of MW, [5] Huang,Y.2016, and M31, [13] Sofue, Y.2015. It is fitted a power regression for velocity depending on radius in halo of both galaxies. Formula is v = a· R^b.

In fourth chapter it is deduced mathematically a DM density profile for MW & M31 in halo region. This new profile is called *Direct DM density* because it is got directly from power regression velocity depending on radius.

In fifth chapter is found a new DM density as power of E, which is mathematically equivalent to Direct DM density. Its formula is DM density = A· E^B. Where A & B are coefficients which depend on a & b, coefficients of velocity power regression in rotation curve. Also are calculated A&B for MW and M31. Finally it is explained that hypothesis of DM depending on gravitational field as Universal law allows enlarge dominion DM as power E for radius inside disc and radius bigger than dominion measures.

In sixth chapter, according theory of DM generated by gravitational field, is defined galactic halo as region where own gravitational field dominates over neighbour gravitational field. Through this criterion is found halo MW = 310 kpc and halo M31 = 460 kpc.

The seventh is a crucial chapter, because it is successfully comparing DM as power E in MW & M31. Both formulas are compared and relative differences throughout dominion of E are below 14 %. Agreement of both functions is the main evidence about DM power E as Universal law.

In eighth chapter is compared DM density as power E with NFW profile given by author of rotation curve in his paper. [5] Huang,Y.2016. NFW density is bigger than DM power E throughout all dominion, and relative differences oscillate between 34% and 13%. Such remarkable differences will be properly justified.

In ninth chapter is calculated total mass through NFW profile and dynamical method. Mass through NFW profile is bigger than through dynamical method. Difference might be explained by the same reason given in previous chapter.
In tenth chapter is calculated Local DM density through DM power E profile, which gives 0,16 GeV/cm^3 and is compared with same magnitude given by [5] Huang,Y.2016, which is 0,32 GeV/cm^3. It is defended that there is not contradiction between both data because the first profile gives Non Baryonic DM only, whereas experimental data measure Baryonic and non Baryonic DM.

It is concluded three main ideas which will be properly justified in following pages.
The first one is that there are strong evidences about that fraction of *Baryonic DM* vs *Non Baryonic DM* inside bulge and galactic disc is bigger than the same fraction inside halo.
The second one is DM generated by gravitational field theory leads rightly a new definition for halo radius. According this theory are calculated halo radius MW equal to 310 kpc and halo radius M31 equal to 460 kpc.
The third one is that there are strong evidences that non baryonic DM density is generated by gravitational field as a Universal law. Main reason to support this hypothesis is conclusion got in chapter seventh.

2. INTRODUCTION

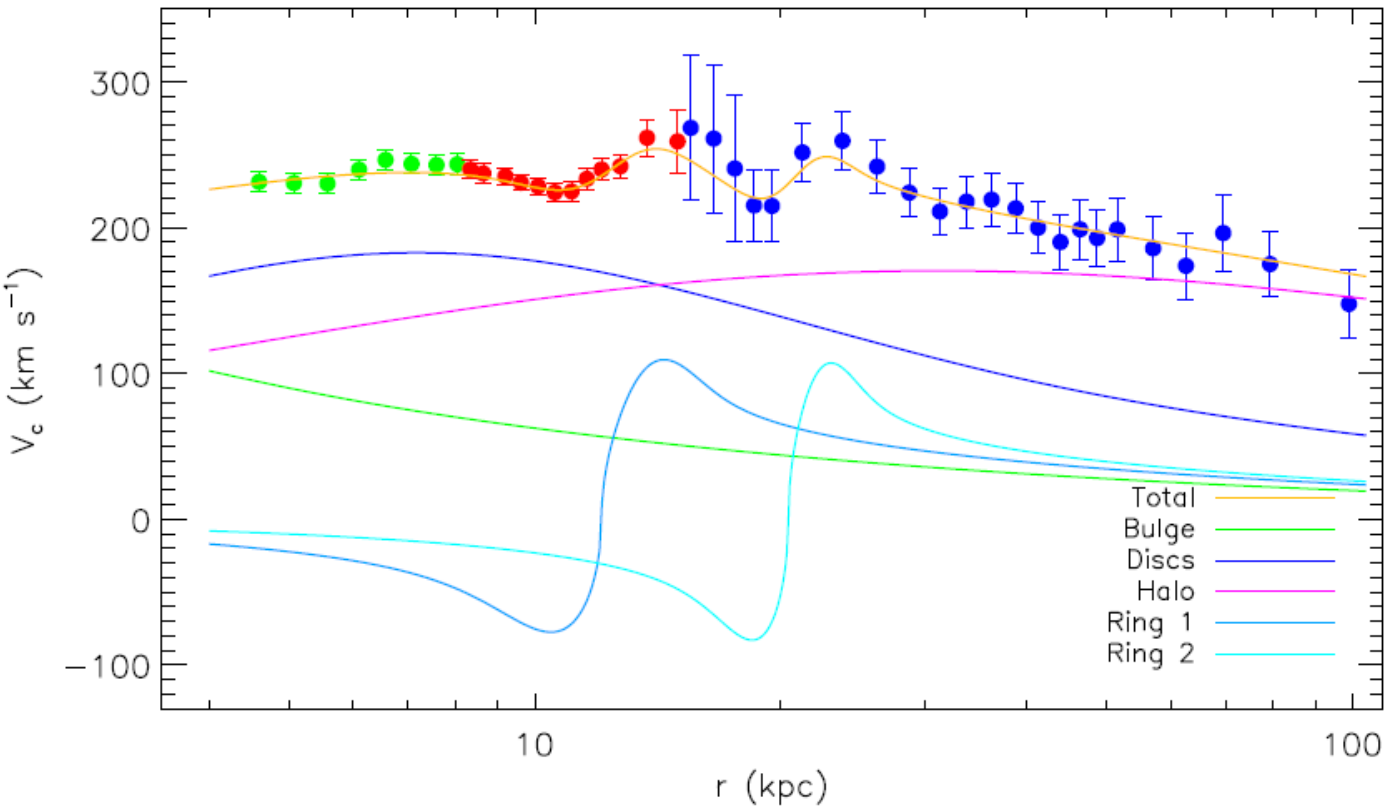
Currently there are strong evidences that it is needed to split DM into baryonic and non baryonic. As it is obvious inside galactic disc there is an unknown amount of baryonic DM such as, giant planets, brown dwarfs, cold gas clouds. Whereas in halo region, baryonic DM or MACHOs, is currently enough constrained by several rigorous research programs, although this problem remains open. See for example, [14] Nieuwenhuizen,T.M. 2010 . [15] Nieuwenhuizen,T.M. 2012. [16] Nieuwenhuizen,T.M. 2010 [17] Wyrzykowski,L. .2010. [18] Hawkins M.R.S. 2015. [20] Brandt. Timothy D.2016. [21] S. Calchi Novati.2014. [22] Torres, S. 2010.

As DM generated by gravitational field theory refers to Non Baryonic DM it is needed to constraint maximum presence of baryonic DM. This is the reason why in this work radius dominion for M31 begin at 40 kpc. See [11] Abarca,M.2016. By similar reason radius dominion for MW begin at 35 kpc.

Unfortunately currently there is not reliable constrictions for Baryonic DM inside halo. Therefore in this paper BDM will be considered negligible and hereafter DM refers only to Non Baryonic DM.

3. OBSERVATIONAL DATA FOR MILKY WAY & M31

3.1 OBSERVATIONAL DATA FOR MILKY WAY. Huang,Y. 2016. Data



r (kpc)	V_c (km s^{-1})	σ_{V_c} (km s^{-1})	tracer	r (kpc)	V_c (km s^{-1})	σ_{V_c} (km s^{-1})	tracer
4.60	231.24	7.00	H I	17.56	240.66	49.91	HKG
5.08	230.46	7.00	H I	18.54	215.31	24.80	HKG
5.58	230.01	7.00	H I	19.50	214.99	24.42	HKG
6.10	239.61	7.00	H I	21.25	251.68	19.50	HKG
6.57	246.27	7.00	H I	23.78	259.65	19.62	HKG
7.07	243.49	7.00	H I	26.22	242.02	18.66	HKG
7.58	242.71	7.00	H I	28.71	224.11	16.97	HKG
8.04	243.23	7.00	H I	31.29	211.20	16.43	HKG
8.34	239.89	5.92	MRCG	33.73	217.93	17.66	HKG
8.65	237.26	6.29	MRCG	36.19	219.33	18.44	HKG
9.20	235.30	5.60	MRCG	38.73	213.31	17.29	HKG
9.62	230.99	5.49	MRCG	41.25	200.05	17.72	HKG
10.09	228.41	5.62	MRCG	43.93	190.15	18.65	HKG
10.58	224.26	5.87	MRCG	46.43	198.95	20.70	HKG
11.09	224.94	7.02	MRCG	48.71	192.91	19.24	HKG
11.58	233.57	7.65	MRCG	51.56	198.90	21.74	HKG
12.07	240.02	6.17	MRCG	57.03	185.88	21.56	HKG
12.73	242.21	8.64	MRCG	62.55	173.89	22.87	HKG
13.72	261.78	14.89	MRCG	69.47	196.36	25.89	HKG
14.95	259.26	30.84	MRCG	79.27	175.05	22.71	HKG
15.52	268.57	49.67	HKG	98.97	147.72	23.55	HKG
16.55	261.17	50.91	HKG	–	–	–	–

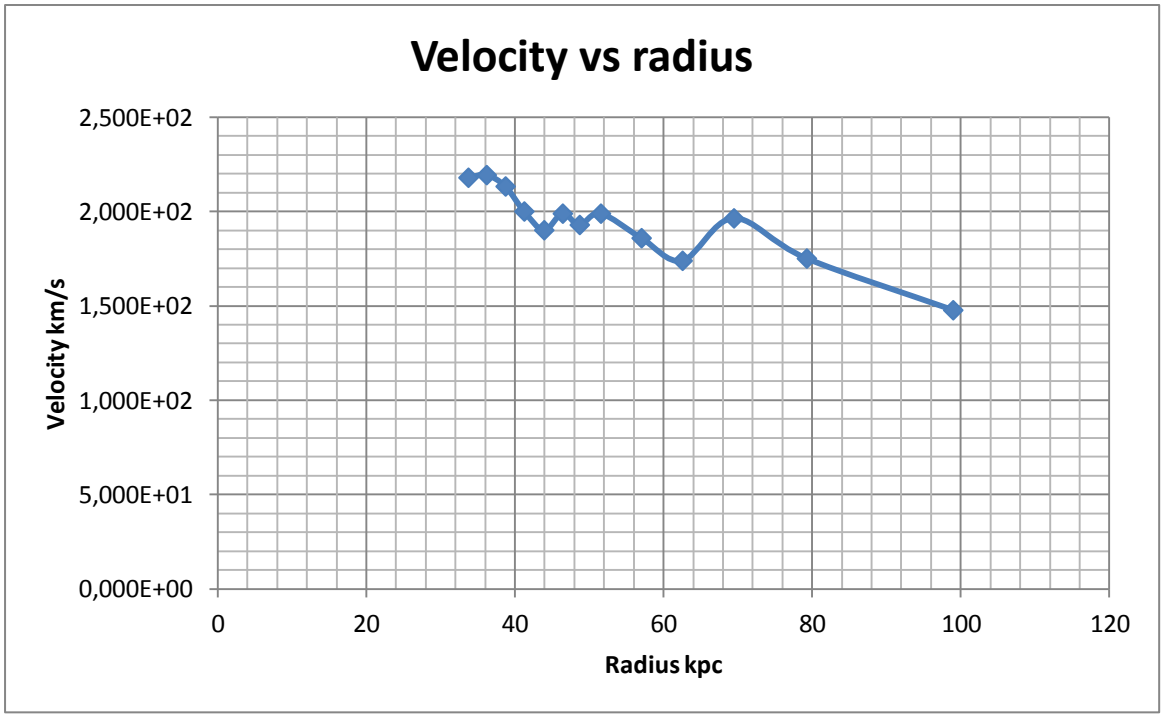
Graphic and table data come from [5] Huang,Y. 2016.

Radius dominion selected has been [33,73 - 98,97] kpc.There are two reasons to do such selection.

The first one, it is crucial baryonic density (dark or visible) would be negligible vs non baryonic DM density. Although disc radius is 20 kpc aprox, near this radius, ratio baryonic density vs non baryonic DM density is not negligible. The second one reason is that for this set of measures, correlation coefficient is a bit bigger regarding data set with more or less elements. In fact r = 0,9.

Radius	Velocity
kpc	Km/s
33,73	2,179E+02
36,19	2,193E+02
38,73	2,133E+02
41,25	2,001E+02
43,93	1,901E+02
46,43	1,989E+02
48,71	1,929E+02
51,56	1,989E+02
57,03	1,859E+02
62,55	1,739E+02
69,47	1,964E+02
79,27	1,751E+02
98,97	1,477E+02

Below is plotted velocity of rotation curve for selected dominion.

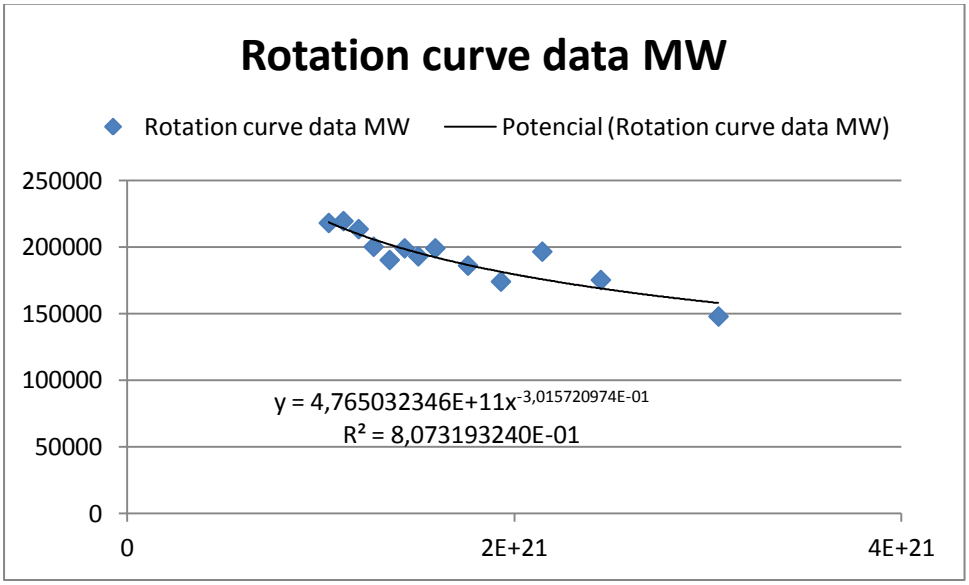


3.1.2 POWER REGRESSION TO ROTATION CURVE AT MILKY WAY HALO

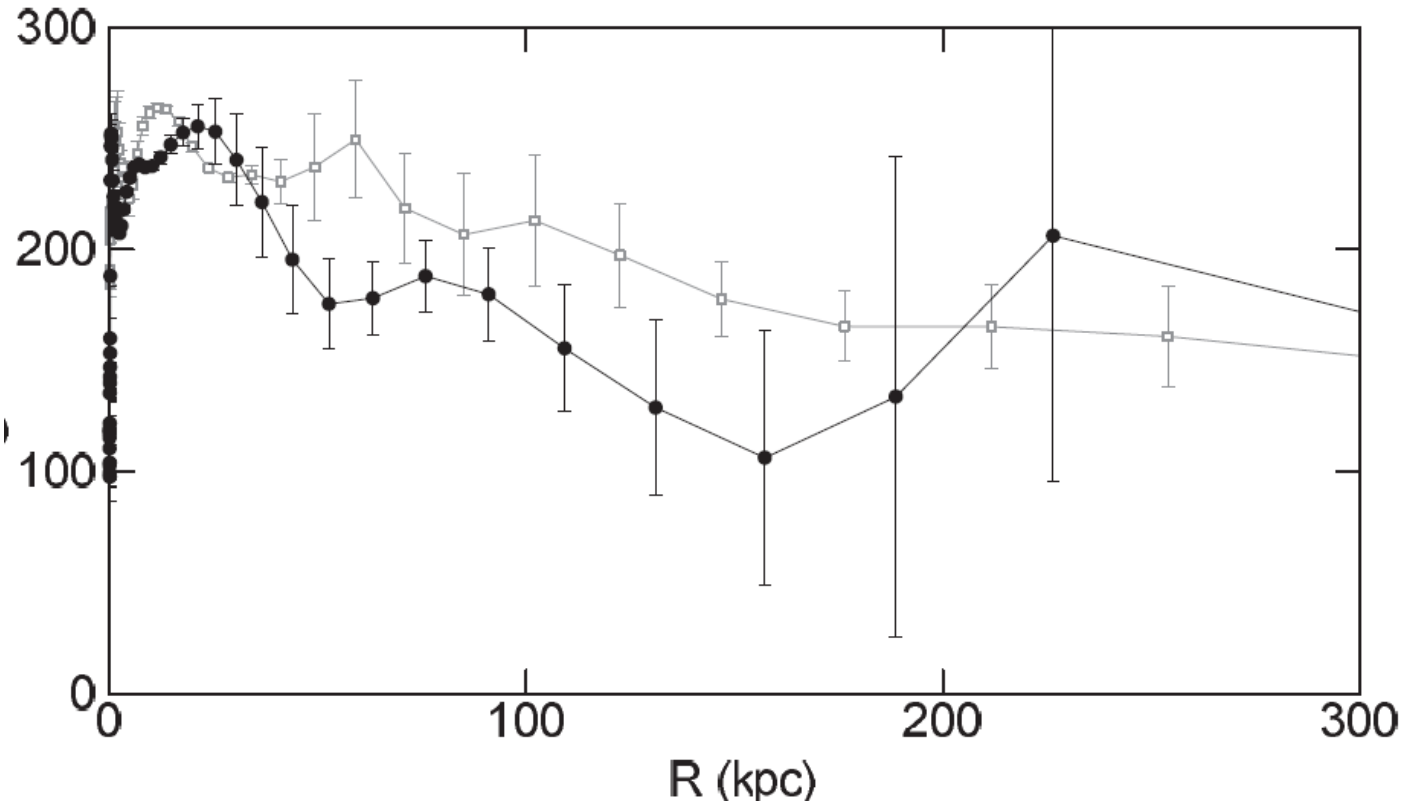
Radius	Velocity	Radius	Velocity	Fitted Vel.	Rel. Diff. of
kpc	Km/s	m	m/s	m/s	Velocities %
33,73	2,179E+02	1,04081E+21	217930	218682,227	0,34398172
36,19	2,193E+02	1,11671E+21	219330	214088,704	-2,44818907
38,73	2,133E+02	1,19509E+21	213310	209753,766	-1,69543293
41,25	2,001E+02	1,27285E+21	200050	205803,99	2,79585944
43,93	1,901E+02	1,35555E+21	190100	201934,089	5,860372
46,43	1,989E+02	1,43269E+21	198900	198591,477	-0,15535565
48,71	1,929E+02	1,50304E+21	192900	195741,108	1,45146196
51,56	1,989E+02	1,59099E+21	198900	192413,166	-3,3713047
57,03	1,859E+02	1,75977E+21	185900	186650,348	0,4020072
62,55	1,739E+02	1,93011E+21	173900	181521,697	4,19877997
69,47	1,964E+02	2,14364E+21	196400	175867,628	-11,6749013
79,27	1,751E+02	2,44603E+21	175100	169006,084	-3,60573762
98,97	1,477E+02	3,05392E+21	147700	158063,787	6,55671197

Power regression of velocity versus radius into I.S. (grey columns) gives this coefficients.

Power regression for Milky Way rot. curve	
V=a*r^b 35kpc < R < 100 kpc	
a	$4{,}765032346 \cdot 10^{11}$
b	-0,3015720974
Correlation coeff.	0,9

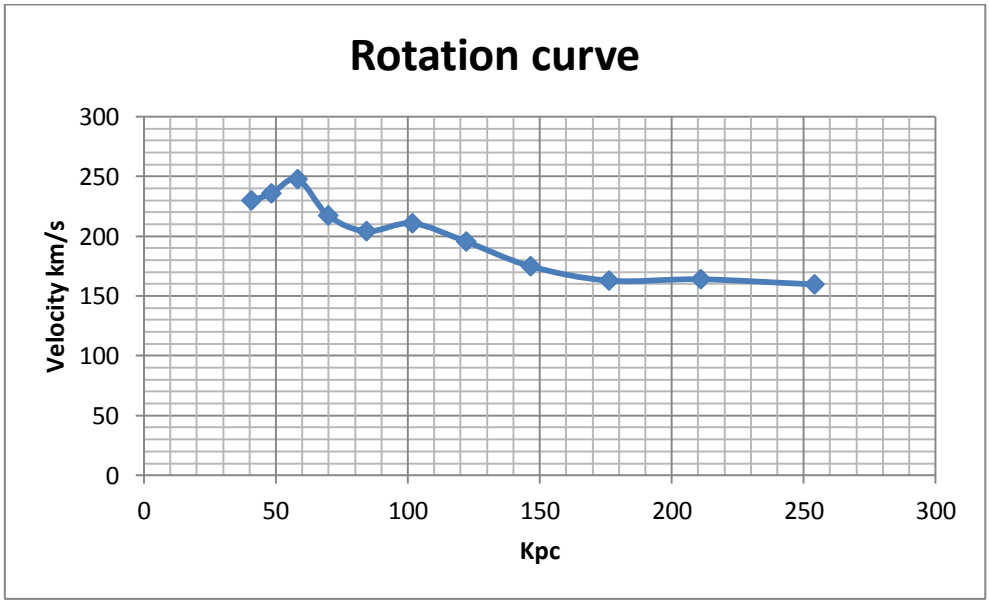


3.2 OBSERVATIONAL DATA FOR M31. Sofue,Y. 2015. Data



Graphic come from [13] Sofue,Y. 2015. Grey line belong to M31 rotation curve and black line to Milky Way.

M31 point data	
Radius	Velocity
kpc	km/s
40,7	230
48,25	235,9
58,2	247,8
69,8	217,4
84,3	204,3
101,7	210,9
122,1	195,6
146,5	175
176,2	163
211	164,1
254,1	159,8



From graphic it is clear there is a high correlation between spin radius and velocity.

Mathematical development why dominion data begin at 40 kpc is in [11] Abarca,M.2016. In short, at this radius ratio baryonic density versus DM density is 1%. So baryonic density for radius bigger than 40 kpc is negligible.

3.2.1 POWER REGRESSION TO ROTATION CURVE OF M31

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

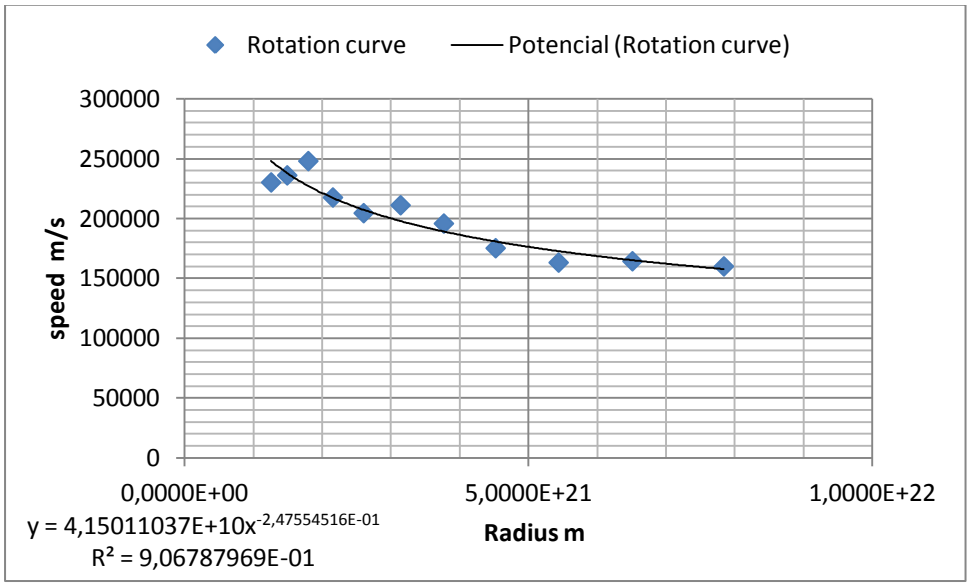
In particular coefficients of $v = a \cdot r^b$ are in table below. Units are into I.S.

Power regression for M31 rot. curve	
V=a*r^b	
a	$4{,}1501104 \cdot 10^{10}$
B	-0,24755452
Correlation coeff.	0,952254

Data fitted are in grey columns below.
In third column is shown results of fitted velocity and fourth column shows relative difference between measures and fitted results.
Correlation coefficient is above 0.95 which is very good correlation.

radius	velocity measures	veloc. Fitted.	Rel. Diff.	Radius
m	m/s		%	kpc
1,2559E+21	230000	2,4827E+05	7,36	40,7
1,4889E+21	235900	2,3803E+05	0,89	48,25
1,7959E+21	247800	2,2723E+05	-9,05	58,2
2,1538E+21	217400	2,1723E+05	-0,08	69,8
2,6012E+21	204300	2,0732E+05	1,46	84,3
3,1382E+21	210900	1,9791E+05	-6,57	101,7
3,7676E+21	195600	1,8915E+05	-3,41	122,1
4,5206E+21	175000	1,8081E+05	3,21	146,5
5,4370E+21	163000	1,7273E+05	5,63	176,2
6,5108E+21	164100	1,6519E+05	0,66	211
7,8408E+21	159800	1,5777E+05	-1,29	254,1

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



In my opinion a correlation coefficient of 0,952254 is a very high correlation if it is considered that M31 is 770 kpc away and errors in measures are not negligible. Therefore this value support strongly hypothesis that rotation curve of M31 follow a law $v = a \cdot r^b$ where a & b are written above.

3.3 ANALISIS VELOCITY POWER REGRESSION DOMINION

Dominion data for MW is 34 up to 100 kpc and for M31 is 40 up to 255 kpc. Lower bound of dominion, mainly is determined by criterion to considerate negligible baryonic density. Upper bound is determinate by experimental measures.

According this criterions it is right to think that it is not possible to enlarge dominion. Following chapters will be developed a new theory of DM which allows to enlarge dominion of DM density, although initially its dominion agrees with velocity power regression dominion.

4 DIRECT D.M. DENSITY ON HALOS OF MILKY WAY & M31

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 $M(<r) = \frac{v^2 \cdot R}{G}$ represents total mass enclosed by a sphere with radius r, by substitution of velocity results $M = \frac{v^2 \cdot R}{G} = \frac{a^2 \cdot r^{2b+1}}{G}$

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.

As density of D.M. is $D_{DM} = \frac{dm}{dV}$ where $dm = \frac{a^2 \cdot (2b+1) \cdot r^{2b} dr}{G}$ and $dV = 4\pi r^2 dr$ results

$$D_{DM} = \frac{a^2 \cdot (2b+1)}{4\pi G} \cdot r^{2b-2}$$

Writing $L = \frac{a^2 \cdot (2b+1)}{4\pi G} \cdot$ 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 M31 HALO

Parameters a & b from power regression of M31 rotation curve allow calculate easily direct DM density.

Below is such function and table.

Direct DM density for M31 halo 40 < r < 260 kpc
$D_{DM}(r) = L \cdot r^{2b-2}$ kg/m^3
L = 1,03701707086078E $\cdot 10^{30}$
2b -2 = -2,49510904

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

Direct DM	Radius	Radius
kg/m^3	m	kpc
2,4570213865E-23	1,234280E+21	40,00
8,9339196948E-24	1,851420E+21	60,00
4,3581911375E-24	2,468560E+21	80,00

2,4974984289E-24	3,085700E+21	100,00
1,5846719874E-24	3,702840E+21	120,00
1,0786979189E-24	4,319980E+21	140,00
7,7304292487E-25	4,937120E+21	160,00
5,7619898451E-25	5,554260E+21	180,00
4,4299881060E-25	6,171400E+21	200,00
3,4923945134E-25	6,788540E+21	220,00
2,8108438328E-25	7,405680E+21	240,00
2,3019796063E-25	8,022820E+21	260,00

4.3 DIRECT DM DENSITY FOR MILKY WAY HALO

Direct DM density for Milky Way halo 34 < r < 100 kpc
$D_{DM}(r) = L \cdot r^{2b-2}$ kg/m^3
L = $1{,}07456689003917 \cdot 10^{32}$
2b -2 = -2,6031441948

Radius	Radius	Direct DM den.
kpc	m	Kg/m^3
35,00	1,0799950E+21	1,897595942E-23
40,00	1,2342800E+21	1,340424455E-23
50,00	1,5428500E+21	7,498451814E-24
60,00	1,8514200E+21	4,664997378E-24
70,00	2,1599900E+21	3,123052300E-24
80,00	2,4685600E+21	2,206062728E-24
90,00	2,7771300E+21	1,623530550E-24
100,00	3,0857000E+21	1,234090813E-24

It is clear that relative differences between Direct DM in MW and M31 at a specific radius are 90 % or higher.

Notice that dominion for Direct DM density is the same than velocity power regression. Will be in next chapter where is introduced a new DM density whose dominion might be enlarged.

5. DARK MATTER DENSITY AS POWER OF GRAVITATIONAL FIELD

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

5.1 GRAVITATIONAL FIELD *E* THROUGH VIRIAL THEOREM

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, 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 $E = a^2 \cdot r^{2b-1}$

Below are tabulated E(r) for MW & M31.

Milky Way Huang data dominion 35 up to 100 kpc		
E virial	Radius	Radius
m/s^2	kpc	m
4,3303574E-11	35,00	1,0799950E+21
3,4958620E-11	40,00	1,2342800E+21
2,4445198E-11	50,00	1,5428500E+21
1,8249653E-11	60,00	1,8514200E+21
1,4253754E-11	70,00	2,1599900E+21
1,1506939E-11	80,00	2,4685600E+21
9,5269728E-12	90,00	2,7771300E+21
8,0463528E-12	100,00	3,0857000E+21

M31 Sofue data dominion 40 kpc up to 260 kpc		
Radius	Radius	E Virial
kpc	m	m/s^2
40,00	1,23428E+21	5,036815266E-11
60,00	1,85142E+21	2,747137450E-11
80,00	2,46856E+21	1,786830491E-11
100,00	3,08570E+21	1,279947977E-11
120,00	3,70284E+21	9,745580687E-12
140,00	4,31998E+21	7,739536828E-12
160,00	4,93712E+21	6,338853095E-12
180,00	5,55426E+21	5,315352710E-12
200,00	6,17140E+21	4,540666972E-12
220,00	6,78854E+21	3,937613385E-12
240,00	7,40568E+21	3,457283979E-12
260,00	8,02282E+21	3,067339974E-12

5.1.1 RELATIVE DIFFERENCE BETWEN *E* IN MW AND *E* IN M31 AT A SPECIFIC RADIUS

Radius			
kpc	E virial MW	E virial M31	relt diff. %
35,00	4,330357374E-11	6,1497902952E-11	2,9585284E+01
40,00	3,495862044E-11	5,0368152659E-11	3,0593801E+01
50,00	2,444519811E-11	3,6079871832E-11	3,2246993E+01
60,00	1,824965279E-11	2,7471374496E-11	3,3568476E+01
70,00	1,425375367E-11	2,1816628629E-11	3,4665645E+01
80,00	1,150693860E-11	1,7868304910E-11	3,5601398E+01
90,00	9,526972827E-12	1,4983206190E-11	3,6415660E+01
100,00	8,046352808E-12	1,2799479770E-11	3,7135314E+01

Relative differences oscillate from 30 % up to 37%. Which are important differences. It is understandable that E for M31 would be a bit bigger than for MW at a specific radius because M31 is a bit bigger and massive than MW.

5.2 DARK MATTER DENSITY AS POWER OF GRAVITATIONAL FIELD IN MW &M31

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. [7] Abarca,M. [8] Abarca,M. [9] Abarca,M. [10] Abarca,M. and others papers quoted in bibliography.

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

MILKY WAY	$D_{DM} = A \cdot E^B$
A	1,27687739294523·10^{-6}
B	1,62377420773729

According parameters a & b got in third chapter, A& B parameters for Milky Way are:

In order to check numerically these parameters, bellow has been tabulated direct DM density and DM density as power of E throughout its dominion. Now it is clear that both are mathematically equivalents.

Milky Way Galaxy – Milky Way Galaxy – Milky Way Galaxy – Milky Way Galaxy -				
$E = a^2 \cdot r^{2b-1}$			$D_{DM}(r) = L \cdot r^{2b-2}$	$D_{DM} = A \cdot E^B$
E virial	Radius	Radius	Direct DM density	DM den. Power E
m/s^2	kpc	m	Kg/m^3	Kg/m^3
4,3303574E-11	35,00	1,0799950E+21	1,897595942E-23	1,8975959E-23
3,4958620E-11	40,00	1,2342800E+21	1,340424455E-23	1,3404245E-23
2,4445198E-11	50,00	1,5428500E+21	7,498451814E-24	7,4984518E-24
1,8249653E-11	60,00	1,8514200E+21	4,664997378E-24	4,6649974E-24
1,4253754E-11	70,00	2,1599900E+21	3,123052300E-24	3,1230523E-24
1,1506939E-11	80,00	2,4685600E+21	2,206062728E-24	2,2060627E-24
9,5269728E-12	90,00	2,7771300E+21	1,623530550E-24	1,6235306E-24
8,0463528E-12	100,00	3,0857000E+21	1,234090813E-24	1,2340908E-24

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

According parameters a & b got in third chapter, A& B parameters for M31 are:

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

- M31 Galaxy - M31 Galaxy - M31 Galaxy - M31 Galaxy - M31 Galaxy - M31 Galaxy - M31 Galaxy -				
		$E = a^2 \cdot r^{2b-1}$	$D_{DM} = A \cdot E^B$	$D_{DM}(r) = L \cdot r^{2b-2}$
Radius	Radius	E Virial	DM dens. power of E	Direct DM density
kpc	m	m/s^2	Kg/m^3	kg/m^3
40,00	1,23428E+21	5,036815266E-11	2,45702138653E-23	2,45702138653E-23
80,00	2,46856E+21	1,786830491E-11	4,35819113751E-24	4,35819113751E-24
120,00	3,70284E+21	9,745580687E-12	1,58467198742E-24	1,58467198742E-24
160,00	4,93712E+21	6,338853095E-12	7,73042924866E-25	7,73042924866E-25
200,00	6,17140E+21	4,540666972E-12	4,42998810603E-25	4,42998810603E-25
240,00	7,40568E+21	3,457283979E-12	2,81084383281E-25	2,81084383281E-25
260,00	8,02282E+21	3,067339974E-12	2,30197960630E-25	2,30197960630E-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 .* $D_{DM} = A \cdot E^B$.

5.3 DOMINION ENLARGEMENT OF D.M. DENSITY AS POWER OF E

Theory of DM generated by gravitational field states that mechanism of DM generation is Universal. Therefore this law $D_{DM} = A \cdot E^B$ should be true not only throughout dominion but also for all galaxies. Reader can consult [8] Abarca,M.2016. *Dark matter density on big galaxies depend on gravitational field as Universal law.*

It is known that DM density is bigger inside intermediate a dwarf galaxies but this fact might be explained by Baryonic DM.

Regarding dominion in MW if it is supposed that for R > 100 kpc baryonic matter is negligible then it is possible to enlarge radius dominion for $D_{DM} = A \cdot E^B$ for $D_{DM}(r) = L \cdot r^{2b-2}$ and $E = a^2 \cdot r^{2b-1}$

In next chapter will be studied an upper bound for dominion.

Regarding lower bound of dominion, 35 kpc, it is clear that law $v = a \cdot r^b$ for radius lower than 35 kpc is false. Therefore $D_{DM}(r) = L \cdot r^{2b-2}$ and $E = a^2 \cdot r^{2b-1}$ are false as well. Apparently $D_{DM} = A \cdot E^B$ should be false. However theory of DM generated by gravitational field as Universal law suggest that A & B should be valid, only it is needed changing calculus for E. Particularly formula $E = \frac{v^2}{r}$ is valid inside galactic disc so knowing rotation curve is easy to calculate E inside galactic disc.

Summarising, A&B has been calculated thanks a dominion where baryonic density is negligible, but $D_{DM} = A \cdot E^B$ is right to calculate non baryonic DM inside MW disc and radius bigger than 100 kpc.

6. A NEW HALO RADIUS FOR MILKY WAY & M31

According theory DM generated by gravitational field, it is right to consider that halo radius a galaxy is the region where its gravitational field dominates over neighbour gravitational field.

Considering that distance between MW & M31 is 770 kpc and $E = a^2 \cdot r^{2b-1}$ it is possible to calculate E for both galaxies in order to find radius with the same E regarding both galaxies.

In table below is written E at different radius for MW & M31. For Radius MW = 310 kpc $E_{MILKY\ WAY} = 1{,}312 \cdot 10^{-12}$ is almost identical to $E_{M31} = 1{,}307 \cdot 10^{-12}$ m/s^2 at radius M31 = 460 kpc. See first row in grey.

So according this theory it is right to consider halo radius of MW = 310 kpc and halo radius of M31= 460 kpc.

Radius MW	Radius MW	Radius M31	radius M31	E MW Huang	E M31 Sofue
kpc	m	kpc	m	m/s^2	m/s^2
250,00	7,7142500E+21	520,00	1,6045640E+22	1,85201226E-12	1,088151203E-12
260,00	8,0228200E+21	510,00	1,5737070E+22	1,73914966E-12	1,120205631E-12
270,00	8,3313900E+21	500,00	1,5428500E+22	1,63704552E-12	1,153867513E-12
280,00	8,6399600E+21	490,00	1,5119930E+22	1,54433057E-12	1,189252080E-12
290,00	8,9485300E+21	480,00	1,4811360E+22	1,45985057E-12	1,226485409E-12
300,00	9,2571000E+21	470,00	1,4502790E+22	1,38262658E-12	1,265705698E-12
310,00	9,5656700E+21	460,00	1,4194220E+22	1,31182355E-12	1,307064721E-12
320,00	9,8742400E+21	450,00	1,3885650E+22	1,24672542E-12	1,350729497E-12
311,00	9,5965270E+21	459,00	1,4163363E+22	1,30506792E-12	1,311324542E-12

7. HYPOTHESIS D.M. DENSITY AS POWER OF E AS UNIVERSAL LAW

7.1 COMPARISON OF D.M. DENSITY AS POWER OF E FOR MW & M31

Below are rewritten parameters A&B for M31 and MW belonging to DM density as power of E formula. Parameters A are similar in both galaxies and B as well. In addition parameters of M31 are a bit bigger than parameters of MW, this way formula of M31 gives results very close to formula of MW. In this epigraph will be shown that results given by both formulas are astonishing closed.

[11] Abarca,M.2016 Data	
M31 galaxy	$D_{DM} = A \cdot E^B$
A	$3{,}766521943774E \cdot 10^{-6}$
B	1,668847537702

Epigraph 5.2 Data for A&B	
MILKY WAY	$D_{DM} = A \cdot E^B$
A	$1{,}27687739294523 \cdot 10^{-6}$
B	1,62377420773729

Table below is the same written in epigraph 5.2 for Milky Way galaxy with a new column added, the fourth column. In this column is calculated DM density as power of E using A & B parameters of M31. The last column compares both DM density values. Relative differences are astonishing little, despite the fact that DM density as power of E for M31 was got for dominion 40 kpc up to 260 kpc. However in table below dominion begin at 35 kpc. At this radius relative difference is 0,62 % and maximum relative difference is 14%. Remember that in chapter four were got Direct DM density depending on radius for MW & M31 and its relative differences were bigger than 90%. Astonishing ¡¡¡

E virial MW data	Radius	Radius	DM den.power E M31	DM den. Power E MW	Rel diff.
m/s^2	kpc	m			%
4,3304E-11	35,00	1,0800E+21	1,9093E-23	1,8976E-23	0,62
3,4959E-11	40,00	1,2343E+21	1,3358E-23	1,3404E-23	-0,35
1,8250E-11	60,00	1,8514E+21	4,5145E-24	4,6650E-24	-3,23
1,1507E-11	80,00	2,4686E+21	2,0910E-24	2,2061E-24	-5,22
8,0464E-12	100,00	3,0857E+21	1,1510E-24	1,2341E-24	-6,73
6,0070E-12	120,00	3,7028E+21	7,0670E-25	7,6776E-25	-7,95
4,6917E-12	140,00	4,3200E+21	4,6787E-25	5,1399E-25	-8,97
3,7876E-12	160,00	4,9371E+21	3,2732E-25	3,6307E-25	-9,85
3,1359E-12	180,00	5,5543E+21	2,3885E-25	2,6720E-25	-10,61
2,6485E-12	200,00	6,1714E+21	1,8018E-25	2,0311E-25	-11,29
2,2732E-12	220,00	6,7885E+21	1,3962E-25	1,5848E-25	-11,90
1,9773E-12	240,00	7,4057E+21	1,1063E-25	1,2636E-25	-12,45
1,7391E-12	260,00	8,0228E+21	8,9301E-26	1,0259E-25	-12,95
1,5443E-12	280,00	8,6400E+21	7,3240E-26	8,4592E-26	-13,42
1,3826E-12	300,00	9,2571E+21	6,0895E-26	7,0686E-26	-13,85
1,3118E-12	310,00	9,5657E+21	5,5781E-26	6,4903E-26	-14,05

Table below is the same written in epigraph 5.2 for M31 galaxy with a new column added, the fifth column. In this column is calculated DM density as power of E using A & B parameters of Milky Way. The last column compares both DM density values. Relative differences are astonishing little, despite the fact that DM density as power of E for Milky Way was got for dominion 35 kpc up to 100 kpc. However in table dominion extend up to 460 kpc. Astonishing ¡¡¡

Radius	Radius	E virial M31	Dm power E M31	DM power E MW	rel diff
kpc	m	m/s^2	kg/m^3		%
40,00	1,2342800E+21	5,03682E-11	2,45702E-23	2,42536E-23	1,31
70,00	2,1599900E+21	2,18166E-11	6,08139E-24	6,23372E-24	-2,44
100,00	3,0857000E+21	1,27995E-11	2,49750E-24	2,62234E-24	-4,76
130,00	4,0114100E+21	8,64639E-12	1,29779E-24	1,38697E-24	-6,43
160,00	4,9371200E+21	6,33885E-12	7,73043E-25	8,37805E-25	-7,73
190,00	5,8628300E+21	4,90259E-12	5,03483E-25	5,52018E-25	-8,79
220,00	6,7885400E+21	3,93761E-12	3,49239E-25	3,86708E-25	-9,69
250,00	7,7142500E+21	3,25258E-12	2,53864E-25	2,83532E-25	-10,46
280,00	8,6399600E+21	2,74563E-12	1,91336E-25	2,15335E-25	-11,14
310,00	9,5656700E+21	2,35805E-12	1,48424E-25	1,68190E-25	-11,75
340,00	1,0491380E+22	2,05387E-12	1,17871E-25	1,34402E-25	-12,30
370,00	1,1417090E+22	1,80996E-12	9,54509E-26	1,09460E-25	-12,80
400,00	1,2342800E+22	1,61082E-12	7,85778E-26	9,05850E-26	-13,26
430,00	1,3268510E+22	1,44573E-12	6,56043E-26	7,59986E-26	-13,68
460,00	1,4194220E+22	1,30706E-12	5,54437E-26	6,45207E-26	-14,07

Notice that last rows in tables above, in grey, have the same E =1,3·10^{-12} because this value of radius is halo border. It is 360 kpc for MW and 460 kpc for M31.

In my opinion this result support strongly hypothesis about DM as power of E as Universal law. Because relative differences throughout dominion below 14 % in this kind of galactic calculus are not important.

Remember that in chapter four were got Direct DM density depending on radius for MW & M31 and its relative differences were bigger than 90%.

7.2 COMPARISON OF D.M. DENSITY AS POWER OF E LAWS FOR MW & [2] Abarca,M.2015.

In paper [2] Abarca,M.2015.*Dark matter density function depending on gravitational field as Universal law.* Author published parameters in table below. These parameters were got through a statistical study of eight rotation curves of giant galaxies. Procedure was tabulate NFW DM density versus gravitational field calculated through Virial formula E = v^2/ R where velocity and radius were taken from rotation curve each galaxy. Through a statistical method was calculated a DM density as power E in average for all galaxies studied. It was not a mathematical rigorous method. However relative differences are under 24 % as is shown in table below.

These values are a bit bigger than A& B parameters got for MW and M31. However they will give values of DM density quite close to calculates above in epigraph 6.1.

[2] Abarca,M.2015. pg 49. Data A&B	
$D_{DM} = A \cdot E^B$	
A	2,526 ·10^{-5}
B	1,74

In table below has been compared DM density as power E of MW and the same law with parameters published in [2] Abarca,M.2015.

Results are astonishingly close.

E virial MW data	Radius	Radius	DM pw as Uni law	DM den. Power E MW	Rel diff.
m/s^2	kpc	m			%
4,3304E-11	35,00	1,0800E+21	2,3441E-23	1,8976E-23	23,53
3,4959E-11	40,00	1,2343E+21	1,6152E-23	1,3404E-23	20,50
1,8250E-11	60,00	1,8514E+21	5,2121E-24	4,6650E-24	11,73
1,1507E-11	80,00	2,4686E+21	2,3362E-24	2,2061E-24	5,90
8,0464E-12	100,00	3,0857E+21	1,2536E-24	1,2341E-24	1,58
6,0070E-12	120,00	3,7028E+21	7,5388E-25	7,6776E-25	-1,81
4,6917E-12	140,00	4,3200E+21	4,9041E-25	5,1399E-25	-4,59
3,7876E-12	160,00	4,9371E+21	3,3790E-25	3,6307E-25	-6,93
3,1359E-12	180,00	5,5543E+21	2,4328E-25	2,6720E-25	-8,95
2,6485E-12	200,00	6,1714E+21	1,8133E-25	2,0311E-25	-10,72
2,2732E-12	220,00	6,7885E+21	1,3899E-25	1,5848E-25	-12,29
1,9773E-12	240,00	7,4057E+21	1,0904E-25	1,2636E-25	-13,71
1,7391E-12	260,00	8,0228E+21	8,7221E-26	1,0259E-25	-14,98
1,5443E-12	280,00	8,6400E+21	7,0932E-26	8,4592E-26	-16,15
1,3826E-12	300,00	9,2571E+21	5,8514E-26	7,0686E-26	-17,22
1,3118E-12	310,00	9,5657E+21	5,3399E-26	6,4903E-26	-17,72

In my opinion this results support strongly hypothesis DM as power E as Universal law. Because relative differences throughout dominion below 20 % in this kind of galactic calculus are not important. In addition there is an unknown amount of baryonic DM inside each galactic disc and galactic halos which change experimental profile for each galaxy. So it is reasonable relative differences around 20 %.

Remember that in chapter four were got Direct DM density depending on radius for MW & M31 and its relative differences were bigger than 90%.

8. DM DENSITY AS POWER OF *E* VERSUS NFW PROFILE

Below are data for NFW profile.

NFW profile [5] Huang,Y.2016
Rs = $14,4 \pm 1,3$ Kpc
Do = $8,19 \cdot 10^{-22}$ kg/m^3

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

In first column is *DM density as power E* calculated in epigraph 5.2. The second column tabulate NFW profile and third column shows relative difference at different radius.

DM pw E	nfw	rel diff.	Radius
Kg/m^3	kg/m^3	%	kpc
1,89760E-23	2,85814E-23	33,61	35
7,49845E-24	1,17712E-23	36,30	50
3,12305E-24	4,89496E-24	36,20	70
1,62353E-24	2,48811E-24	34,75	90
9,62933E-25	1,43372E-24	32,84	110
6,23356E-25	9,00350E-25	30,77	130
4,29493E-25	6,01987E-25	28,65	150
3,10067E-25	4,22188E-25	26,56	170
2,32119E-25	3,07437E-25	24,50	190
1,78881E-25	2,30782E-25	22,49	210
1,41162E-25	1,77637E-25	20,53	230
1,13619E-25	1,39637E-25	18,63	250
9,29919E-26	1,11747E-25	16,78	270
7,72073E-26	9,08177E-26	14,99	290
6,49026E-26	7,48053E-26	13,24	310

For radius lower than 90 kpc relative differences are almost 35 %, although they are going decreasing progressively when radius increase. In addition it is important to notice that *NFW profile* gives bigger densities than *power E profile.*

It is important to analyze reason this remarkable differences.

In fact it is easy to understand it, because DM power of E was got through power regression of velocity in halo region. In chapter three was explained that reason to select dominion 34 kpc up to 100 kpc is to guarantee that baryonic density would be negligible. However NFW is fitted throughout disc and halo i.e. from 5 kpc up to 100 kpc and inside region 5kpc up to 34 kpc there is an unknown amount of baryonic DM.

As a result NFW fits DM density with data density bigger than do it DM density as power of E.

Also it is important to notice that the bigger radius is the lower relative difference is. In my opinion this happen because baryon DM is not negligible inside disc but its influence decrease as it is considerate bigger radius in halo region.

The missing baryon or baryonic DM is currently an open issue and reader can consult following paper to know about baryonic DM in galaxies. See [15] Nieuwenhuizen,T.M. 2012. [17] Wyrzykowski,L.2010. [18] Hawkins M.R.S. 2015. [20] Brandt. Timothy D.2016. [21] S. Calchi Novati.2014. [22] Torres, S. 2010.

9. MASSES IN MILKY WAY

9.1 DARK MATTER TRHOUGH NFW PROFILE

According NFW DM density profile, total DM enclosed by a sphere with R radius is

$$M(<R) = 4\pi R^3{}_S \cdot D_o \cdot \left[\ln(1+x) - \frac{x}{1+x} \right]$$

Calling $f(x) = \left[\ln(1+x) - \frac{x}{1+x} \right] = \ln(1+r/Rs) - \frac{r}{r+Rs}$ and $Z_{NFW} = 4\pi R^3{}_S \cdot D_0$ then

$$DM_{NFW}(<r) = Z_{NFW} \cdot f(x)$$

According [5] Huang,Y.2016 data for Milky Way $Z_{NFW} = 4{,}53 \cdot 10^{11}$ Msun.
According [5] Huang,Y.2016. Baryonic mass enclosed in bulge and disc MW is $8{,}1 \cdot 10^{10}$ Msun

Fourth column show total mass adding Baryonic mass to third column which show DM at sphere r.

Radius		Radius	NFW DM(<R)	Tot M(<r)
kpc		m	M sun	Msun
	35	1,08E+21	2,38E+11	3,19E+11
Virial radius	255,7	7,89013E+21	8,99E+11	9,8E+11
Halo radius MW	310	9,56567E+21	9,78E+11	1,06E+12

9.2 DYNAMICAL MASS

Power regression for MW chapter 3.	
V=a*r^b 35kpc < R < 100 kpc	
a	$4{,}765032346 \cdot 10^{11}$
b	-0,3015720974
Correlation coeff.	0,9

Beside is table with power regression velocity got in chapter 3. However in chapters 5 & 6 it was explained reason to can enlarge dominion up to 310 kpc.

In other words, despite the fact that measures in rotation curve reach up to 100 kpc, hypothesis DM generated by gravitational field state the same law throughout halo region, which extend up to 310 kpc.

As $M(<r)=\frac{v^2\cdot R}{G}$ represents total mass enclosed by a sphere with radius r, by substitution of velocity results $M(<r)=\frac{v^2\cdot R}{G}=\frac{a^2\cdot r^{2b+1}}{G}$. This mass is called dynamical mass because it can explain Newtonian dynamics of galactic rotation curve. Dynamical mass is considered total mass enclosed inside a sphere r.

Radius kpc	Dynamical mass Msun	DM(<R) Msun
35	$3{,}8\cdot10^{11}$	$3\cdot10^{11}$
Virial radius 255,7	$8{,}374\cdot10^{11}$	$7{,}56\cdot10^{11}$
Halo radius 310	$9{,}04\cdot10^{11}$	$8{,}23\cdot10^{11}$

Third column shows DM(<r) enclosed inside a sphere r. This value is got subtracting Baryonic mass $=8{,}1\cdot10^{10}$ Msun to dynamical mass.

In particular M(< 255,7 kpc) = $8{,}374\cdot10^{11}$ M sun and subtracting Baryonic mass it is got DM(< 255,7 kpc) = $7{,}564\cdot10^{11}$ Msun which is 16% lower than DM by NFW = $9{,}81\cdot10^{11}$ Msun at 255,7 kpc.

Reason to explain that dynamical method gives lower masses than NFW is the same that was explained in chapter eight. NFW profile gives bigger values than DM power E profile because it is fitted with bigger values because of disc values which include an unknown amount of Baryonic DM, whereas DM power E comes from data belonging to radius bigger 35 kpc where it is supposed Baryonic DM is negligible.

10. LOCAL DARK MATTER DENSITY

10.1 CURRENT DATA FOR LOCAL DM DENSITY

In his remarkable paper the author - [19] J. I. Read.2014- presents a review of ancient and recent measures of local DM density which is summarized in table below.

Label	Reference	Description	Sampling	ρ_{dm} [$M_\odot$ pc^{-3}]	ρ_{dm} [GeV cm^{-3}]
a) Local measures (ρ_{dm})					
Kapteyn	Kapteyn (1922)	–	–	0.0076	0.285
Jeans	Jeans (1922)	–	–	0.051	1.935
Oort	Oort (1932)	–	–	0.0006 ± 0.0184	0.0225 ± 0.69
Hill	Hill (1960)	–	–	-0.0054	-0.202
Oort	Oort (1960)	–	–	0.0586 ± 0.015	2.2 ± 0.56
Bahcall	Bahcall (1984a)	–	–	0.033 ± 0.025	1.24 ± 0.94
Bienayme†	Bienayme et al. (1987)	–	–	0.006 ± 0.005	0.22 ± 0.187
KG†	Kuijken & Gilmore (1991)	–	–	0.0072 ± 0.0027	0.27 ± 0.102
Bahcall	Bahcall et al. (1992)	–	–	0.033 ± 0.025	1.24 ± 0.94
Creze	Creze et al. (1998)	–	–	-0.015 ± 0.015	-0.58 ± 0.56
HF†	Holmberg & Flynn (2000b)	–	–	0.011 ± 0.01	0.4 ± 0.375
HF†	Holmberg & Flynn (2004)	–	–	0.0086 ± 0.0027	0.324 ± 0.1
Bienayme	Bienaymé et al. (2006)	–	–	0.0059 ± 0.005	0.51 ± 0.56
		Latest measurements			
MB12	Moni Bidin et al. (2012)	CSF	412	0.00062 ± 0.001 [0 ± 0.001]	0.023 ± 0.042 [0 ± 0.042]
BT12	Bovy & Tremaine (2012)	CSF	412	0.008 ± 0.003	0.3 ± 0.11
G12	Garbari et al. (2012)	VC	2×10^3	$0.022^{+0.015}_{-0.013}$	$0.85^{+0.57}_{-0.5}$
G12*	Garbari et al. (2012)	VC + Σ_b	2×10^3	$0.0087^{+0.007}_{-0.002}$	$0.33^{+0.26}_{-0.075}$
S12	Smith et al. (2012)	CSF	10^4	0.005 [no error] [0.015]	0.19 [0.57]
Z13	Zhang et al. (2013)	CSF	10^4	0.0065 ± 0.0023	0.25 ± 0.09
BR13	Bovy & Rix (2013)	CSF + MAP	10^4	0.006 ± 0.0018 [0.008 ± 0.0025]	0.22 ± 0.07 [0.3 ± 0.094]
b) Global measures assuming spherical symmetry ($\rho_{dm,ext}$)					
S10	Salucci et al. (2010)	NP	–	0.011 ± 0.004	0.43 ± 0.15
CU10	Catena & Ullio (2010)	NFW; SP	–	0.0103 ± 0.00072	0.385 ± 0.027
WB10	Weber & de Boer (2010)	NFW/ISO; WP	–	0.005 - 0.01	0.2 - 0.4
I11	Iocco et al. (2011)	gNFW; WP; ML	–	0.005 - 0.015	0.2 - 0.56
M11	McMillan (2011)	NFW; SP	–	0.011 ± 0.0011	0.4 ± 0.04

Although it is advisable to read the paper, briefly I comment that measures of group a) are made through local methods which involve measures of stars few hundred parsecs away. Local measures use the vertical kinematics of stars near the Sun called `tracers'.

Group of measures b) involve global measures which extrapolate $\varphi_{DM-EXTR}$ from the rotation curve of Galaxy.

10.2 LOCAL DARK MATTER DENSITY. MEASURES VS THEORY

Below are gathered some formulas got previously which will be used to calculate Local DM density.

In chapter three was got power regression for rotation curve in MW halo. Dominion 34 up to 100 kpc.

Power regression for Milky Way rot. curve	
V=a*r^b	34< r < 100 kpc
a	$4{,}765032346 \cdot 10^{11}$
b	-0,3015720974
Correlation coeff.	0,9

In chapter four has been got *Direct DM density*

Direct DM density for Milky Way halo 34 < r < 100 kpc
$D_{DM}(r) = L \cdot r^{2b-2}$ kg/m^3
L = 1,07456689003917·10^32
2b -2 = -2,6031441948

In chapter 5 has been got DM density as power of E for MW and M31

MILKY WAY	$D_{DM} = A \cdot E^B$
A	1,27687739294523·10^-6
B	1,62377420773729

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

In chapter seven was used power of E profile got in previous paper [2] Abarca,M.2015

$D_{DM} = A \cdot E^B$ [2] Abarca,M.2015	
A	2,526 ·10^-5
B	1,74

Below are gathered some useful conversion units and current data Sun.

USEFUL CONVERSION UNITS	
1 kpc = 3.0857 ·10^19 m	Msun = 1,99·10^30 kg
1 m M_Θ/pc^3 = 0,001 M_Θ/pc^3 = 6,768·10^-23 Kg/m^3	
1 m M_Θ/pc^3 = 10^-3 M_Θ/pc^3 = 0,038 GeV/cm^3	

CURRENT DATA SUN
Galactocentric distance = 8,3 kpc V_{SUN} = 240 km/s $E_{SUN} = V^2$/ Radius = 2.249 · 10^-10 m/s^2.

10.2.1 Local DM density through Direct DM density

If formula $D_{DM}(r) = L \cdot r^{2b-2}$ is calculated for Sun data. Direct DM density at Sun = 8,038·10^-22 kg/m^3 = =11,87 mMsun/pc^3 = 0,445 GeV/cm^3. This value is close to biggest values in table above. However it is wrong because direct DM density is got from power regression formula $v = a \cdot r^b$ and this formula is correct inside dominion 34 kpc up to 100 kpc. In fact for radius R_{SUN} = 8,3 kpc gives V_{SUN} = 333,8 Km/s which is totally wrong.

10.2.2 Local DM density through DM as power of E

According DM density generated by gravitational field theory, there is no problem to accept formula of $D_{DM} = A \cdot E^B$ inside region where baryonic density is not negligible. To get formula parameters A & B was necessary to study DM density at halo region in order to calculate pure non-baryonic DM density. However theory state that non baryonic DM is generated by E everywhere.
Below are results of Local DM density for three different values of A&B. Results are reasonably closed.

$D_{DM} = A \cdot E^B$	Local DM density for different values of A&B Non – Baryonic D.M.
$E_{SUN} = V^2$/ Radius = 2.249·10^-10 m/s^2	
Milky Way A&B	2,75·10^-22 kg/m^3 = 4,07 m M_Θ/pc^3 = 0,155 GeV/cm^3.
M31 A&B	2,985 ·10^-22 kg/m^3 = 4,41 m M_Θ/pc^3 = 0,168 GeV/cm^3.
A &B from [2] Abarca,M.2015 data.	4,12 ·10^-22 kg/m^3 = 6,09 m M_Θ/pc^3 = 0,231 GeV/cm^3.

Values of Local DM density got through MW & M31 parameters are very similar 0,16 GeV/cm^3. This value is close to some ones got by recent measures: Smith (2012) = 0,19 GeV/cm^3 and Iocco (2011) = 0,2 GeV/cm^3.
The other one 0,231 GeV/cm^3 agrees fully with recent measures. See above table [9] J. I. Read.2014.

Finally Local DM density stated by [5] Huang,Y.2016 is 0.32 GeV/cm^3 , justly twice than got through MW parameters A &B.

It is important to explain that there is not contradiction to accept values calculated above and measures. According non baryonic DM theory, this one is generated by gravitational field. However inside galactic disk there is an unknown amount of baryonic DM. In my opinion this is the reason why measures of Local DM density are clearly bigger than non baryonic Local DM density calculated in this chapter.

Reader can consult following papers to know about baryonic DM or missing baryons challenge in galaxies. [14] Nieuwenhuizen,T.M. 2010 .[15] Nieuwenhuizen,T.M. 2012. [16] Nieuwenhuizen,T.M. 2010.[17] Wyrzykowski,L. .2010. [18] Hawkins M.R.S. 2015. [20] Brandt. Timothy D.2016. [21] S. Calchi Novati.2014. [22] Torres, S. 2010.

11. CONCLUSION

The main conclusions are three ideas.

The first one is that there are strong evidences that suggests there is a non negligible amount of baryonic DM inside bulge and galactic disc. Main reasons to support this one are that NFW profile is bigger than DM power profile throughout dominion, and relative differences oscillate between 34 % and 13%. Second reason to support the statement is that Local DM density measures are around two times bigger than Local DM calculated through *DM power E profile.*

The second one is a new definition for galactic halo which is the region where own gravitational field dominates over gravitational field of galactic neighbour. According this new definition, the new halo radius for MW is 310 kpc and for M31 is 460 kpc.

The third one is that there are strong evidences that non baryonic DM density is generated by gravitational field as a Universal law. Apart twelve papers previously published to defend such hypothesis, the main reason to support this hypothesis is conclusion got in chapter seventh where was clearly exposed that DM power E for MW and DM power E for M31 differs less than 14 % throughout dominion E. Despite the fact that they have been compared inside the new radius dominion, 310 kpc for MW and 460 kpc for M31.

In addition in chapter seven also were compared DM power E in MW versus DM power of E profile published in [2] Abarca,M.2015. Results differed less than 20%, despite the fact that such profile was got through a statistical method very different to mathematical method followed to get DM power E for MW in this paper.

In my opinion is important follow studying DM as power E in different galaxies in order to compared themselves to check if DM as power E is a Universal law or not.

In previous papers I have not found any reason to reject DM power E as Universal law for giant galaxies.

It is known that DM density inside intermediate and dwarf galaxies is bigger at a specific E value, but this one is another story.

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