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Dark Matter – Is it Needed?

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Abstract

The idea that the outer stars of a galaxy resp. the outer galaxies of a cluster of galaxies are rotating too fast around their gravitational centres and therefore can not be kept on their orbits by the gravitation of the baryonic matter leads to the assumption of extra matter, the „dark matter“, whose gravitation is suited to keep the outer stars/galaxies on their orbits.

It is demonstrated that if the gravitational acceleration as a function of the distance from the gravitational centre is determined correctly, the observed orbital velocities can be explained solely by the baryonic matter and Newton’s laws and therefore „dark matter“ is not needed. It is not even necessary To explain the other effects ascribed to it, „dark matter“ is not neeeded either as the higher gravitational accelerations necessary for these effects are delivered solely by the baryonic matter.

1 Introduction

There are several observation results regarding the movement of stars in galaxies and of galaxies in clusters of galaxies which, according to the actual state of science, cannot be explained by Newton’s laws solely. The actual state of science is that according to Newton’s laws the orbital velocity of stars should decrease with respect to the distance from the gravitational centre. But in reality, it increases [1] and so the outer stars resp. galaxies are far too fast to be kept on their orbitals solely by the baryonic matter of their galaxy resp. cluster.

This leads to the postulate of additional matter, either distributed as constant density of matter throughout the galaxy or as halo around the galaxy. However, such matter could not be observed until now, its nature is unknown and therefore it is called „dark matter“. But the question is if the effect of the „missing matter“ can be explained on another way.

2 The Distribution of Matter in a Spiral Galaxy

Looking on a spiral galaxy at a large scale perpendicular to its rotational plane, it looks like a circular disc with nearly constant volume density of its matter („star gas“). The less dense regions between the spiral arms do not change relations much [3].

At the edge of a galaxy there is a certain gravitational acceleration g_0, and at the gravitational centre zero acceleration because the gravitational accelerations of all matter cancel out there. At the constant volume density presumed above the value of the gravitational acceleration increases linearly with the distance from the gravitational centre from zero to g_0 at the edge of the galaxy according to the example of the earth [2]. Therefore, the gravitational acceleration on a star is proportional to its distance from the gravitational centre. It does not matter that the galaxy is not a sphere as in the example [2], as the linear dependency is given even with a one-dimensional rod.

This gravitational acceleration has to deliver the centripetal acceleration for the star on its orbit to stay there, resulting in the orbital velocity v being proportional to the distance r of the star from the gravitational centre. This means that the orbital velocity v increases linearly with r resp. the orbital angle velocity is constant and independent from r (Appendix, 6.1).

This result was yielded under idealised conditions (orbits of the stars are circles, constant volume density throughout the whole galaxy). This is justified to work out the principle of the rotational dynamics of a galaxy. In reality, the volume density of matter nearby the gravitational centre is significantly higher than farer away, and in the gaps between the spiral arms less than within them, but only a few % and therefore insignificant [3]. Under these conditions, gravitational acceleration outside the bulge with respect to the distance from the boundary of the bulge first lowers, but with growing distance increases again with a maximum value at the boundary of the galaxy. The measurement [1] confirms this statement: The picture of the orbital velocities shows that they raise linearly with respect to the distance from the gravitational centre, i.e. their angle velocity is constant; more outside, where the matter density is lower, the angle velocity lowers, but the orbital velocity raises again with the approach towards the edge of the galaxy.

As the stars are kept on their orbits in spite of their raising orbital velocities whith respect to the raising gravitatonal acceleration approaching the edge of the galaxy, a hypothetic „dark matter“ is not needed to explain these observations. baryonic matter and Newton’s laws are suited and sufficient. A rough estimate of the orbital velocities by means of a galaxy model containing two regions of a bulge with higher constant and the rest with lower constant matter density and with only the baryonic matter as total matter shows this clearly (Appendix, 6.2). Using the data of the milky way, already this coarse model yields the correct magnitude of the orbital velocity of the sun (approx. 230 km/s) without adaptation, but not of a star at the edge of the milky way (approx. 600 km/s, Appendix 6.3). The orbital velocity of such a star is significantly lower [1], from which can be concluded that the model is too simple. An approach with linearly descending matter density from the edge of the bulk to the edge of the galaxy yields the measured order of magnitude of the stars near the edge of the galaxy.

As the gravitatonal acceleration at the edge of the galaxy and even more outside has the same value as under the assumption of „dark matter“, but without it, the stronger as expected light refraction of passing light compared to the classic model is explained freely.

3 Clusters of Galaxies and Superclusters

The reflections on the example of a galaxy can be transmitted to the diverse hierarchical formings of clusters of galaxies because all cluster members rotate around a gravitational centre and with growing distance from it between it and a certain cluster member an increasing and between the cluster member and the edge of the cluster a decreasing number of cluster members are present. This, however, causes the increase of the gravitational acceleration with increasing distance from the gravitational centre, as was shown by the example of a spiral galaxy (Chapter 2), because with increasing distance more and more cluster members increase the gravitation in the direction to the gravitational centre and less cluster members contribute gravitational force in the opposite direction. Therefore again, no „dark matter“ is needed to explain the increasing gravitational acceleration with increasing distance from the gravitational centre.

4 Role of the „Dark Matter“ for the Structural Forming of the Universe

It is argued that the structural forming of the universe by the baryonic matter alone could not be performed in the time available because the gravitational acceleration of this matter was much too small to create the respective „matter accumulations“. As the gravitational acceleration at the edge of galaxies or clusters of galaxies is much bigger than by means of the classic model, namely exactly as big as with the assumption of „dark matter“, it acts on the structural forming exactly as expected by the „dark matter“, but just without it, only by means of the baryonic matter.

5 Conclusions

All effects ascribed to „dark matter“ with one exception can be explained by this proposed model, without the need of „dark matter“. But with „dark matter“ obsolete, there is missing 25 % of the total energy necessary to keep the universe flat. Fortunately, this problem can be solved in a simple way: 25 % of an unknown energy are now missing, so why not replace it by another unknown energy and postulate that now the amount of dark energy within the universe be 95 % instead of 70 %, and the universe is flat again.

6 Appendix

6.1 Orbital Velocity of Stars in a Spiral Galaxy

In the simplified model of a spiral galaxy with constant matter density the gravitational acceleration b_G increases linearly with the distance r from the gravitational centre to the edge of the galaxy from 0 up to g_0:

$$b_G = \frac{r}{r_0} g_0 \quad (1)$$

This acceleration acts as zentripetal acceleration:

$$b_Z = \frac{v_B^2}{r} \quad (2)$$

Equating yields:

$$v_B = \sqrt{\frac{g_0}{r_0} r} \quad (3)$$

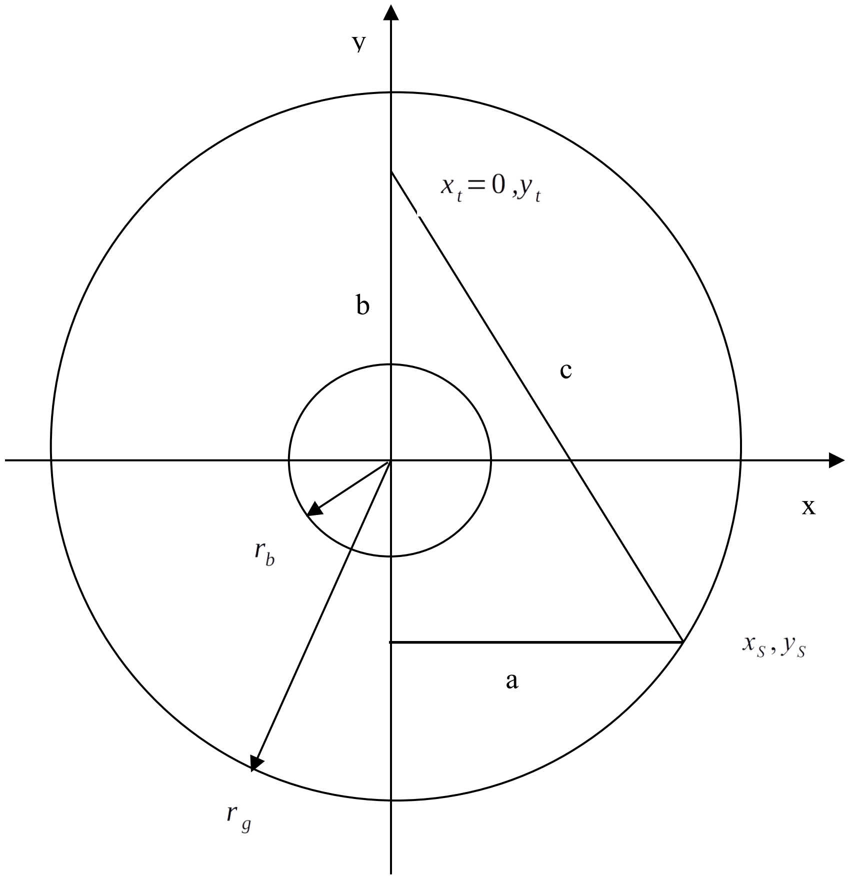
So, the orbital velocity of a star increases linearly with its distance from the gravitational centre, its orbital angle velocity $\frac{v_B}{r}$ is constant, hence independent from its distance.

6.2 Rough Galaxy Model for Estimating the Orbital Velocities

The distribution of the baryonic matter in the galaxy is approximated by a higher matter density in the bulge und a smaller one up to the edge of the galaxy. The edges of the bulge and the galaxy have the shape of a circle, their respective matter densities are constant. The thickness of the galaxy is neglected as it is small compared with its perimeter. Therefore, the examination can be done two-dimensionally. Picture 1 illustrates this by looking at the rotational plane of a galaxy.

$x_t = 0, y_t$	test point at whose location the gravitational acceleration is calculated
x_S, y_S	intersection of the horzontal line y = const with the right side edge of the galaxy
r_b	radius of the bulge
r_g	radius of the galaxy
x = 0	vertical straight line over which the contributions of all horizontal straight lines y = const to the gravitational acceleration at the test point $x_t = 0, y_t$ are summed up
a	horizontal straight line over which from x = 0 to x_S the contributions db_g to the gravitational acceleration of all differential surface densities of matter at the test point $x_t = 0, y_t$ are summed up
b	right side of the right-angled triangle a, b, c which together with hypotenuse c allows the calculation of the angle ($\cos\varphi$), which yields the contributions db_{gy} of the respective surface densities to the gravitational acceleration in y-direction
c	distance of the differential surface element from the test point $x_t = 0, y_t$
db_g	differential contribution to the gravitational acceleration

db_{gy} differential contribution to the gravitational acceleration in y-direction
G gravitational constant



Picture 1: Model of a Spiral Galaxy

The surface F_g of the galaxy is separated into differential surface elements dx * dy of the matter density dm, each of which, according to Newton's acceleration and gravitation laws, yields a contribution to the gravitational acceleration at the test point $x_t = 0, y_t$:

$$dm = dx * dy * \frac{M_g}{F_g} \tag{4}$$

Equating acceleration and gravitation law:

$$db_g = G * \frac{dm}{c^2} \tag{5}$$

The amount of this acceleration in y-direction is

$$db_{gy} = db_g * \cos\varphi \ , \quad \cos\phi = \frac{b}{c} = \frac{y_t - y}{\sqrt{x^2 + (y_t - y)^2}} \tag{6}$$

combination yields the differential equation

$$db_{gy} = G * dx * dy * \frac{M_g}{F_g} * \frac{y_t - y}{[x^2 + (y_t - y)^2]^{\frac{3}{2}}} \qquad (7)$$

This differential equation does not seem to be solubal algebraically. Therefore, by means of a c-programme, the approach of a numerical solution was chosen (cf. Appendix 6.4). The result for the gravitational accelerations and orbital velocities at 30 equidistant values from the gravitational centre up to 50% beneath the edge of the galaxy is shown in Appendix 6.3. The first three pictures show the results for constant matter density outside the bulge, the latter three for linearly decreasing matter density downto zero at the edge of the galaxy.

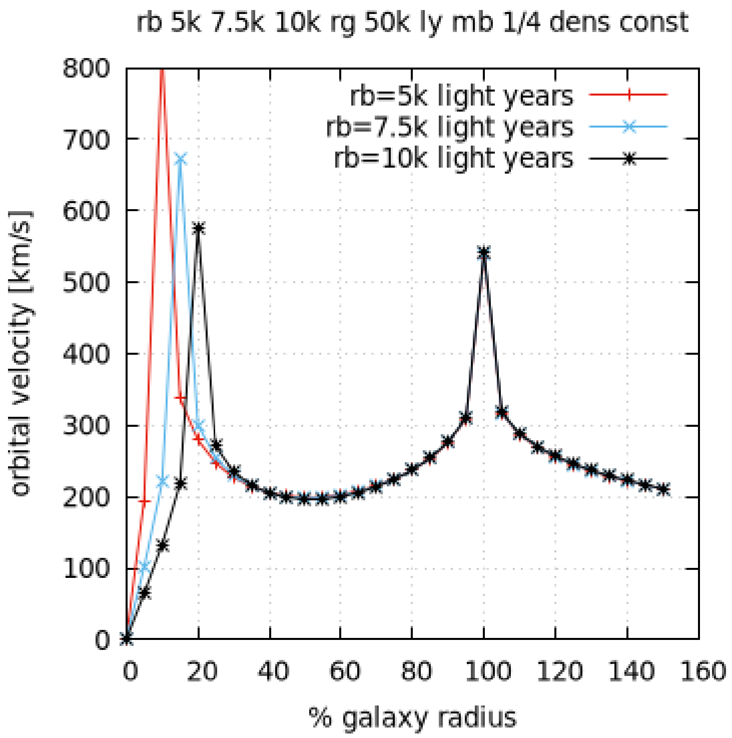
6.3 Result of the Calculation of the Accelerations and Orbital Velocities

These values were calculated with the parameters bulge radius 5, 7.5 and 10 thousand light years, galaxy radius 50, 60 and 70 thousand light years and bulge matter 1/5, ¼ and 1/3 of the galaxis matter, baryonic galaxis matter, example milky way, 4e41 kg, constant or linearly decreasing matter density downto zero at the edge of the galaxy outside of the bulge.

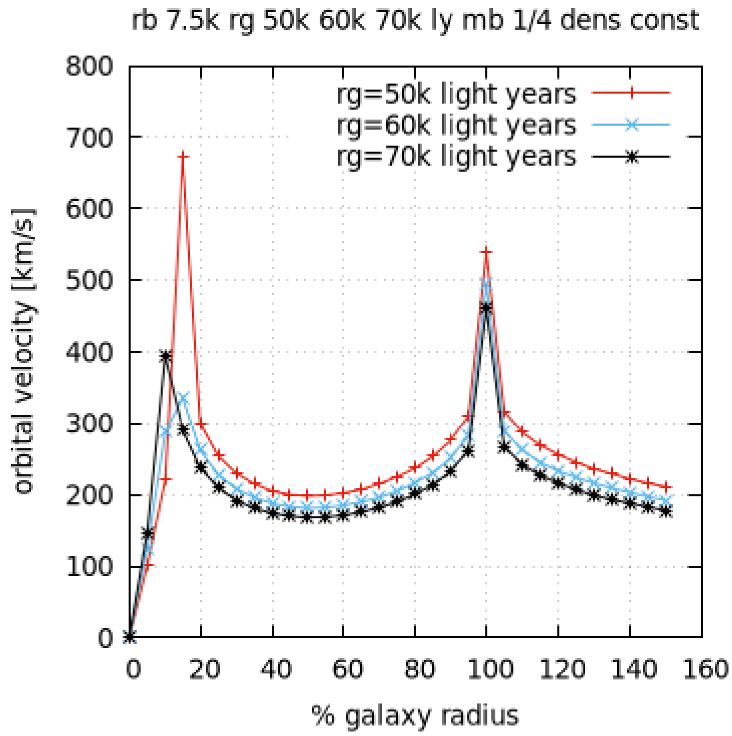
radius: 0 % acceleration: 0.00e+00 m/s² orbital velocity: 0.00e+00 km/s
radius: 5 % acceleration: 4.35e-10 m/s² orbital velocity: 1.01e+02 km/s
radius: 10 % acceleration: 1.03e-09 m/s² orbital velocity: 2.20e+02 km/s
radius: 15 % acceleration: 6.39e-09 m/s² orbital velocity: 6.73e+02 km/s
radius: 20 % acceleration: 9.51e-10 m/s² orbital velocity: 3.00e+02 km/s
radius: 25 % acceleration: 5.47e-10 m/s² orbital velocity: 2.54e+02 km/s
radius: 30 % acceleration: 3.72e-10 m/s² orbital velocity: 2.30e+02 km/s
radius: 35 % acceleration: 2.78e-10 m/s² orbital velocity: 2.15e+02 km/s
radius: 40 % acceleration: 2.23e-10 m/s² orbital velocity: 2.05e+02 km/s
radius: 45 % acceleration: 1.88e-10 m/s² orbital velocity: 2.00e+02 km/s
radius: 50 % acceleration: 1.66e-10 m/s² orbital velocity: 1.98e+02 km/s
radius: 55 % acceleration: 1.52e-10 m/s² orbital velocity: 1.99e+02 km/s
radius: 60 % acceleration: 1.44e-10 m/s² orbital velocity: 2.02e+02 km/s
radius: 65 % acceleration: 1.40e-10 m/s² orbital velocity: 2.07e+02 km/s
radius: 70 % acceleration: 1.39e-10 m/s² orbital velocity: 2.15e+02 km/s
radius: 75 % acceleration: 1.42e-10 m/s² orbital velocity: 2.25e+02 km/s
radius: 80 % acceleration: 1.49e-10 m/s² orbital velocity: 2.37e+02 km/s
radius: 85 % acceleration: 1.60e-10 m/s² orbital velocity: 2.54e+02 km/s
radius: 90 % acceleration: 1.78e-10 m/s² orbital velocity: 2.76e+02 km/s
radius: 95 % acceleration: 2.14e-10 m/s² orbital velocity: 3.10e+02 km/s
radius: 100 % acceleration: 6.11e-10 m/s² orbital velocity: 5.38e+02 km/s
radius: 105 % acceleration: 2.02e-10 m/s² orbital velocity: 3.17e+02 km/s
radius: 110 % acceleration: 1.59e-10 m/s² orbital velocity: 2.87e+02 km/s
radius: 115 % acceleration: 1.33e-10 m/s² orbital velocity: 2.69e+02 km/s
radius: 120 % acceleration: 1.15e-10 m/s² orbital velocity: 2.56e+02 km/s
radius: 125 % acceleration: 1.02e-10 m/s² orbital velocity: 2.45e+02 km/s
radius: 130 % acceleration: 9.09e-11 m/s² orbital velocity: 2.36e+02 km/s
radius: 135 % acceleration: 8.20e-11 m/s² orbital velocity: 2.29e+02 km/s
radius: 140 % acceleration: 7.45e-11 m/s² orbital velocity: 2.22e+02 km/s
radius: 145 % acceleration: 6.82e-11 m/s² orbital velocity: 2.16e+02 km/s
radius: 150 % acceleration: 6.27e-11 m/s² orbital velocity: 2.11e+02 km/s

Table 1: These data are an example for the parameters bulge radius 7.5 thousand, galaxy radius 50 thousand light years, relative matter part of the bulge ¼ and matter density outside the bulge constant, from which gnuplot created the diagram Picture 2 blue line

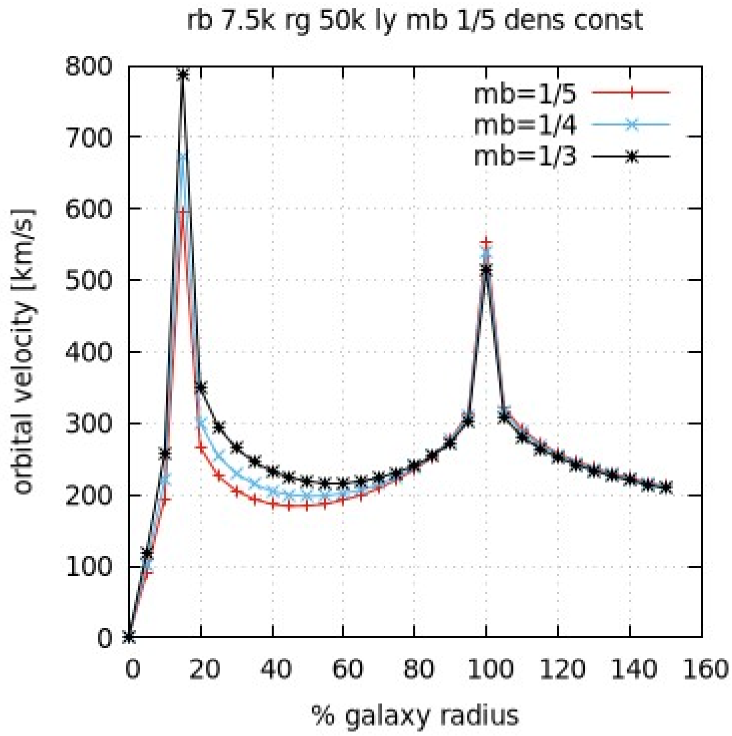
The following diagrams show the variations of the orbital velocity according to the bulge radius, the galaxy radius and the share of the bulge matter in the galaxy matter, on the one hand with constant (Pictures 2, 3 and 4), on the other hand with linearly decreasing matter density downto zero at the edge of the galaxy (Pictures 5, 6 and 7).



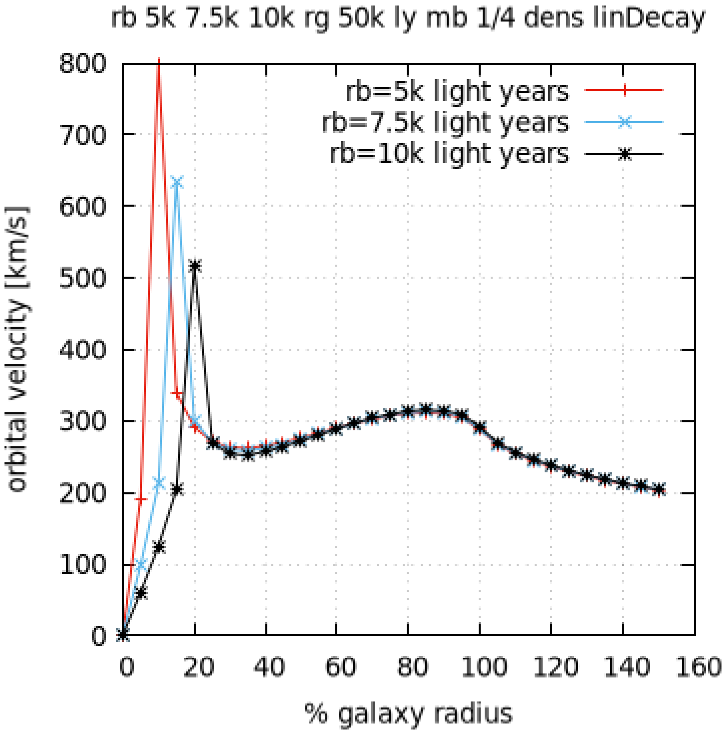
Picture 2: Variation of the Orbital Velocity According to the Bulge Radius, Density of Galaxy Matter Constant



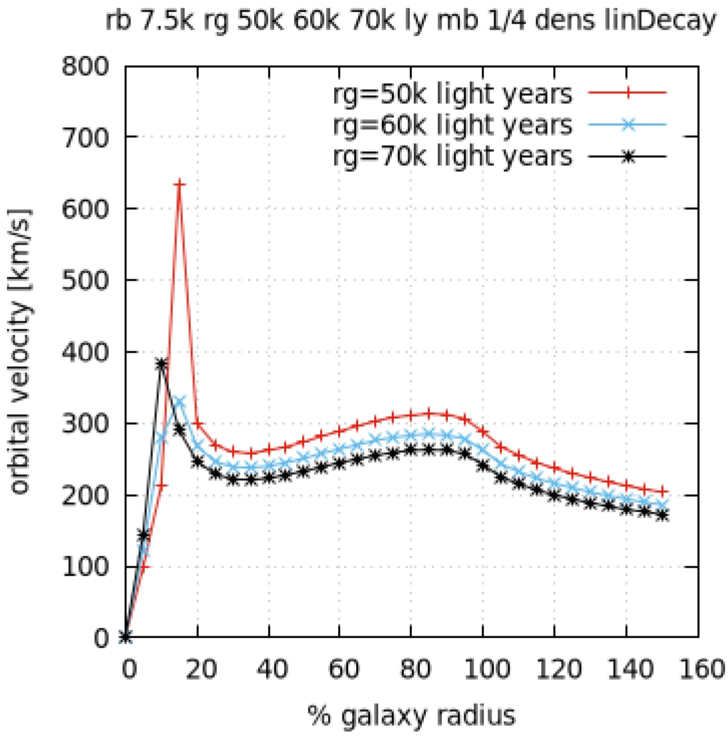
Picture 3: Variation of the Orbital Velocity According to the Galaxy Radius, Density of Galaxy Matter Constant



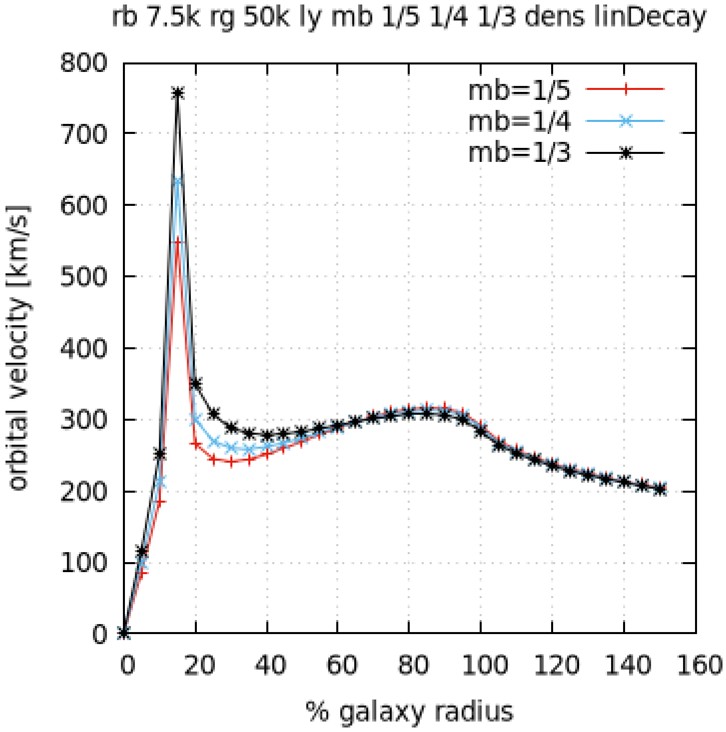
Picture 4: Variation of the Orbital Velocity According to the Relative Bulge matter, Density of Galaxy Matter Constant



Picture 5: Variation of the Orbital Velocity According to the Bulge Radius, Density of Galaxy Matter Decreasing Linearly



Picture 6: Variation of the Orbital Velocity According to the Galaxy Radius, Density of Galaxy Matter Decreasing Linearly



Picture 7: Variation of the Orbital Velocity According to the Relative Bulge matter, Density of Galaxy Matter Decreasing Linearly

It turns out that the orbital velocities of the sun, at the edge of the galaxy and outside of it are not very sensitive with respect to the variations of the three parameters. Looking at the variations of the bulge radius and the relative share of the bulge matter this is reasonable because the galaxy bulge is far away from the sun, the edge of the galaxy and outside of it. But even the variation of the galaxy radius has not much influence on the orbital velocities at the edge of the galaxy and more outside, and even at the highest galaxy radius 50 % outside the galaxy at 105000 light years the velocities still have values about 200 km/s and a variation of only 10 %.

6.4 C-Programme Which Calculates the Model 6.2

```
/****************************************************************************
*                                                                          *
*    This code is the exclusive property of                                *
*                                                                          *
*                 Dr. Hartmut Schwab                                       *
*                                                                          *
*                                                                          *
* Copyright (C) Hartmut Schwab 2021 - 2026                                 *
*                                                                          *
* All rights reserved                                                      *
*                                                                          *
****************************************************************************/
```

```
#include <stdio.h>
#include <math.h>

#define LIGHT_SECOND        3e8           /* meter */
#define HOUR                3600          /* seconds per hour */
#define DAY                 24            /* hours per day */
#define YEAR                365           /* days per year */
#define GY_RADIUS           50000         /* light years, radius of galaxy */
#define GB_RADIUS           7500          /*           "           "      bulge  */
#define GC                  6.674e-11     /* gravitation constant, m*m*m/(kg*s*s) */
#define MG                  4e41          /* baryonic matter of the galaxy (milkyway), kg */
#define MB                  MG/3          /* baryonic matter of the galaxy bulge */
#define PI                  3.14159
#define FALSE               0
#define TRUE                !FALSE

#define LIGHT_YEAR          (LIGHT_SECOND * HOUR * DAY * YEAR)
#define DX                  (LIGHT_YEAR * 10.0)
#define DY                  DX
#define RG                  (GY_RADIUS * LIGHT_YEAR)
#define AG                  (PI * RG * RG)
#define RB                  (GB_RADIUS * LIGHT_YEAR)
#define AB                  (PI * RB * RB)
#define REAL_MATTER         (MG - MB)
#define DM                  (REAL_MATTER / (AG - AB) * DX * DY)
                                          /* mass density at the edge of bulge */
#define GDM                 (GC * DM)
#define DMB                 (MB / AB * DX * DY)  /* constant mass density in the bulge */
#define GDMB                (GC * DMB)
```

```
/***************************************************************************
 *
 * function: int main(int argc, char *argv[])
 *
 * description: calculates the velocity of a star around the galactical centre
 *         of a spiral galaxy up to 1.5 * GY_RADIUS with the constants of the milky way
 *
 * prerequisites:
 *
 * parameters:
 *name             type          description
 *  ---------------+-------------+-------------------------------------------
 *
 * return values:
 *name             description
 *  ---------------+-------------------------------------------------------
 *
 * imported funktions
 *
 * side effects:
 *
 * possible faults:
 *
 ***************************************************************************/
int main(int argc, char *argv[])
{
        unsigned int    i;
        double          x, xs, a_square,
                        y, yt, b, b_square, y_square,
                        c, c_square, r,
                        cosphi,
                        bgy, bgy1, dbgy1, bgy2, dbgy2,
                        im, sumim = 0.0, localDensity, factor, orbitalVelocity;

        FILE            *fp;
        unsigned short  newFile;
        char *          filename = "mgLinDec_rb7.5_rg50_mb0.33.dat";
```

```
printf("radius:   0 %%  acceleration: 0.00e+00 m/s²  orbital velocity: 0.00e+00 km/s\n");
fp = fopen (filename, "r");
newFile = fp == NULL ? TRUE : FALSE;
if (newFile == FALSE)
        fclose (fp);

if (newFile == TRUE)                    /* file does not exist */
{
        fp = fopen (filename, "w");
        fprintf(fp, "  0 0.00e+00\n");
}
else
        fp = fopen (filename, "a");

for (i = 1; i <= 30; i++, bgy1 = 0.0, bgy2 = 0.0)
{
        yt = RG * i / 20.0;             /* y coordinate of the accelerated test point */

        /* integration in y direction */
        for (y = -RG; y < RG; y += DY)
        {
                /* cross section edge of galaxy with horizontal straight line */
                y_square = y * y;
                xs = sqrt(RG * RG - y_square);
                b = yt - y;
                b_square = b * b;

                /* integration in x direction */
                for (x = 0.0; x < xs; x += DX)
                {
                        a_square = x * x;
                        c_square = a_square + b_square;
                        c = sqrt(c_square);

                        r = sqrt(a_square + y_square);
                                        /* distance of differential area element DX, DY
```

from origin of coordinate system */

```
if (c > 0.0)        /* avoid division by zero */
{
        cosphi = b / c;
        /* decomposition gravitational force, part parallel to y axis */

        if (r < RB) /* actual differential area element is in the bulge */
        {
                dbgy1 = GDMB * cosphi / c_square;
                /* c_square: denominator from gravitational law */

                /* unknown seldom fault, can be neglected*/
                if ((dbgy1 > 1.0e-9) || (dbgy1 < -1.0e-9))
                        printf ("i: %3i dbgy1: %1.2e x: %1.2e y:
%1.2e\n", i, dbgy1, x, y);
                else
                        bgy1 += dbgy1;
        }
        else
        {
/*              localDensity = 1.0;     /* constant matter density in
                                           the galaxy without bulk */
                localDensity = (1.0 - (r - RB) / (RG – RB));
                                                /* linear decay */

                if (i == 1) /* calculate integrated matter (sumim) */
                        sumim += localDensity;
                        /* sum of matter densities of all differential
                           area elements depending on distance from
                                                galaxy centre */
                dbgy2 = GDM * localDensity * cosphi / c_square;
                                /* c_square: denominator from
                                                gravitational law */

                /* avoid unknown error at x = 0 */
                if ((dbgy2 > 1.0e-10) || (dbgy2 < -1.0e-10))
                        printf ("i: %3i dbgy2: %1.2e x: %1.2e y:
%1.2e\n", i, dbgy2, x, y);
```

```
                    else
                              bgy2 += dbgy2;
               }
          }
     }
}
if (i == 1)
     factor = REAL_MATTER / 2.0 / DM /sumim; /* REAL_MATTER is matter
                                                of complete galaxy without
                                                bulge, sumim only right
                                                half, thus "/ 2.0" */
bgy = bgy1 + bgy2 * factor;

/* the left half of the galaxy contributes the same value */
bgy *= 2.0;
orbitalVelocity = sqrt(bgy * yt) / 1000.0;
printf ("radius: %3i %%  acceleration: %1.2e m/s²  orbital velocity: %1.2e km/s\n",
               5 * i, bgy, orbitalVelocity);
if (newFile == TRUE)
     fprintf (fp, "%3i %1.2e\n", 5 * i, orbitalVelocity);
else
     fprintf (fp, " %1.2e\n", orbitalVelocity);
     }
     fclose (fp);

     return 0;

} /* main */
```

7 Bibliography

[1] Denys Mayshew: *Indirekte Suche nach Dunkler Materie, Bild „Beispiel für die beobachtete Umlaufgeschwindigkeit...“*. URL: https://uni-tuebingen.de/fakultaeten/mathematisch-naturwissenschaftliche-fakultaet/fachbereiche/physik/institute/astronomie-und-astrophysik/astronomie-hea/forschung/prof-santangelo-abteilung-hochenergieastrophysik/datenanalyse-und-modellierung/indirekte-suche-nach-dunkler-materie/ (Abruf 12.2.2026)

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[3] Dave Palmer: *Die Milchstraße, Kapitel „Die Spiralarme“, Abschnitt 3.* URL:https://abenteuer-universum.de/Galaxien/milch.html (Abruf 12.2.2026)