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Relativistic invariant Laplace wave equation used on galaxies

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Abstract: *In this paper an extended version of a new universal formula of the rotation velocity distribution of galaxies and a new formula of the energy density distribution of galaxies are presented.They are based on a relativistic invariant LaPlace wave equation where it has been possible to obtain expressions for the rotation velocity - and energy density distributions versus distance to the galactic centre. Several mathematical proofs of these new formulas are also given. These formulas are divided into a Keplerian (general relativity)-and a relativistic (special relativity) part.*

According to the rotation velocity distribution of the galaxies the rotation velocity increases very rapidly from the center and reach a plateau which is constant out to large distance from the centre. This is in accordance with observations and is also in accordance with the main structure of rotation velocity versus distance from different galaxy measurements. It is also possible to determine the mass, radius and maximum rotation velocity of the galaxy from these rotation velocity-and energy density calculations.

Computer simulations were also performed to establish and verify the rotation velocity and energy density distributions in the galaxy system, according to this paper. These computer simulations are in accordance with observations in two and three dimensions. It was also possible to study the matching percentage in these calculations showing a very high matching percentage between theoretical and observational values with this new formula. The energy density distributions were also shown of several galaxies together with comparing photos from the space of these galaxies. This comparison gave a very realistic appearance.

Keywords: *Astrophysics, Spiral galaxies, Theory of Relativity and Universal Formula*

I. Introduction

It is common in physics that electron circular movement around atoms and planetary circular movement around the sun follow the usual Keplerian relationship $V \alpha (1 / \sqrt{R})$, where V is the rotation velocity and R is the distance to the nucleus of the atom or the centre of the sun respectively.

The mass of a spiral galaxy can be determined from the dependence of its rotational velocity as a function of the distance from the center of the galaxy. Such a rotational curve has been determined from gas and stars in the distant parts of our galaxy, far beyond our distance to the center. Unexpectedly, it does not follow the Keplerian decrease in which the circular
rotation velocity V decreases $\alpha R^{-1/2}$ where R is the distance to the center. According to the
the 3:rd law of Kepler the mass of a galaxy can be expressed as :

$$\mathbf{M = V^2 R / G} \qquad \textbf{(1)}$$

and the rotation velocity as :

$$\mathbf{V = (G M / R)^{1/2}} \qquad \textbf{(2)}$$

where G is the gravitation constant.

By using these formulas it is possible to determine the mass and rotation speed at a certain distance of the galaxy. According to these equations both mass and rotation velocity will
decrease with increasing distance, which is established today.

In the 1970s and 1980s radio astronomers discovered that the spiral rotation velocity remains constant with increasing radius Freeman (1) ,Rubin and Ford (2). They studied neutral hydrogen clouds at 21-cm radio wavelength and in the optical wavelength in spiral galaxies and found non-Keplerian rotation curves. These facts were not in accordance to the established views and came as a shock to the establishment.

This is illustrated in Combes et al.(3) (Figs 3.1-3.3) , where the velocities of many spiral galaxies increase the velocity very rapidly at small distances up to a constant plateau at larger distances from the galaxy center. Astronomers discovered that many galaxies rotated at very high velocities.

To explain this most astronomers believe that this is caused by introducing dark matter in the Keplarian equations above and to keep the galaxies together. They believe that most matter in a galaxy consists of dark matter and only a minor part consists of ordinary matter which emits light.

In Barrera and Thelin (4) we have presented a new formula about the formation of galaxies. It is based on the relativistic Schwarzschild/ Minkowski metric, Schwarzschild (5),Einstein (6), where it has been possible to obtain a formula for the rotation velocity and also a density distribution versus distance to the galactic center. Similar rotation velocity profiles to our new formula have also been observed from data published in established books in this field. These profiles are in accordance to observations, as is seen in equations (1-10) in Barrera and Thelin (4). Computer simulations of equations 19 and 22 of Barrera and Thelin (4) were also performed to establish and verify the velocity and density distributions suggested in that paper.

According to this rotation velocity formula, the rotation velocity increases very rapidly from the center and reach a plateau which is constant out to big distance from the center. This has also been observed in many papers, Sofue and Rubin.(7) and Combes et al.(3).

In another paper by Barrera and Thelin (8) an improvement is made of the rotation velocity formula for galaxies compared to equation(19) of Barrera and Thelin (4) and is seen in equation (33) of Barrera and Thelin (8). The new improved rotation formula in equation 33 is divided into one Keplerian (general relativity) part and one relativistic (special relativity) part, which also makes it possible to use this formula for atoms, planets and galaxies. A mathematical proof of this new universal formula is also given. Computer simulations in 2 and 3 dimensions with this new formula were also achieved, giving it a strong support of the appearance of atoms, planets and galaxies. In Table 1 of Barrera and Thelin (8) galaxy parameters and matching between theoretical and observational data are also studied for a number of galaxies.

In this very paper an extended verification of the rotation velocity formula of galaxies from papers (4) and (8) together with a new energy density formula of galaxies are presented. A number of different mathematical methods using a relativistic invariant Laplacian formula used in spherical coordinates and also using quaternions are presented. All these methods show similar expressions of the rotation velocity formulas to the papers (4) and (8). With these methods the masses of a number of galaxies are also determined. Computer simulations in 2 and 3 dimensions of the new energy density formula are also achieved for a number of galaxies. These images are also compared to photographs from space and are very alike. A general complete galaxy equation in spherical coordinates is also presented together with a trial to express formulas of bandwidth and angular oscillations of galaxies.

II. The relativistic invariant Laplace wave equation

To obtain such a formula we start with studying such a formula for a lightwave :

$$\nabla^2 \psi - (1 / c^2) \psi_{tt} = 0 \qquad (3)$$

where a sinusiodal wave function is shown with c = speed of light and c = ω / k, where ω = angular frequency.

This formula (3) is an example of a relativistic invariant Laplacian wave equation Engström (9) p.129. It is invariant because it fulfills the Lorenz transformation Kay (10) p.172 and 167 and has proportionality in all coordinate systems. Then we transform this equation into spherical coordinates and use spherical harmonics in Råde and Westergren (11) p.264 with the "chain rule". After that we project the equation onto a plane in order to eliminate an unnecessary constant so it can represent a spiral galaxy.

This relativistic invariant Laplacian formula has the following appearance

$$(\partial^2\psi / \partial r^2) + (2/r) (\partial\psi / \partial r) + ((\partial^2\psi / \partial \theta^2) + (\cot \theta / r^2) (\partial\psi / \partial \theta)) + ((1 / (r^2 \sin^2 \theta)) (\partial^2\psi / \partial \varphi^2)) - (1/ C^2) (\partial^2\psi / \partial t^2) = 0 \qquad (4)$$

where r = distance to centre, C = wave phase constant , θ = spherical angle and will be a basis equation for galaxies. This formula is also invariant according to the Lorenz transformation according to Kay (10) p.167 and has proportionality in all coordinate systems.

This equation can be rewritten as:

$$\psi_{rr} + (2/r) \psi_r - (l (l+1) / r^2) Y_{nl} - (1 / C^2) \psi_{tt} = 0 \qquad (5)$$

In equation (5) Y_l is here a spherical harmonics function and ψ_{rr} and ψ_r are wave function deravities and **l** is the azimuthal quantum number. These spherical harmonics are compositions of orthogonal sines- and cosines functions and Legendre polynomials which are transformed into spherical coordinates according to Kay (10) p.167.

Now we assume an inward (spiral) wave propagation solution of the following appearance including a time term :

$$\psi(r, \theta, t) = (f (r + \theta) / r) = (\sin (r + \theta) / r)(\exp (-i C t) \qquad (6)$$

with the derivaties

$$\psi_r(r, \theta, t) = (\cos (r + \theta) / r - \sin (r + \theta) / r^2) (\exp (-i C t) \qquad (7)$$

$$\psi_{rr}(r, \theta, t) = (2 \sin (r + \theta) / r^3 -2 \cos (r + \theta) / r^2 - \sin (r + \theta) / r) (\exp (-i C t) \qquad (8)$$

These functions inserted in equation 5 will give the following equation

$$\psi_{rr} + (2/r) \psi_r - (l (l+1) / r^2) Y_n - (1 / C^2) \psi_{tt} = 0 \qquad (9)$$

The radial distribution will be :

$$f'' - ((l (l+1) f / r^2) + C^2 f = 0 \qquad (10)$$

$$\mathbf{r^2 f'' + (r^2 C^2 - l (l + 1) f = 0} \qquad \mathbf{(11)}$$

We now want to choose the easiest solution by setting **l** = 0, which leads to the sinc (Spherical Bessel functions) function solution :

$$\mathbf{f (r , \theta) = (\sin (r + \theta) / r)} \qquad \mathbf{(12)}$$

The general solution together with the time term will be :

$$\mathbf{\psi(r, \theta, t) = (\sin (r + \theta) / r) (\exp (-i C t)} \qquad \mathbf{(13)}$$

Similar equations for the cosine part will be :

$$\mathbf{f (r , \theta) = (\cos (r + \theta) / r)} \qquad \mathbf{(14)}$$

The general solution including the time term equals :

$$\mathbf{\psi(r, \theta, t) = (\cos (r + \theta) / r) (\exp (-i C t)} \qquad \mathbf{(15)}$$

The spiral galaxy model described is an energy density wave theory model and the resulting solution shall be powered by 2, i.e

$$\mathbf{\Psi (r, \theta, t) = | \psi (r, \theta, t) |^2 \approx (1 / r)} \qquad \mathbf{(16)}$$

Equation (16) shows a normal procedure in quantum mechanics used for atoms. Now we are using the same procedure for galaxies.

The energy density fall-off rate is therefore proportional to the inverted distance to the centre of the galaxy. The equation is invariant in coordinate system transformations, and invariant under a Lorenz transformation since the solution is produced by the relativistic invariant Laplace equation. It has the general and special relativity characteristics, such as rotation velocity where $\mathbf{\psi = v_{rot}{}^2}$ which gives :

$$\mathbf{v_{rot} = (M / r)^{1/2} (1\text{-}w^2)^{1/2} + (v^2_{max} - (M / r) w^2)^{1/2}} \qquad \mathbf{(17)}$$

where w is a weighing term used for balancing the equation , M is the mass of the galaxy and v_{max} is the maximum rotation velocity of the galaxy. Gravity units are applied in this equation. Equation (17) is similar to the rotation velocity formulas in papers 4 and 8.

III. General solution of relativistic invariant Laplace equation in spherical coordinates using Quaternions

The general equation to the galaxy relativistic Laplace equation in spherical coordinates from equation 24 in gravitational units projected onto the polar plane is using quaternions

$$\mathbf{i^2 = j^2 = k^2 = -1 \quad (18) \quad ij = k = -ji \ (19) \quad jk = i = -kj} \qquad \mathbf{(20)}$$

$$\mathbf{ki = j = -ik} \qquad \mathbf{(21)}$$

where i , j and k are bases for quaternions.

Trigonometric one in pairs gives as an example :

$$\mathbf{| \ (ix + jy) \ | = | \ (jx +yk) \ | = | \ (ix + yk) \ | = (x^2 + y^2)^{1/2}}$$

$$\mathbf{\text{if } (x^2 + y^2)^{1/2} = 1} \qquad \mathbf{(22)}$$

$$\mathbf{| \ (j \sin\alpha + k \cos \alpha) \ \sin \beta + i \cos \beta \ | = | \ (j \sin\alpha \ \sin\beta + k \cos \alpha \sin\beta) + i \cos\beta \ | = | \ \sin\beta + i \cos\beta \ | = (\sin^2\beta + \cos^2\beta)^{1/2} = 1} \qquad \mathbf{(23)}$$

with quaternions i,j,k we have :

$$\mathbf{\psi = - B^2 ((jM \sin (r + n \varphi +\text{-} C t) / r + kM \cos (r + n \varphi +\text{-} C t) /r) + A^2v^2_{max} + A^2 (M/r)} \qquad \mathbf{(24)}$$

A = constant for the galaxy body (Keplerpart), **B =** constant for the spiral arms (relativistic part), **C** = wave phase constant , n = number of arms, φ = spherical angle, r = distance

$$\mathbf{| \ v_{rot} \ |^2 = - B^2 \ | \ ((jM \sin (r + n \varphi +\text{-} C t) / r + kM \cos (r + n \varphi +\text{-} C t) /r) \ | + A^2v^2_{max} + A^2 (M/r)} \qquad \mathbf{(25)}$$

$$\mathbf{| \ v_{rot} \ |^2 = B^2 \ v^2_{max} - B^2 (M/r) \ (\sin^2 (r + n \varphi +\text{-} Ct) + \cos^2 (r + n \varphi +\text{-} C t))^{1/2} + A^2 (M/r)} \qquad \mathbf{(26)}$$

Trigonometry gives :

$$\mathbf{| \ v_{rot} \ |^2 = A^2 (M/r) + B^2 (v^2_{max} - (M/r))} \qquad \mathbf{(27)}$$

Using a complex coefficient on B we obtain in gravitation units :

$$\mathbf{v_{rot} = A (M/r)^{1/2} + i B (v^2_{max} - (M/r))^{1/2}} \qquad \mathbf{(28)}$$

This is our general rotation velocity formula for galaxies similar to papers (4)and (8).

IV. Projection of spherical solution into flat polar spiral galaxy

To get the energy density distribution structure of a spiral galaxy **ψ** we simply project the solution into the polar plane, hence we could set $\mathbf{B^2 \ v^2_{max} = 0}$ also the sine- and cosine terms in equation (24) form a phase shifted wave which we represent by a sine function, and they come from the already projected sinc functions.

$$\mathbf{v_{proj}{}^2 = \psi = - B^2_{pi} \ (M \sin (r + n \varphi +\text{-} C t)) / r + B^2_{qj} (M \cos (r + n \varphi +\text{-} C t)) / r + A^2 (M / r)} \qquad \mathbf{(29)}$$

then we have the energy density function.

$$\mathbf{\psi = | v_{proj} |^2 = | \ B^2_p (M \sin (r + n \varphi +\text{-} C t)) / r \ | + | \ B^2_q (M \cos (r + n \varphi +\text{-} C t))/r \ | +}$$

| A^2 (M / r) | which gives **(30)**

$\boldsymbol{\psi = v_{proj}{}^2 = |\ A^2\,(M/r)\ |\ +\ |\ -B^2\,(p^2 + q^2)^{1/2} \sin(\alpha + \beta)\,(M/r)\ |}$ **(31)**

where α = (r + n φ +- ct) and β = arctan (q / p) is the phase angle and p = switching coefficients for the sine part and q = switching coefficient for the cosine part.

In this way we can control the shape of the galaxy by the constants A and B, a large value of B gives an octopus/ spider like galaxy with long arms/ legs, while a large value of A gives a galaxy with thick body and short arms. Observe that since the galaxy equation has two variable solutions A^2 (M/r) and B^2 ($p^2 + q^2$)$^{1/2}$ (M sin(α + β) / r we must separate the solutions with imaginary bases since an ordinary modulus would mix the solutions and go out of phase making discontinuous jumps in the energy density functions. The p and q values fine-tune the shape of the arms.

V. Bandwidth for galaxy equation

Using the relativistic invariant Laplace equation (4) we can rewrite this equation like equation (5) with a spherical harmonics function. Next we assume a spiral inward wave propagation :

$\boldsymbol{\psi(r, \theta) = (f(r/\lambda + \theta/\lambda)/r) = (\sin(r/\lambda + \theta/\lambda)/r)(\exp(-i\,C\,t)}$ **(32)**

with λ = bandwidth and **θ** = spherical angle with the radial distribution like equations 10 and 11 with the general solution :

$\boldsymbol{\psi(r, \theta, t) = (\sin(r/\lambda + \theta/\lambda)/r)(\exp(-i\,C\,t)}$ **(33)**

VI. Angular oscillations for galaxy equation

Using the relativistic invariant Laplacian form as in equation (4) we can rewrite this equation as equation (5). Y_l is here a spherical harmonics function. We then assume an inward spiral wave propagation solution multiplied with a sinusoidal function depending only on θ. The general solution equals :

$\boldsymbol{\psi(r, \theta, t) = (\sin(r/\lambda + \theta/\lambda)/r)(\exp(-i\,C\,t)\sin(m\,\theta)}$ **(34)**

The derivation of the cosine part is completely analog. This oscillation can be seen on the arms of galaxies and have a much higher frequency than the other angular parts.

VII. The complete galaxy equation in spherical coordinates

$$\boldsymbol{(\partial^2\psi/\partial r^2) + (2/r)(\partial\psi/\partial r) + ((\partial^2\psi/\partial\theta^2) + (\cot\theta/r^2)(\partial\psi/\partial\theta)) + ((1/(r^2\sin^2\theta))(\partial^2\psi/\partial\varphi^2)) - (1/c^2)(\partial^2\psi/\partial t^2) = 0} \qquad \textbf{(35)}$$

which can be rewritten in a shorter version under certain restrictions as :

$$\boldsymbol{\nabla^2\psi - (1/c^2)(\partial^2\psi/\partial t^2) = 0} \qquad \textbf{(36)}$$

which is similar to the light wave equation (3).

The difference between the Laplace equation and the relativistic galaxy equation determines the amount of uniform rotation in its own coordinate system.

$\boldsymbol{v_{rtot} = A\,(M/r)^{1/2} + i\,B\,(v^2_{max} - (M/r))^{1/2}}$ **(37)**

Equation (37) is also similar to the rotation velocity formulas in papers (4) and (8) and equations (17) and (28) in this paper. The first term of equation (37) concerns the galaxy body (Keplerpart) and the second part concerns the spiral arms(relativistic part) in gravitation units.

VIII. Results and figures with the new rotation velocity formula and the new energy density formula

In this section "experimental" results are presented from computer simulations made.

All the computer simulation graphs are obtained by using the new rotation velocity formula in equation (28) and the new energy density distribution formula in equation (31).

In Table 1 Radius , V_{max} , Estimated and approximated Mass are presented for the galaxies studied.

By using equation (28) very good match percent is achieved. The approximated mass values are following the corresponding equation from Combes (3) p.83 which have higher values.

The results from the galactic computer simulations are presented in Figs (1 - 5) in 2 and 3 dimensions respectively together with photograph from the space (Wikipedia pictures from the Hubble spacecraft) for comparison. The simulation program used was a Pascal program.

IX. Discussion

We can se from section 2 and 3 from Barrera and Thelin (4) that the velocity formula between velocity and distance to the center of the galaxy has a $\sqrt{x}$- structure. These facts are based on results presented in Combes (3) and Lang (12) and are not based on Kepler`s 3:rd law directly. These relationships are observed by the astronomers where the velocity reach a constant speed between 5 and 10 kpc from the center of the galaxy. A similar structure is also obtained by using the theory of relativity and the Schwarzschild metric in equation 19 of Barrera and Thelin (4) and from the new expanded formula (33) of the Barrera and Thelin (8) paper and is seen in Figs (5-7) in that paper. In these papers a steep rising of the velocity (angular and circular in km/s) at low distances is observed. After that rising, a plateau is reached, which will be dominating up to large distances.

In this very paper an extended verification of the rotation velocity formula of galaxies from papers (4) and (8) together with a new energy density formula of galaxies are presented. These formulas have been derived with different mathematical methods together with a relativistic invariant Laplacian formula used in spherical coordinates and also using quaternions. This is also shown in this very paper where such graphs are shown for the galaxies NGC7606, 3200, 801, 1417 and IC724 . All the observational graphs of the rotation velocity- distance curves are showing very good correlation between theoretical and observational values Figs (1b – 5b).

Our model is also in accordance to the energy density distribution in the galaxy where computer simulations were performed on these galaxies, where the energy density versus distance was studied giving a realistic structure (Figs 1a -5a), where also photographic pictures from space of these galaxies are shown. The similarity between experimental graphs and pictures is outstanding and gives a strong support of the results of this paper.

It was also possible to calculate the Radius , V_{max} , Estimated Mass of the galaxies studied, which are shown in Table 1. By using equation (28) very good match percents are achieved. The approximated mass values follow a corresponding equation from Combes (3) p.83, which gives higher values.

The observations from Freeman (1) and Rubin (2) are also observed by many astronomers and have been a controversial discovery, because it contradict Kepler`3:rd law, which will follow a $(1/\sqrt{r})$ - dependence according to equation (2) and is not observed in any galaxies. Therefore many astronomers claim that there must be a large amount of dark matter in the galaxy, which is the cause of this discrepancy and also hold the galaxies together at those high rotation speeds.

Similar $\sqrt{x}$- structures of the velocity curves as our curves have also been obtained in the so called Mond- project, where a modification of the Newton`s law is applied Sanders (13).

This very paper and our earlier papers in (4) and (8) and also the paper by Sanders (13) raise the question if there is so much dark matter in the universe ? Our rotation curves fit very well with observations anyhow.

An astonishing fact from this paper is the use of quantum mechanical (slightly corrected) calculations for galaxies which seem to be valid here. Such calculations are otherwise normally used for atoms. It is also interesting to note the similarity between the LaPlace equations (3) for a light wave and equation (36) for a galaxy. It is fascinating how quantum mechanics and relativity theory can be unified here from the results of this paper. From all the results here it is also possible to claim that a galaxy seems to contain a big system of gravity waves. This wave structure is also obvious when looking on all the figures (calculated and photos).

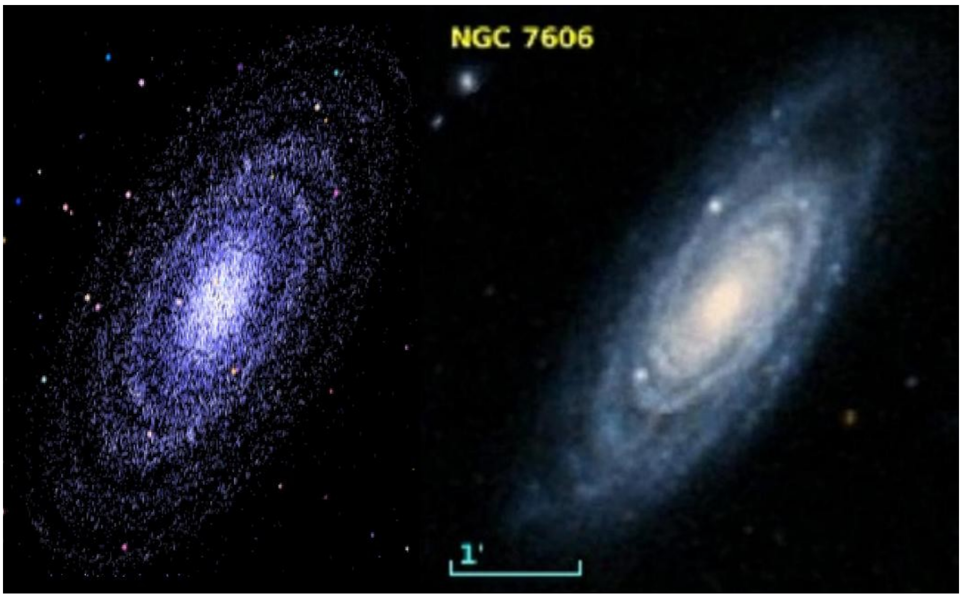

Fig 1a NGC7606 Computer simulations of randomly distributed 25000 “stars” distributed like an ellipsoid in a galaxy (left). Equation 31 about the energy density distribution versus distance to the centre has been used. The right figure is a photograph from space.

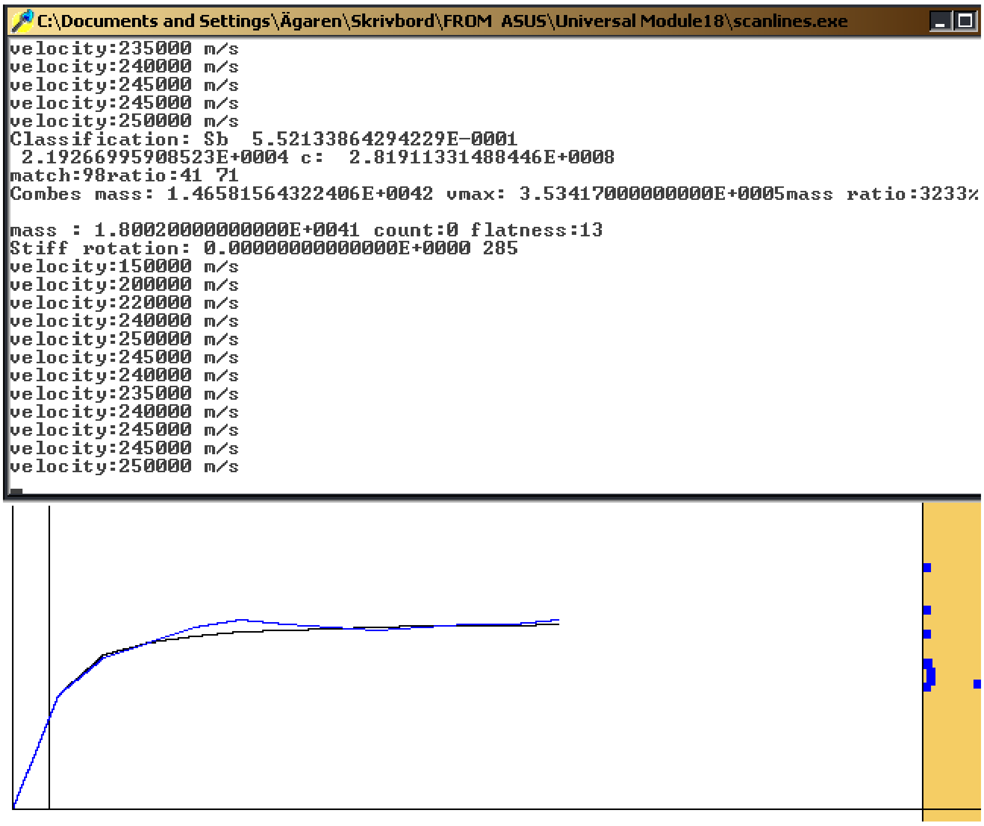

Fig 1b Velocity distributions versus distance of the galaxy **NGC 7606** These graphs do follow the observational velocity distributions. (Computer simulations) Match 98 % Equation 28 has been followed

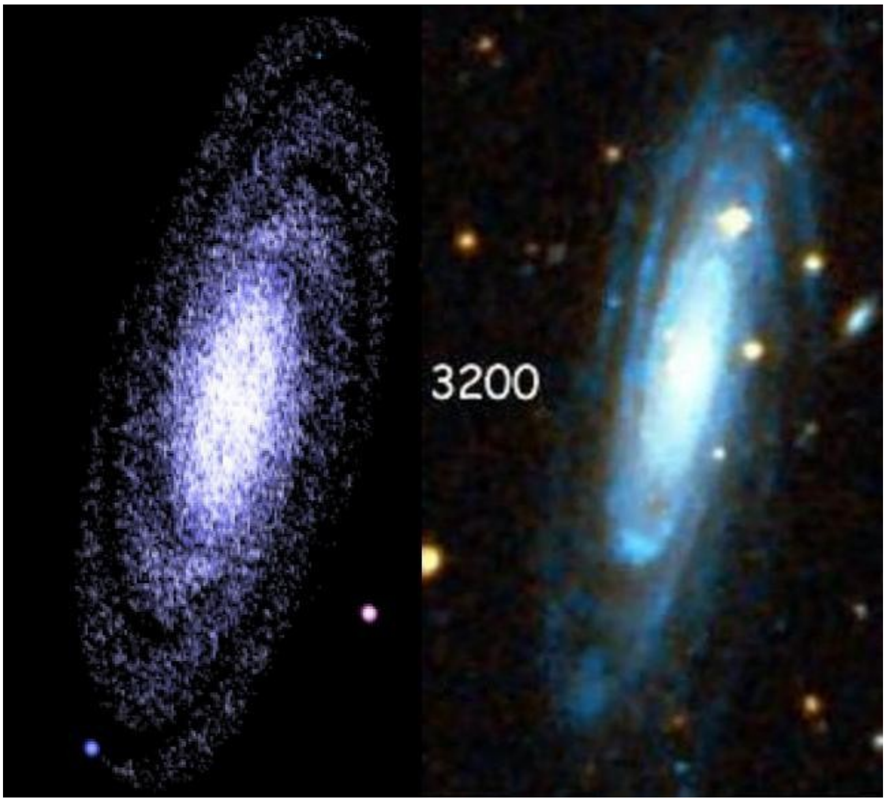

Fig 2a NGC3200 Computer simulations of randomly distributed 25000 "stars" distributed like an ellipsoid in a galaxy (left). Equation 31 about the energy density distribution versus distance to the centre has been used. The right figure is a photograph from space.

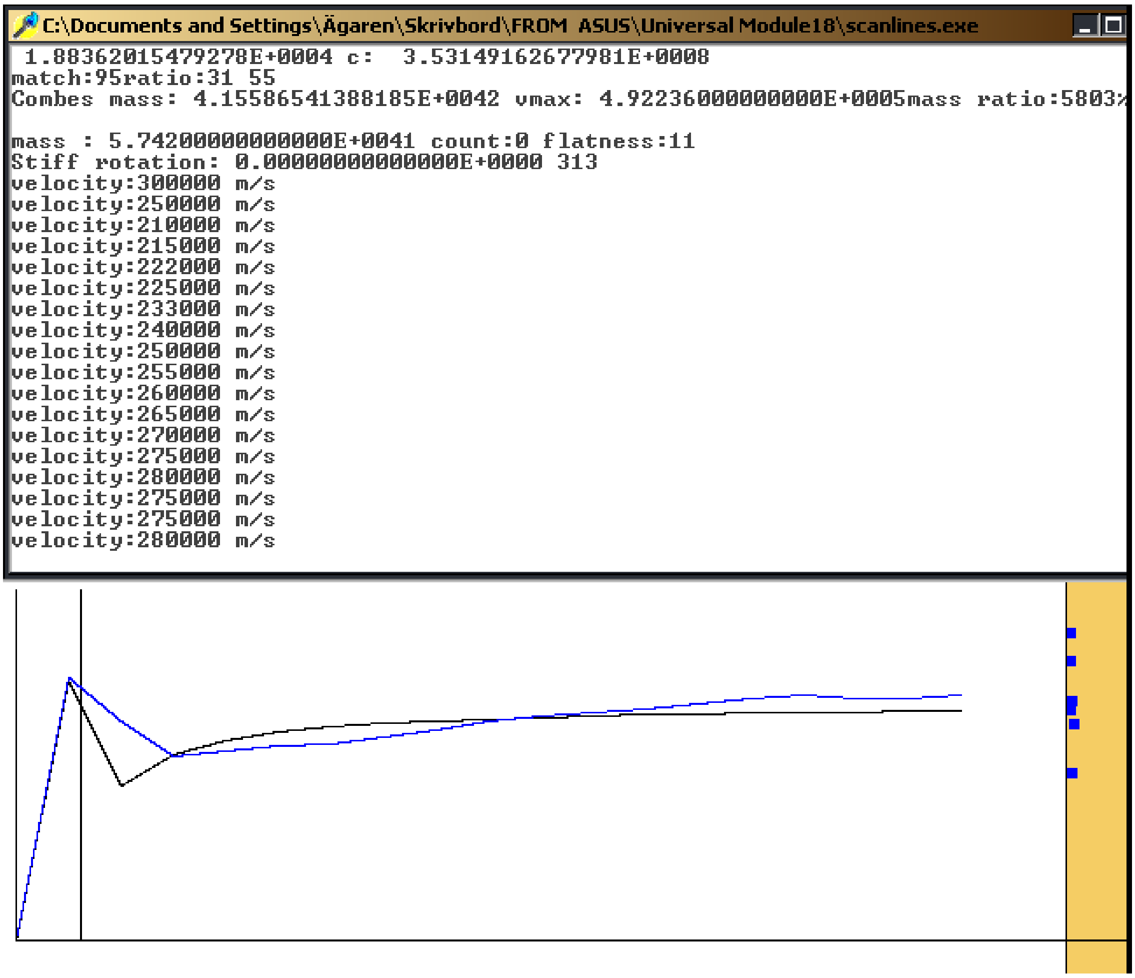

Fig 2b Rotation velocity distributions versus distance of the galaxy **NGC 3200** These graphs do follow the observational velocity distributions. (Computer simulations) Match 95 % Equation 28 has been followed

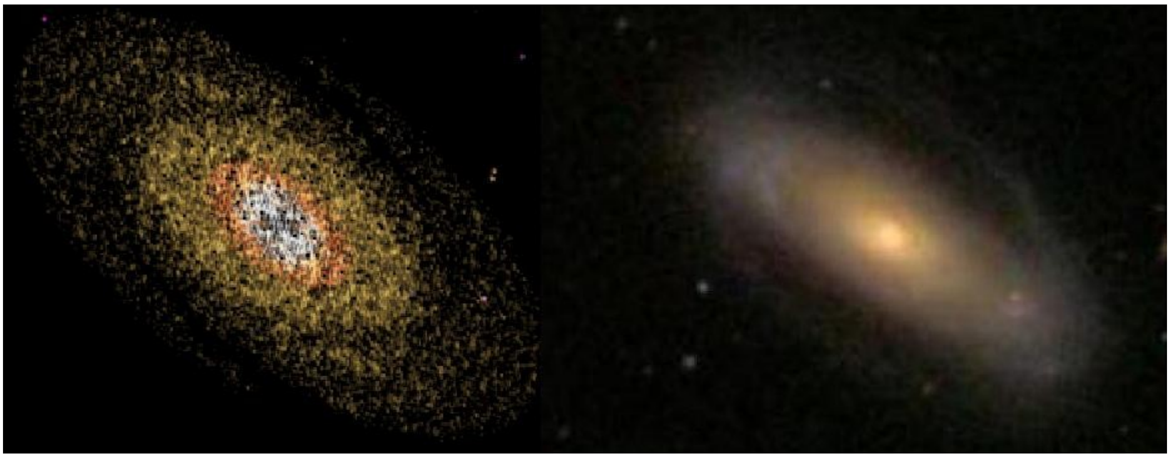

Fig 3a IC724 Computer simulations of randomly distributed 25000 “stars” distributed like an ellipsoid in a galaxy (left). Equation 31 about the energy density distribution versus distance to the centre has been used. The right figure is a photograph from space.

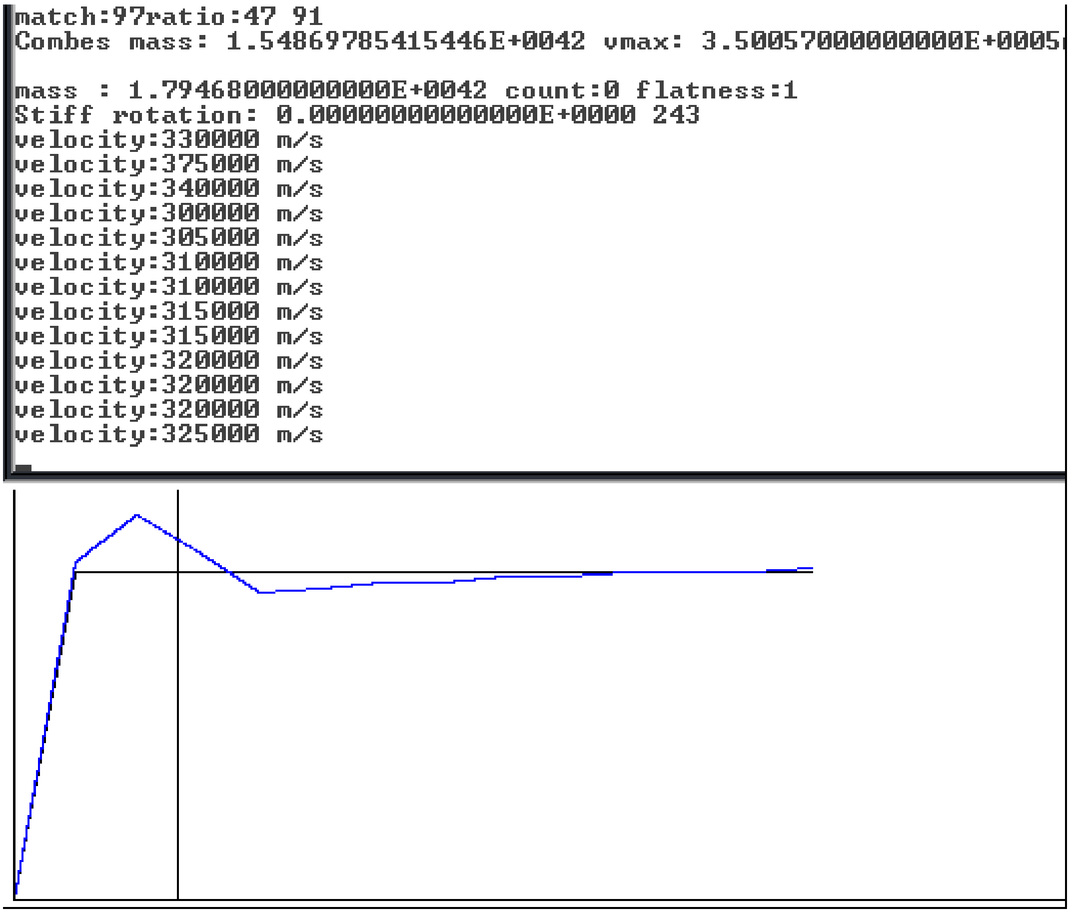

Fig 3b Velocity distributions versus distance of the galaxy **IC724**These graphs do follow the observational velocity distributions.(Computer simulations) Match 97 % Equation 28 has been followed.

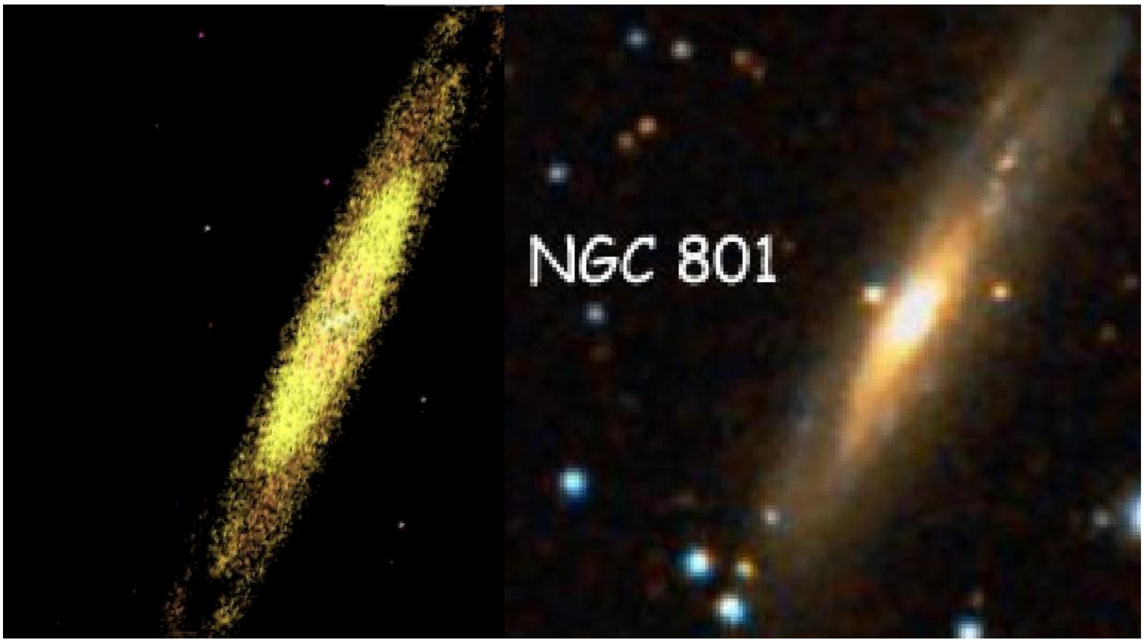

Fig 4a NGC801 Computer simulations of randomly distributed 25000 "stars" distributed like an ellipsoid in a galaxy (left). Equation 31 about the energy density distribution versus distance to the centre has been used. The right figure is a photograph from space.

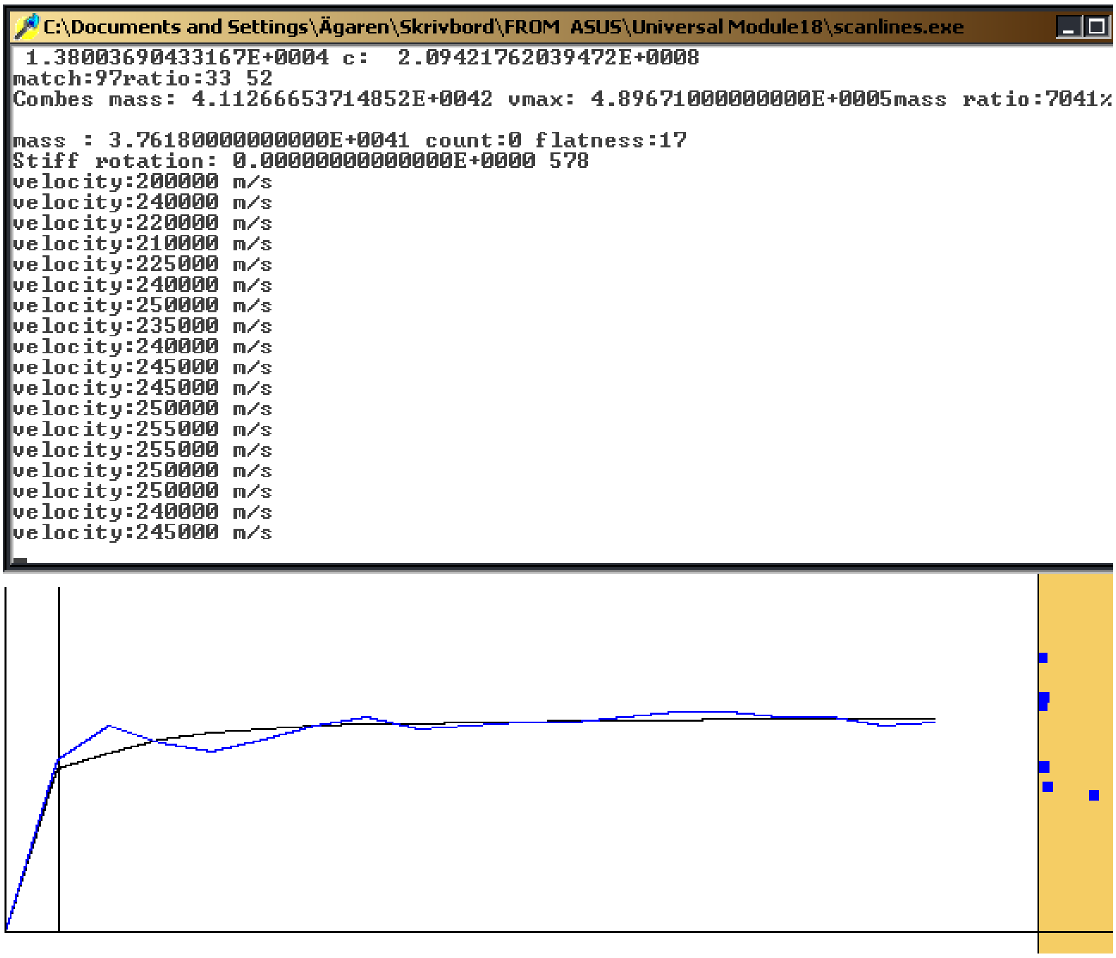

Fig 4b These graphs do follow the observational rotation velocity distributions. Velocity distributions versus distance of the galaxy **NGC 801** These graphs do follow the observational velocity distributions. (Computer simulations) Match 97 % Equation 28 has been followed

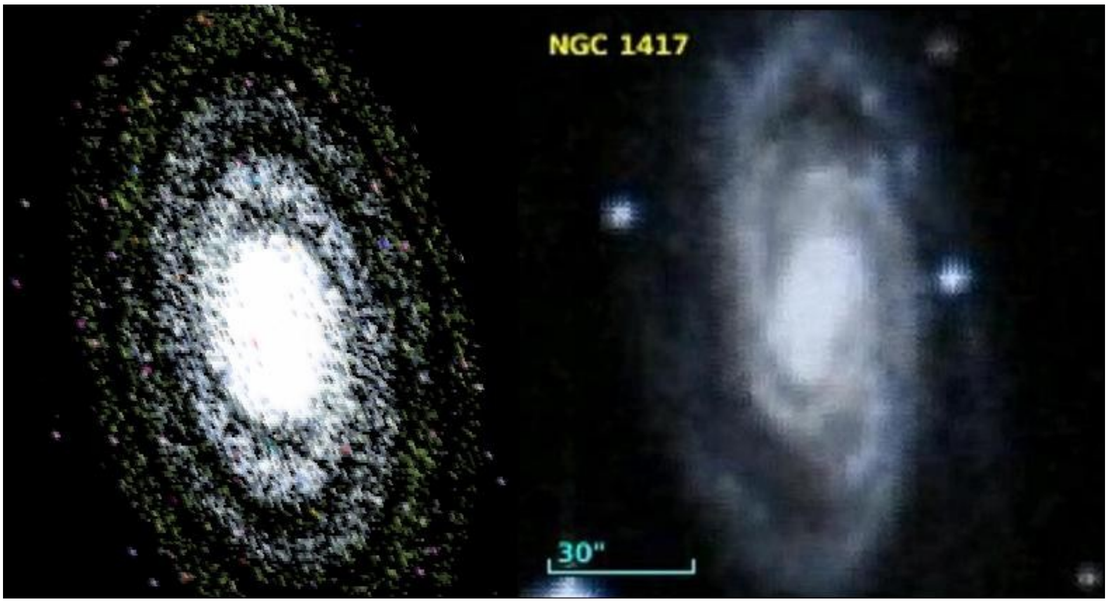

Fig 5a NGC 1417 Computer simulations of randomly distributed 25000 "stars" distributed like an ellipsoid in a galaxy (left). Equation 31 about the energy density distribution versus distance to the centre has been used. The right figure is a photograph from space.

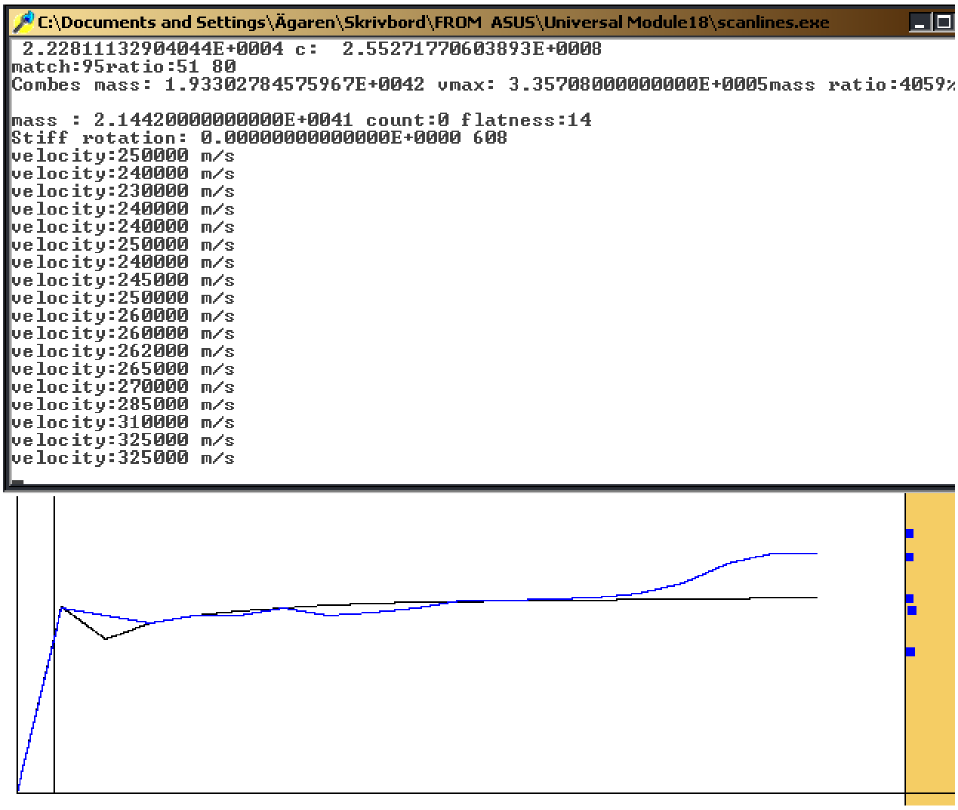

Fig 5b Rotation velocity distributions versus distance of the galaxy **NGC 1417** These graphs do follow the observational velocity distributions. (Computer simulations) Match 94% Equation 28 has been followed

Table 1

- **Galaxy , match %, radius , v_{max} , mass kilogramme new/combes.**

- NGC3200 , 95 % 180000 ly,304000 m/s, $8.8 \cdot 10^{41}$kg, ($1.9 \cdot 10^{42}$kg)
- NGC801 , 97 % 180000ly, 316000 m/s, $1.3 \cdot 10^{42}$kg, ($2.3 \cdot 10^{42}$kg)
- UGC2885 , 91 % 216000ly, 320000 m/s , $2.2 \cdot 10^{42}$kg, ($4 \cdot 10^{42}$kg)
- Milky-Way 95 % 80000ly , 359000 m/s, $7.2 \cdot 10^{41}$kg, ($3 \cdot 10^{42}$kg)
- NGC7606 , 98 % 110000ly, 330000 m/s , $6.5 \cdot 10^{41}$kg, ($1.4 \cdot 10^{42}$kg)
- UGC12810 94 % 180000ly, 297000 m/s, $1.6 \cdot 10^{42}$kg, ($3.8 \cdot 10^{42}$kg)
- NGC1417 , 94 % 180000ly, 310000 m/s, $8.9 \cdot 10^{41}$kg, ($1.8 \cdot 10^{42}$kg)
- UGC10205 96 % 95000ly, 372000 m/s, $6.6 \cdot 10^{41}$kg, ($8.6 \cdot 10^{41}$kg)
- IC724 , 97 % 130000ly, 382000 m/s , $1.2 \cdot 10^{42}$kg, ($2.4 \cdot 10^{42}$kg)
- NGC1024 , 93 % 180000ly, 395000 m/s, $1.6 \cdot 10^{42}$kg, ($3.9 \cdot 10^{42}$kg)
- NGC4378 , 98 % 100000ly, 367000 m/s, $7.3 \cdot 10^{41}$kg, ($1.6 \cdot 10^{42}$kg)
- NGC7083 , 98 % 100000ly, 319000 m/s, $6.2 \cdot 10^{40}$kg, ($1.0 \cdot 10^{41}$kg)

The mean matching equals 96%. The mass numbers in parentheses is the old mean mass values are $2.3 \cdot 10^{42}$ kg measured with $M_{tot} = (2/\pi)\, v_{rot}^2\, R/G$ (Combes (3) p. 83 and is about a factor 2.1 larger than the new ones with a mean of $1.1 \cdot 10^{42}$kg.

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