

Determination of spiral orbits with constant tangential velocity

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Abstract

Starting from the premise that the internal dynamics of galaxies can be described by a movement of stars on spiral paths, in this paper the spiral paths are determined, matching the observed constancy of the orbital velocity.

1 Introduction

Comparing the observed orbital velocities of stars in galaxies with the calculations using Newton's laws of gravity, one comes across a surprising contradiction. The Newtonian equations of motion show that the stars that are located far away from the center have to move more slowly than those located closer to the center. Lower speeds are expected again only very close to the center, because the center is composed of a very dense collection of many stars that has to be treated mathematically rather as a compact body than a point shaped central mass. For illustration here the image (Fig. 2) shows the most magnificent 'Whirlpool galaxy', which was taken by the Hubble Space Telescope.



Fig. 1:
Spiral galaxy M51
'Whirlpool galaxy',
image taken by the
Hubble Space
Telescope

(List of image
sources, see
below)

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The computed velocity distribution using Newton's gravitational equations is shown in the following diagram as compared with the measured velocities of the stars.

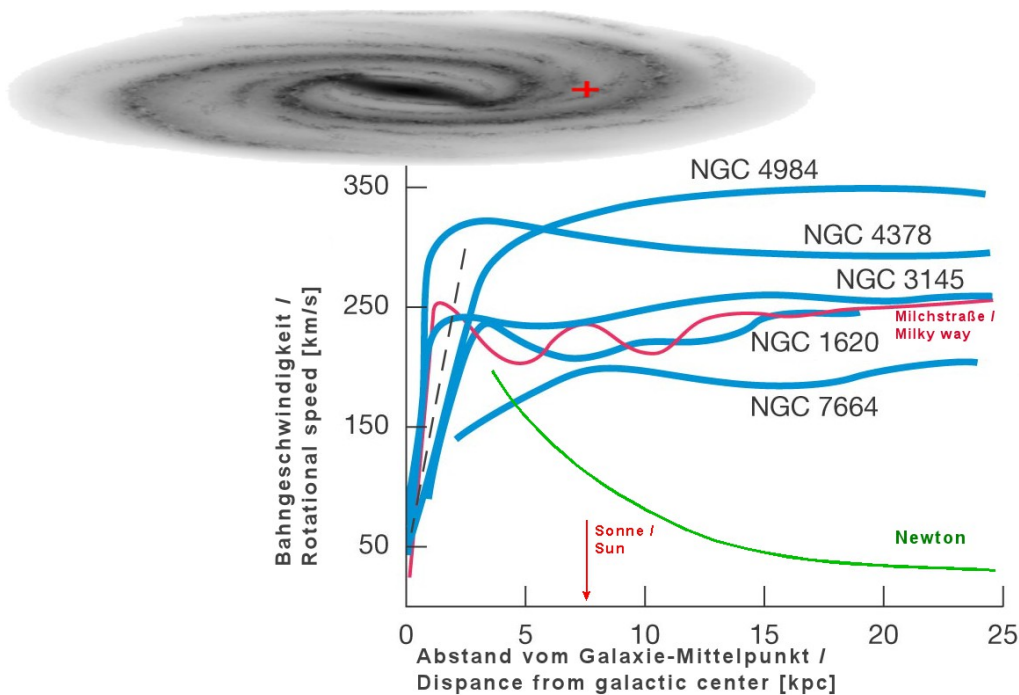


Fig 2: Rotational speed V in dependence of the distance R to the center.

The green line shows the expected speed according to Newton, which decreases towards the outside, and the gray-dashed line the decrease very close to the center.

Near to the center, the measured velocity agrees really well with the calculation. However, for greater distances from the center a surprising discrepancy appears. The measured velocities are nearly independent from the distance to the center. The red curve shows the measurement for our own Milky Way, but is also true for other spiral galaxies.

To bridge this gap between the calculation according to Newton and the observation, in the established physics additional Dark Matter is postulated, whose nature is still unknown.

The ECE theory is treading a different path instead. It is assumed that the stars do not circulate in nearly circular orbits around the center but move in a spiral path from their origin at the center to the outside. Thereby a gravitational torsion field is assumed, that has to be described in other ways than according to Newton.

One class of such spiral orbits, the Hyperbolic Spiral, was described in a previous paper [1] and made visible by an animation program [2], see Fig. 3.

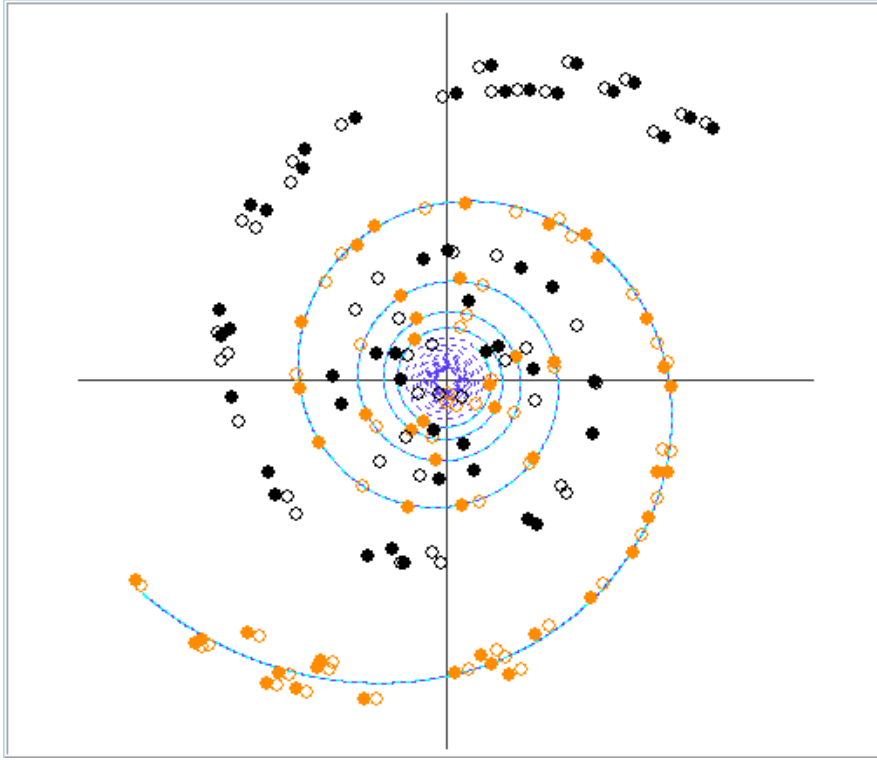


Fig. 3:
Animation of the
star movement
following a
Hyperbolic Spiral.

2 Calculation

In the present work now spiral paths will be determined that match the constant velocity of the star in the exterior of the galaxy as accurately as possible.

As an approach a spiral path is selected in which both the angle and the radius are exponential functions of time.

$$\theta = \theta_0 \left(\frac{t}{t_0} \right)^A \quad (1)$$

$$r = r_0 \left(\frac{t}{t_0} \right)^B \quad (2)$$

The special case $A = -1$ and $B = 1$ results in the above mentioned hyperbolic spiral.

It is now requested that the velocity of the star is a constant, in particular, regardless of their distance r to the center.

$$v_T(t, \theta(t), r(t)) = \text{const.} \quad (3)$$

In the present consideration, only the tangential component of the velocity is taken into account, which is the perpendicular to the radius extending component of the velocity – also named as angular or azimuthal component. It is the product of the temporal change of the angle θ and the distance r from the center.

$$v_T = r \frac{d}{dt}(\theta) \quad (4)$$

Inserting the above equations (1) and (2) yields

$$v_T = r_0 \left(\frac{t}{t_0}\right)^B \frac{d}{dt} \left(\theta_0 \left(\frac{t}{t_0}\right)^A\right) \quad (5)$$

$$v_T = r_0 \frac{t^B}{t_0^B} A \theta_0 \frac{t^{A-1}}{t_0^A} \quad (6)$$

$$v_T = A r_0 \theta_0 \frac{t^{A+B-1}}{t_0^{A+B}} \quad (7)$$

In order to satisfy the required condition, namely the constancy of v_T , the exponent of t must be zero.

$$A + B - 1 = 0 \quad (8)$$

Using this result, for a given exponent A , the exponent B can now be determined.

$$B = 1 - A \quad (9)$$

In the above equations (1) and (2)

$$\theta = \theta_0 \left(\frac{t}{t_0}\right)^A \quad (10)$$

$$r = r_0 \left(\frac{t}{t_0}\right)^B \quad (11)$$

B can now be inserted

$$r = r_0 \left(\frac{t}{t_0}\right)^{1-A} \quad (12)$$

whereby the constraint ensures that r is not constant as well. Dissolved after time t this equation gives

$$t = t_0 \left(\frac{r}{r_0}\right)^{\frac{1}{1-A}} \quad (13)$$

and inserted into (1 / 10), finally yields the desired spiral

$$\theta = \theta_0 \left(\frac{r}{r_0}\right)^{\frac{A}{1-A}} ; \quad A \neq 1 \quad (14)$$

The resulting functions $r(t)$ and $\theta(t)$ show for the following ranges different behaviors with increasing t :

$$\begin{aligned}
A < 0 & : \theta \text{ decreases, } r \text{ increases} \\
A = 0 & : \theta \text{ constant, } r \text{ increases} \\
A = 1 & : \theta \text{ increases, } r \text{ constant} \\
A > 1 & : \theta \text{ increases, } r \text{ decreases}
\end{aligned}
\tag{15}$$

For $A > 1$, the stars are moving from the outside inwards, not fulfilling the premise. Also the special cases $A = 0$ and $A = 1$ should be excluded from the animation.

3 Animation

Based on the determined formulas, an animation program was written. The used programming language is Delphi 2007.

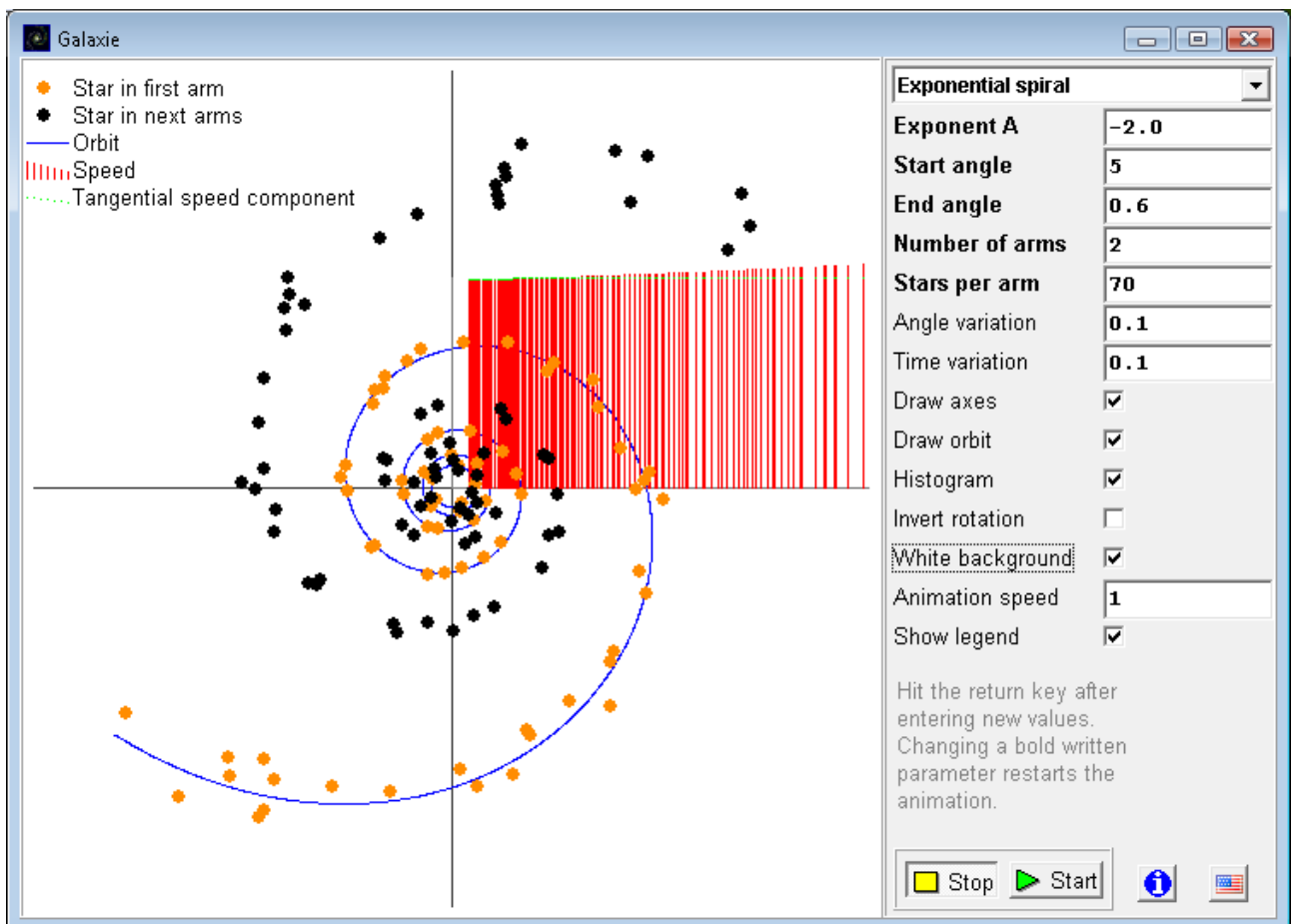


Fig. 4: Animation of a spiral form similar to the Whirlpool galaxy

In the animation, the velocity distribution is shown with red lines as a function of the radius. The lines are interrupted by green pixels. The lower part of the lines corresponds to the tangential component of the velocity, and the entire line equals the total rate which is composed of tangential and radial component. It is clearly apparent that in this example the overall rate is only slightly above the tangential speed. For not too short distances from the center, the results from the animation are quite well in line with the measured values of Fig. 2.

References:

- [1] M. W. Evans, H. Eckardt, B. Foltz, R. Chechire *Applications of ECE theory: the relativistic kinematics of orbits* AIAS website, 2013, <http://www.aias.us/documents/uft/a238thpaper.pdf>
- [2] B. Foltz *Animation program* AIAS website, 2013, <http://www.aias.us/documents/LectureMaterials/Galaxy.zip>

Image sources:

1 Image is part of:

NASA, ESA, M. Reagan and B. Whitmore, R. Chandar, S. Beckwith, Hubble Heritage Team
Spiral Galaxy M51, Hubble Space Telescope, NASA website, 2013,
http://www.nasa.gov/images/content/509938main_whirlpool_lg.jpg

2 Image created with use of:

http://physics.uoregon.edu/~jimbrau/BrauImNew/Chap25/6th/25_01Figureb-F.jpg (21.3.2013),
http://abyss.uoregon.edu/~js/images/gal_rotation.gif (21.3.2013),
http://www.spitzer.caltech.edu/uploaded_files/images/0008/1661/ssc2008-10a_Ti.jpg (21.3.2013),
http://www.spitzer.caltech.edu/uploaded_files/images/0003/1669/ssc2008-10b_Ti.jpg (21.3.2013)

3 M. W. Evans, H. Eckardt, B. Foltz, R. Chechire *Applications of ECE theory: the relativistic kinematics of orbits* AIAS website, 2013, <http://www.aias.us/documents/uft/a238thpaper.pdf>