Mass Distributions of 5 Hypothetical Disk Galaxies

Edgeworth S,
24 December 2016

From only the shapes of these 5 idealised disk galaxy rotation curves, this project calculates the mass distributions in normalised units.

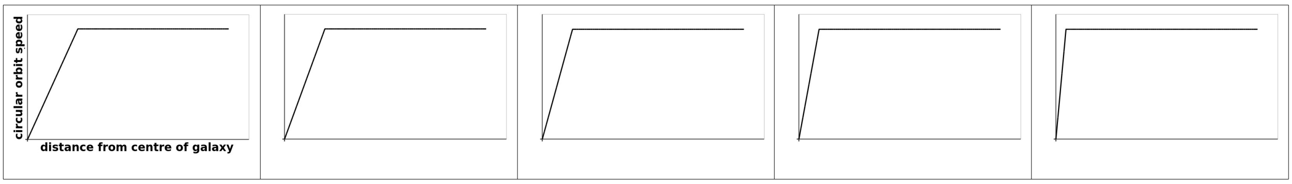

Figure 1: Five idealised disk galaxy rotation curves

The 5 rotation curves differ in having the transition, from linearly rising to flat, at 25%, 20%, 15%, 10%, and 5% of the disk radius, respectively.

The software used for this project is based on the method described by K F Nicholson [1-5]. For each of the 5 hypothetical galaxies, it solves the mass distribution, and quantifies the rotation curve, in normalised units.

A disk galaxy is treated as an axisymmetric circular disk, with a finite radius, and a finite thickness, with all the mass contained within the disk. The rotation curve is assumed to be complete, and assumed to be the speeds of circular orbits in the mid-plane of the disk. For this project, the disk is assumed to have a constant thickness equal to 0.05 times the disk radius, and a flat vertical density distribution.

A standard scale-free system of units is used, in which:
The radius of the disk galaxy = 1,
the total mass of the disk galaxy = 1,
and, at distance r = 1 from a hypothetical point-mass, of mass m = 1, the circular orbit speed = 1.
In this system of units, the gravitational constant G = 1.

The results for mass distribution are presented in graphs of surface mass density (smd).

The results also include the rotation curves quantified in normalised units. A dotted line shows part of the continuation of the rotation curve, for hypothetical particles of negligible mass beyond the outer rim of the disk. And another dotted line shows a small part of the rotation curve which would result, if hypothetically the entire mass of the galaxy was concentrated in a tiny point at its centre.

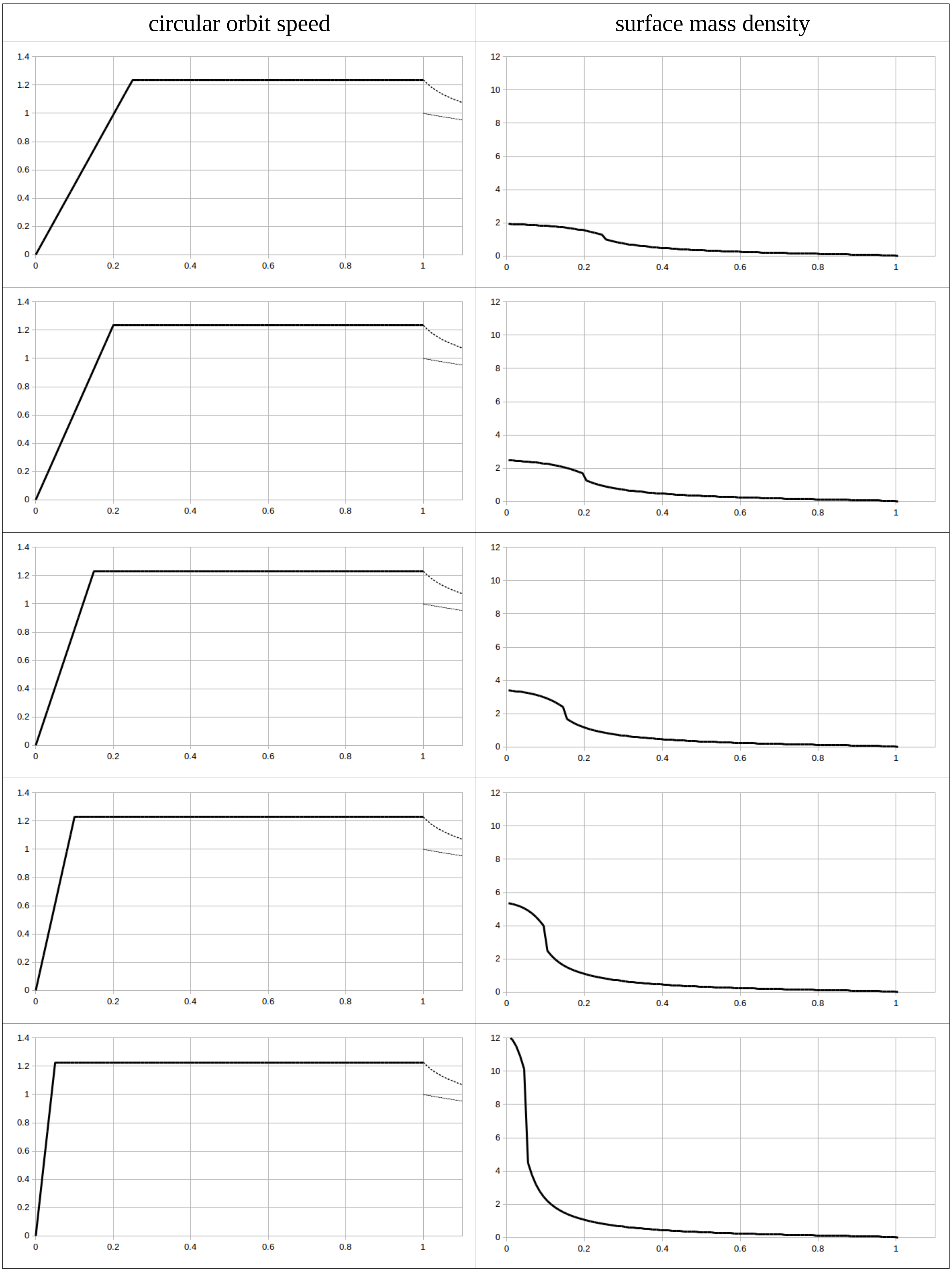

Figure 2: Graphs of normalized results for five hypothetical disk galaxies
(horizontal axis = radial distance from centre of galaxy)

The circular orbit speed throughout the flat part of the rotation curve, and the maximum value of surface mass density near the centre, are presented for each of the 5 hypothetical disk galaxies, in the following table.

$r_{transition}$	smd_{max}	$speed_{max}$
0.25	1.95	1.237
0.20	2.49	1.233
0.15	3.41	1.230
0.10	5.36	1.228
0.05	12.10	1.227

Figure 3: Table of normalized results for five hypothetical disk galaxies

Discussion

1. For all 5 hypothetical disk galaxies, the transition from linearly rising to flat (in the circular orbit speed graph), is seen to correspond with a transition from higher surface mass density inside that radius, to lower surface mass density outside it.

2. As the rotation curve transition point is moved closer to the centre of the disk galaxy, the maximum value of surface mass density, near the centre of the disk galaxy, increases greatly. The surface mass density at the centre of the galaxy with transition at 0.05, is more than six times greater, than the surface mass density at the centre of the galaxy with transition at 0.25.

3. It is remarkable that, although these 5 hypothetical disk galaxies have different rotation curve transition points, and very different maximum surface mass density near the centre, their circular orbit speeds on the flat portions of their rotation curves differ from each other by less than 1%.

References

Disk-galaxy density distribution from orbital speeds using Newton's law
K F Nicholson (2000)
http://arxiv.org/abs/astro-ph/0006330

Galaxy mass distributions for some extreme orbital-speed profiles
K F Nicholson (2001)
http://arxiv.org/abs/astro-ph/0101401

Galaxy Mass Distributions from Rotation Speeds by Closed-Loop Convergence
K F Nicholson (2003)
http://arxiv.org/abs/astro-ph/0303135

Galactic mass distribution without dark matter or modified Newtonian mechanics
K F Nicholson (2003, revised 2007)
http://arxiv.org/abs/astro-ph/0309762

Errors in equations for galaxy rotation speeds
K F Nicholson (2003)
http://arxiv.org/abs/astro-ph/0309823