Task sheet to rotation curves

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Task 1

Think about how the galaxy should be orientated to be observed?
Here are some pictures as example:

Inclination angle $i = 0°$
Galaxy: NGC 6814
Credit: Abb. 1

Inclination angle $i \approx 60°$
Galaxy: NGC 7606
Credit: Abb. 2

Inclination angle $i = 90°$
NGC 4762
Credit: Abb. 3

Task 2

Calculate the radial velocities from the measured wavelengths and plot them over the distance from the galaxy center! Use $\lambda_0 = 21.106$Å and 1pc$= 3.1 \cdot 10^{16}$m!

λ in Å	Radius R in Mpc	$v_{rotation}$ in $\frac{\text{km}}{\text{s}}$
21.1195	1	
21.1130	2	
21.1173	5	
21.1194	7	
21.1201	10	
21.1208	15	
21.1211	20	
21.1215	22	
21.1213	25	

Task 3

Derive for circular orbits the formula for the velocity v in dependence of the distance r. Assume a radially symmetric mass distribution.

Task 4

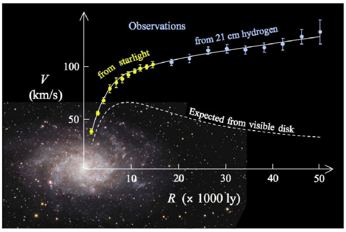
Assuming circular orbits, compute the velocities of the planets in our solar system. Plot the resulting rotation curve v over r.

Task 5

Formulate an expectation for the rotation curve of the Milky Way, assuming that the mass in the bulge to be $1.6 \cdot 10^{10} M_\odot$ and in the disk to be $4 \cdot 10^{10} M_\odot$

Task 6

The observed rotation curves of spiral galaxies are of the following form:



This cannot be explained by visible mass alone. Assuming that dark matter is the source of the difference between the observed and the predicted rotation curves, please calculate the mass of the dark matter depending on the velocities $v(r)$ and $v_{axis}(r)$

Task 7

To find out how dark matter is distributed through out a spiral galaxy, please consider a simple rotation curve consisting of a linear and a constant branch. Assume a spherically symmetric mass distribution of the form

$$\mu(r) \sim r^k$$

For the mass use the formula

$$M(r) = 4\pi \int_{r_0}^{r} \mu(\rho)\rho^2 \mathrm{d}\rho$$

a) Please calculate the mass of the bulge in dependence of k.

b) Using the formula for v from Task 3 and the result from a please determine the exponent k for the bulge (v r). Calculate the mass of the bulge in dependence of r and the complete mass M_B of the bulge.

c) To determine k for the halo ($v = \text{const}$), consider the total mass to be composed of the mass of the bulge M_B and the mass of the halo M_H.

$$M(r) = M_B + M_H(r)$$

Calculate the mass outside of the bulge with the integral for the mass. Determine the exponent k using the results of b) and Task 3. Find a formula for the mass of the halo in dependence of r.

d) Compare the rotation curve of the bulge to the rotation curve of a rigid body.