assistant

To determine the acceleration of a mass in the outer regions of the galaxy NGC 6946, I must first understand the nature of its motion. The problem describes objects, like stars or nebulae, as moving on circular orbits around the galactic center. The force causing this motion is gravity. According to Newton's laws, a mass moving in a circle must be experiencing a constant acceleration directed towards the center of the circle. This is the centripetal acceleration.

The magnitude of this centripetal acceleration, **a**, for an object moving with a speed `v` in a circular path of radius `r` is given by the fundamental relation: [a = \frac{v^2}{r}] This is the acceleration I need to estimate. The problem directs me to use the data for NGC 6946 presented in Figure 1(B). This figure shows the rotational velocity `v_c` as a function of the distance `r` from the galactic center.

I need to examine the "outer regions" of the galaxy. Looking at the graph, for large radii (for instance, `r > 15` kpc), the velocity curve becomes nearly flat. This indicates that the orbital velocity (v_c) approaches a constant value in these outer regions. From the graph, I can estimate this constant velocity to be approximately: [v_{c, \infty} \approx 200 \text{ km/s}] To calculate the acceleration, I must select a representative point in this outer region. Let me choose a large radius where the curve is clearly flat, for example, `r = 20` kpc.

Now, I must convert these values into standard SI units to calculate the acceleration in m/s^2. The given velocity is: [v_c = 200 \text{ km/s} = 200 \times 10^3 \text{ m/s} = 2.0 \times 10^5 \text{ m/s}] The chosen radius is `r = 20` kpc. Using the conversion factor provided in the problem text, $1 \text{ kpc} = 3.09 \times 10^{19} \text{ m}$: [r = 20 \text{ kpc} = 20 \times (3.09 \times 10^{19} \text{ m}) = 6.18 \times 10^{20} \text{ m}] Now I can substitute these values into the equation for centripetal acceleration: [a_m = \frac{v_c^2}{r} = \frac{(2.0 \times 10^5 \text{ m/s})^2}{6.18 \times 10^{20} \text{ m}}] [a_m = \frac{4.0 \times 10^{10} \text{ m}^2/\text{s}^2}{6.18 \times 10^{20} \text{ m}}] [a_m \approx 0.647 \times 10^{-10} \text{ m/s}^2] Rounding to a reasonable number of significant figures based on the precision of reading the graph, I find the estimated acceleration: [a_m \approx 6.5 \times 10^{-11} \text{ m/s}^2]