Dark Matter – Analyzing Galaxy UGC 11748

We can see Galaxy UGC 11748. Most of the stars lie within a radius of 1.64 x 10^{20}m. Physicists have been able to calculate the mass of these stars by the **Brightness Method**. The mass has been determined to be 1.54 x 10^{41} kg (or 77.4 billion times the mass of our sun!!). We call this the '**luminous mass'**. Why?

It is expected that the stars that lie outside this radius will orbit in the same way that planets orbit the sun. That is, the Fc needed for objects to follow a circular path is supplied completely by Fg. (Fg = mg does NOT work out in space – it is a short cut for objects on earth only).

The focus of this activity is to analyze these far stars. →

Diagram

Useful formulas

$F_{net} = ma$ $F_c = mv^2/r$

$F_g = Gm_1m_2/r^2$

Data

Star of interest				
Orbital radius (x 10^{20} m)	Measured speed (x 10^5 m/s)	Calculated speed (x 10^5 m/s)	Gravitational Mass (kg)	Missing Mass (%)
A: 1.85	2.47	2.36	1.69	8.99
B: 2.75	2.40			
C: 3.18	2.37			
D: 4.26	2.25			
E: 6.48	2.47			

1. Graph – Use the data above to graph measured speed (y axis) vs. orbital radius (x axis). The graph should be at least ½ page big. The y axis should go from 0 to 2.5 with the unit being (x 10^5 m/s). The x axis should go from 0 to 7 with the unit being (x 10^{20} m). Make sure you label the axes.

   Draw a line or curve of best fit (refer to page ……. In your text) . Label this '**measured'**.

2. For each orbital radius (see chart), calculate the speed expected if the only mass causing this rotation is the luminous mass. Record your answers in the column '**Calculated speed'**. One answer is provided for you. You should do the math and make sure you get the same answer! If you do, you know your math is good.

   a) Show a sample calculation

   b) Plot the calculated speed against orbital radius on the graph you've already started (#1). Draw a line/curve of best fit. Label this '**calculated'**.

3. Compare the 'measured' and 'calculated' lines on the graph. Discuss a possible explanation for any difference.

4. **Gravitational Mass**: The measured speeds are accurately measured. Let's work backwards and determine what mass is responsible for the force of gravity pulling these stars in a circle. Set Fc = Fg and think about what m_1 and m_2 represent. It will be helpful to go back to $Fc=mv^2/r$ calculations and see what the variables represent.

   a) Show a sample calculation.

   b) Record your answers in the chart in the '**Gravitational Mass**' column.

5. For each star, calculate the % difference between the gravitation mass and the luminous mass. Represent this difference as a percentage of the gravitational mass.

   a) Show a sample calculation.

   b) Record you answers in the '**missing mass'** column.

6. Explain the significance of the missing mass.

Name:

Application – 15 marks.

Application	**/15**
#1, #2 Graph	
#3 - 3 marks	
#4 - 3 marks	
#5 – 2 marks	
#6 - 2 marks	