

## 8.7: Wrapping It Up 8 - What Is the Matter With NGC 3198?

In this activity we will be studying the spiral galaxy NGC 3198 (Figure A.8.4). We will use measurements of the rotation curve of the galaxy and of the brightness of the galaxy in order to determine whether it contains dark matter, and if so, how much.



Figure A.8.4: Image of the spiral galaxy NGC 3198. Credit: Frei, Guhathakurta, Gunn, and Tyson, 1996, *Astronomical Journal*, Vol. 111, p. 174

### 8.7.0.1: PART I. MODELING A ROTATING GALAXY

In this part of the exercise, you will use a set of rotating rings to model how the stars and gas in this galaxy rotate. To do this, open up the interactive galaxy modeler:

#### Play Activity

In the upper-right hand corner, you will see a graph of the galaxy's rotation curve.

- The graph only shows the velocities on the side of the galaxy that is moving away from us.
- You can click on the data points in the graph to see the velocities of the stars and gas in NGC 3198 at different radii, or distances, from the galaxy's center.



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Next, model the galaxy's rotation using the slider bars at the bottom right.

- Use the left-most slider bar to match the velocity of the data point closest to the center of NGC 3198.
- Use the next slider bar to match the velocity of the next data point on the graph, and so on, out to the right-most slider bar, which you will use to match the velocity of the right-most data point on the graph (farthest from the center of NGC 3198).
- Once you have matched the sliders to the velocities in the graph, click on "Update" at the bottom.
- The rotating rings on the left will now simulate the velocities you have input with the sliders.
- Congratulations! You have now modeled the rotation of NGC 3198.



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### 8.7.1: PART II. MEASURING NGC 3198'S TOTAL GRAVITATIONAL MASS

Now you will fill out the missing data in different columns of Table A.8.1. Go back to the rotation curve of NGC 3198. Remember that you can click on the data points to read how fast the stars and gas in the galaxy are rotating at different radii from the galaxy's center.

1. Click on and read the data points in the rotation curve graph. Fill in the velocity and radius information in Table A.8.1.



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### 8.7.2: PART III. MEASURING NGC 3198'S LUMINOUS MASS

In the first part of this activity, you measured NGC 3198's total mass at several different radii. Now, you are going to take a closer look at the luminosity (absolute brightness) of the galaxy and think about what the brightness measured at different radii tell us about the amount of light-emitting matter (like stars, gas, and dust) that is in NGC 3198.

The luminosity graph shows the total luminosity of NGC 3198 encircled within several radii. For instance, the data point at  $R = 2.5$  kpc shows the total luminosity of all the stars and gas and dust within a circle of radius 2.5 kpc from the center of the galaxy. The data point at  $R = 10$  kpc shows the total luminosity of all the stars and gas and dust within a circle of radius 10 kpc from the center of the galaxy. And so on.



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Now take a look at the graph of NGC 3198's luminosity.

- You can do this by clicking on “Show/Hide Luminosity Profile” above the rotation curve.
- You should now be able to see graph of the galaxy's rotation curve, and below that, the graph of the galaxy's luminosity versus radius.



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### 8.7.3: PART IV. DARK AND LUMINOUS MATTER IN NGC 3198

Now we can compare the amount of luminous matter in NGC 3198 (measured in Part III) to the total amount of matter in NGC 3198 (measured in Part II). This will give us insight into whether NGC 3198 has any dark matter, and if so, how much.



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