11.5: Wrapping It Up 11 - Black Hole Densities

Learning Objectives

- Explain the following laws within the Ideal Gas Law

Once material crosses the Schwarzschild radius of a black hole there is no escape; not even light is moving fast enough to get back out. Imagine a sphere around the black hole singularity reaching out to the Schwarzschild radius. This sphere represents the effective volume of the black hole. Yes, it's mass is seemingly concentrated in a point, but the sphere encompassing the region of no return is much larger. More massive black holes have larger Schwarzschild radii, so how does their average density compare to smaller examples?

11.5.1: Part I: Black Hole With an Average Density Like Water

The average density of any object is its mass divided by the volume it occupies. For a spherical object with radius R, the volume is $\frac{4}{3}\pi R^3$. Liquid water has an average density of 1000 kg/m^3. Using the Schwarzschild radius to estimate the volume, how massive must a black hole be to have the average density of water? How does this mass compare to the sun?

1.

2.

3.

4. If the average density is equal to that of water (1000 kg/m^3), what is the mass of the black hole in kg?

5.

11.5.2: Part II: Black Hole at the Center of the Galaxy

1. The supermassive black hole at the center of the Milky Way has a mass of $4 \times 10^6 \, \mathrm{M_{Sun}}$. What is the average density of this black hole?

2.

3.

4.